



National Research  
**FLAGSHIPS**  
Climate Adaptation



2010 International Climate Change Adaptation Conference  
**Climate Adaptation Futures**  
Preparing for the unavoidable impacts of climate change

Conference Handbook



29 June – 1 July 2010, Gold Coast Convention Centre,  
Gold Coast, Queensland, Australia

## CONFERENCE ORGANISING TEAM

**Jean Palutikof**  
**Andrew Ash**  
**Mark Stafford Smith**  
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Kerry Fitzgerald  
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Cher Page

We gratefully acknowledge the considerable time and effort invested by many individuals and organisations in planning for, and running this Conference, especially by CSIRO, NCCARF and YRD staff, Martin Parry (Conference adviser), the Conference Domestic and International Steering Committees, Steve Turton (post-Conference field trips), Jan McDonald and Peter Grace (Domestic Steering Committee), all session chairs and convenors, and Conference volunteers.



## CONFERENCE HOSTS

# NCCARF CSIRO

### SILVER

Australian Government  
Department of Agriculture,  
Fisheries and Forestry

### BRONZE

Office of Climate Change,  
Department of Environment  
and Resource Management,  
Queensland Government

WWF

Gold Coast City Council

## CONFERENCE PARTNER

Geoscience Australia

## SUPPORT FOR DEVELOPING COUNTRY PARTICIPANTS

AusAid

International Geosphere-  
Biosphere Programme (IGBP)

Swedish Environment Secretariat  
in Asia (SENSA), Bangkok,  
Thailand Regional Climate Change  
Adaptation Knowledge Platform

## NCCARF PARTNERS

### Major Partner:

Australian Government  
Department of Climate Change  
and Energy Efficiency

Griffith University

Queensland Government

Macquarie University

Queensland University of Technology

The University of Newcastle

James Cook University

University of Southern Queensland

University of the Sunshine Coast

Murdoch University

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# WELCOME



Professor Jean Palutikof  
Director, NCCARF

Welcome to the 2010 International Climate Change Adaptation Conference, Climate Adaptation Futures: Preparing for the unavoidable impacts of climate change. On behalf of the Conference International Steering Committee, we are delighted to welcome 1000 participants from around 55 countries to this event, which will be one of the first international forums to focus solely on climate impacts and adaptation.

Climate change is one of the most important environmental, social and economic issues facing the world today. Despite growing efforts to reduce greenhouse gas emissions, some impacts such as more intense floods, droughts, bushfires, and rising sea levels are now inevitable. We must therefore plan for and adapt to these changes, in order to minimise the negative impacts and enhance the benefits to natural systems, societies, and human activities and well-being. This represents a challenge for decision making at all levels, from individuals to governments, and in business and industry.

This Conference will showcase leading impacts and adaptation research from Australia and around the world. With an exciting program of over 500 presenters, it will explore the contribution of adaptation science to planning and policy making, and how robust adaptation decision making can proceed in the face of uncertainty about the impacts of climate change.



Dr Andrew Ash  
Director, CSIRO Climate  
Adaptation Flagship

## INTERNATIONAL STEERING COMMITTEE

**Jean Palutikof (Conference Convenor)**, NCCARF, Australia

**Andrew Ash (Conference Co-Convenor)**, CSIRO Climate Adaptation Flagship, Australia

**Neil Adger**, Tyndall Centre for Climate Change, University of East Anglia, United Kingdom

**Joseph Alcamo**, Chief Scientist, UNEP

**Tim Carter**, Finnish Environment Institute (SYKE), Finland

**Kristie Ebi**, Executive Director, Technical Support Unit, Working Group II, IPCC

**Chris Field**, Co-chair Working Group II, IPCC, and Carnegie Institution for Science, USA

**Kathy Hibbard**, Pacific Northwest National Laboratory, USA

**Saleemul Huq**, International Institute for Environment and Development, United Kingdom

**Kathy Jacobs**, Assistant Director OTSP, US Executive Office of the President,

**Rik Leemans**, Chair of the Earth System Science Partnership, and Wageningen University, Netherlands

**Jian Liu**, Chief of Climate Change Adaptation Unit, UNEP

**Antonio Magalhães**, Director, Second International Conference on Climate, Sustainability, and Development in Semi-Arid Regions, Brazil

**Carlos Nobre**, Centre for Earth System Science, National Institute for Space Research, Brazil

**Balgis Osman-Elasha**, African Development Bank (AfDB), Tunisia

**Martin Parry**, Grantham Institute and Centre for Environmental Policy, Imperial College London, UK

**Cynthia Rosenzweig**, NASA Goddard Institute for Space Studies and Columbia University, USA

**Mark Stafford Smith**, Science Director, CSIRO Climate Adaptation Flagship, Australia

**Will Steffen**, Australian National University, Australia

**Coleen Vogel**, University of the Witwatersrand, South Africa

**Jean-Pascal van Ypersele**, IPCC Vice-Chair, Université catholique de Louvain, Belgium

**Marie Waschka**, NCCARF, Australia

# ABOUT THE NATIONAL CLIMATE CHANGE ADAPTATION RESEARCH FACILITY



An initiative of the Australian Government, the National Climate Change Adaptation Research Facility (NCCARF) was established in 2008 to lead the Australian research community in a national inter-disciplinary effort to generate the information needed by decision-makers in government, and in vulnerable sectors and communities, to manage the risks of climate change impacts.

NCCARF has coordinated the development of a series of National Climate Change Adaptation Research Plans, undertakes a program of synthesis and integrative climate change adaptation research, has established and coordinates eight Adaptation Research Networks, and works to engage with research end users and to improve their access to information to support climate change adaptation.

Based at Griffith University's Gold Coast campus, NCCARF is a partnership between the Australian Government Department of Climate Change and Energy Efficiency, Griffith University, the Queensland Government, James Cook University, Macquarie University, Murdoch University, Queensland University of Technology, The University of Newcastle, University of Southern Queensland, and the University of the Sunshine Coast.

## Major Partner:



**Australian Government**  
**Department of Climate Change  
and Energy Efficiency**

## Partners:



## ABOUT CSIRO CLIMATE ADAPTATION FLAGSHIP

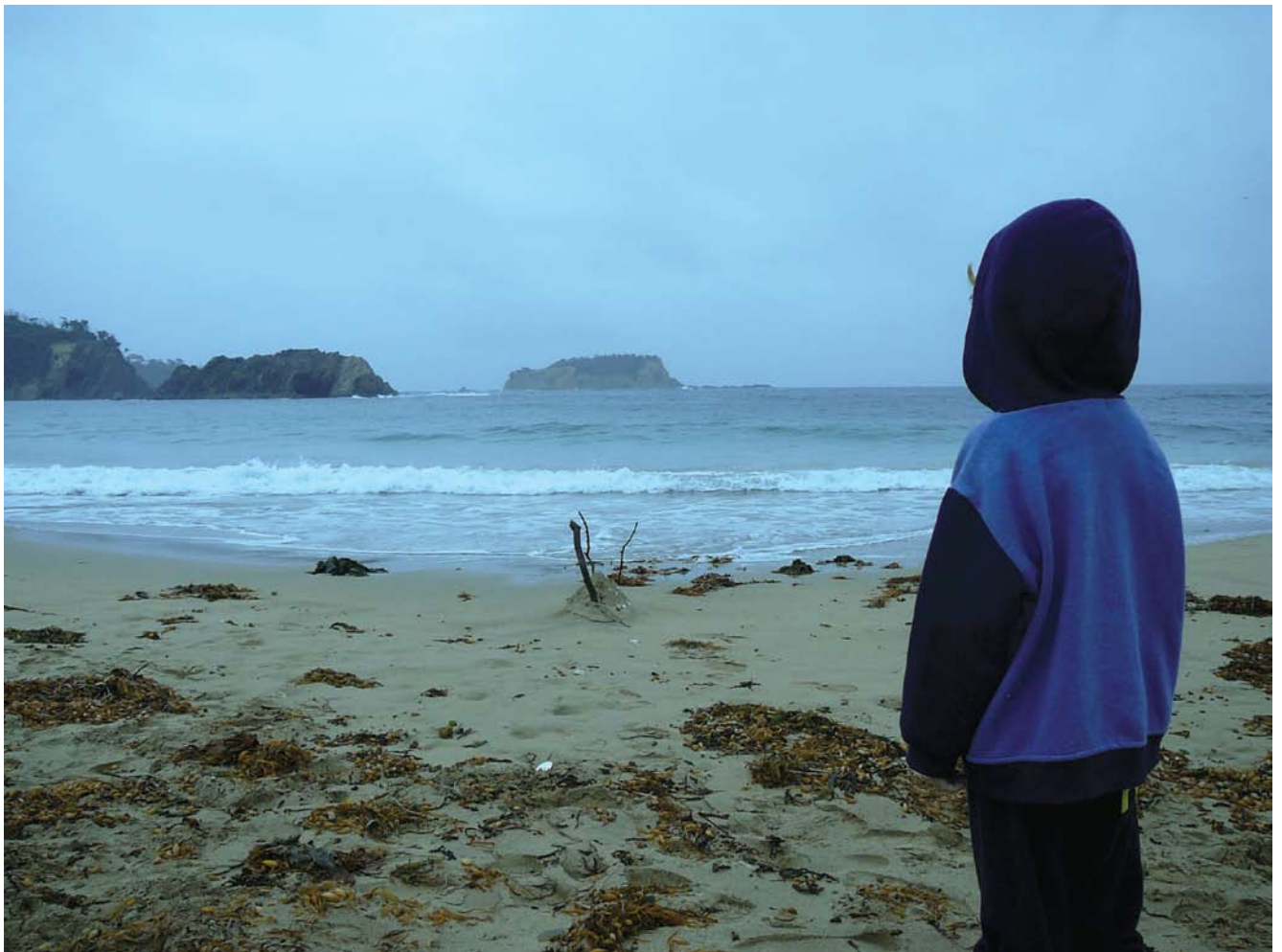
National Research  
**FLAGSHIPS**  
Climate Adaptation



The CSIRO Climate Adaptation Flagship is a multidisciplinary research partnership enabling Australia to adapt more effectively to the impacts of climate change and variability and informing national planning, regulation and investment decisions. CSIRO's leading scientists work in partnership with governments, industries and communities to deliver integrated solutions to this urgent national challenge.

Our research covers a range of adaptation focal areas underpinned by climate and social research aimed to improve our understanding of both the climate system and our human response to changes. The Flagship delivers regional and national scale climate change projections and vulnerability assessments to support adaptation. We have projects which address urban coastal vulnerability in settlements by developing design, infrastructure and management solutions to enhance adaptive capacity. We are developing conservation strategies to maximise resilience in marine and terrestrial ecosystems threatened by climate change. As well as developing effective adaptation options for Australia's primary industries and rural regions in responding to climate change and variability we are supporting our neighbours in the Asia-Pacific in their efforts to adapt to climate change.

With increased scientific understanding of climate change and variability, of its impacts and of adaptation responses, Australia can formulate an effective response in planning, management, technological innovation, regulation and investment decisions.



## SPONSORS AND PARTNERS

### Silver



**Australian Government**  
**Department of Agriculture,  
Fisheries and Forestry**

### Australia's Farming Future

**Australia's Farming Future (AFF) is the Australian Government's program to help our primary producers adapt and respond to climate change.**

By supporting research and development, training, financial advice and assistance AFF assists primary producers to secure a sustainable and profitable future in a changing climate.

If you are interested in the challenges and opportunities that climate change presents to our primary industries come to the morning session on 'Adapting agriculture to climate change' on Tuesday 29 and Wednesday 30 June.

**More information on AFF is available at our exhibition stall and at:**

**Website** [www.daff.gov.au/farmingfuture](http://www.daff.gov.au/farmingfuture)

**Email** [farmingfuture@daff.gov.au](mailto:farmingfuture@daff.gov.au)

**Phone** 1800 638 746



australia's farming future

**DEPARTMENT OF AGRICULTURE, FISHERIES AND FORESTRY**

Australia's Farming Future (AFF) encourages the development of innovative research and on-farm demonstrations. Large scale collaborative projects have commenced that involve a range of Australian organisations such as research providers, industry groups, universities and state governments. Approximately \$40 million worth of projects are now underway in Australia on climate change adaptation research to develop better management practices, strategies and technologies. These projects complement other areas of research under AFF on emissions reduction and soil carbon. The research will improve opportunities for primary producers to respond to climate change and manage emissions while improving productivity.

More information is available at: [www.daff.gov.au/farmingfuture](http://www.daff.gov.au/farmingfuture).



## Bronze

### Office of Climate Change, Department of Environment and Resource Management, Queensland Government



The Queensland Government is proud to sponsor the 2010 International Climate Change Adaptation Conference.

Queensland is particularly vulnerable to climate change impacts such as sea level rise, more frequent heatwaves, more intense rainfall events in some regions and drought in others. Without practical action, priceless natural assets such as the Great Barrier Reef and the industries that rely on our natural environment such as agriculture, mining and tourism are at risk.

Successful adaptation will depend on effective communication of the science of climate change to ensure community level responses are well planned and targeted to reduce the dangerous impacts on human health, water security, industry, our built environment, emergency services and ecosystems.

Queensland's climate change response was the first in Australia to include a detailed Adaptation Action Plan to prepare communities and industries across the state for the physical impacts of climate change. ClimateQ: toward a greener Queensland, released in August 2009, sets out the next crucial steps to mitigate and adapt to the effects of climate change in Queensland.

### WWF - Australia



WWF is the world's largest and most experienced independent conservation organisation. It has close to five million supporters and a global network active in more than 100 countries. Our mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

WWF advocates for sustainable climate adaptation policy at national and international levels. Together with its many partners, WWF has conducted adaptation projects in diverse areas, such as Northern Australia, the Mekong, the Andes, Central Yangtze, Eastern Himalayas, East Africa, Southern Ocean, Fiji, the Sundarbans, and the Coral Triangle.

For more information visit: <http://www.wwf.org.au/>

### Gold Coast City Council



The dynamic nature of the Gold Coast – its location, growth, development and demand for services – makes its exposure to climate change unique. Protection of our natural assets, strengthening the economy, population growth and building sustainable communities are some of our city's biggest challenges.

In response, Council has developed the Climate Change Strategy 2009-14. The strategy builds on our existing climate change related activities and provides a well defined plan, using targeted actions for mitigation and adaptation. One of the first outcomes of the strategy has been the development of the Gold Coast Principles for Intergovernmental Climate Change Collaboration which aim to facilitate increased opportunities for aligning projects and creating partnerships in the climate change arena. For more information visit: [goldcoast.qld.gov.au/climatechange](http://goldcoast.qld.gov.au/climatechange)

## EXHIBITORS

Antarctic Climate and Ecosystems  
Cooperative Research Centre

BMT WBM Pty Ltd

Bureau of Meteorology

Centre for International Forestry  
Research

CLIMsystems Ltd

CSIRO

NCCARF

NCCARF National Adaptation  
Research Networks

## SPONSORS AND PARTNERS

### Conference Partner

#### Geoscience Australia



**Australian Government**

**Geoscience Australia**

APPLYING GEOSCIENCE TO AUSTRALIA'S  
MOST IMPORTANT CHALLENGES

Geoscience Australia is custodian of the geographic and geological data and knowledge of the nation. It creates, maintains and disseminates geographic and geological knowledge to provide:

- advice to Government to support policy development and decision making;
- information to the minerals, petroleum and energy sectors to enhance national wealth and energy security;
- information about the land and marine jurisdiction for environmental, economic and social purposes;
- the fundamental framework for all Australia's spatial information and jurisdictional boundaries;
- information on natural hazards and risks for community safety and resilience;
- information on groundwater for environmental, economic and social purposes; and
- education and public event programs to promote awareness of geoscience.

### Support for developing country participants



**ADAPTATION  
KNOWLEDGE  
PLATFORM**



**Australian Government**

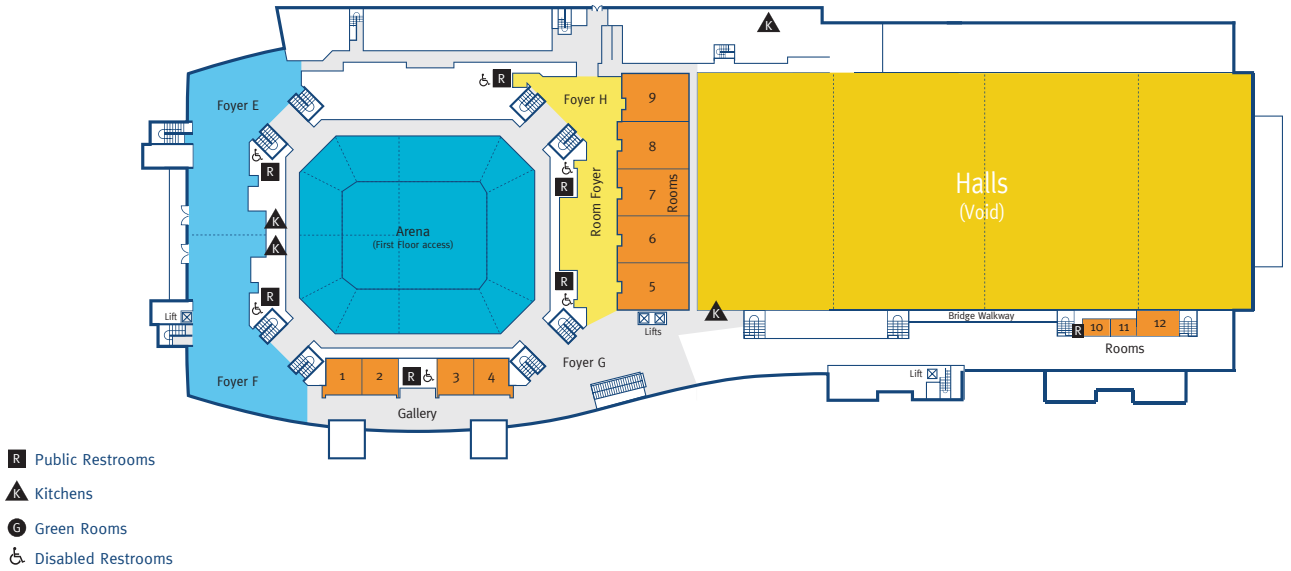
**Aid Program**

**GLOBAL  
IGBP** International  
Geosphere-Biosphere  
Programme  
**CHANGE**

# FLOOR PLAN – CONFERENCE VENUE

## Gold Coast Convention & Exhibition Centre

### First floor

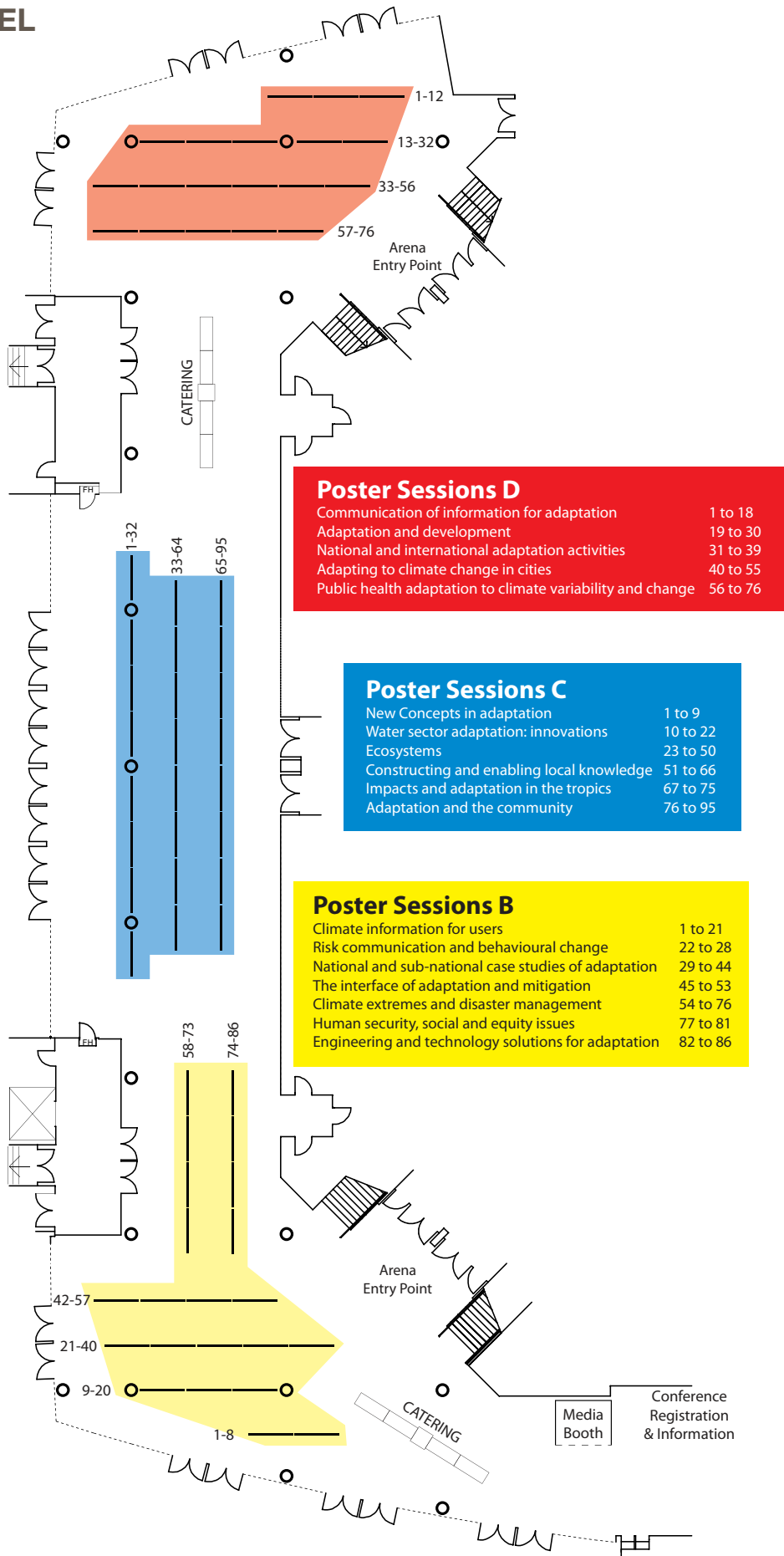


### Ground floor



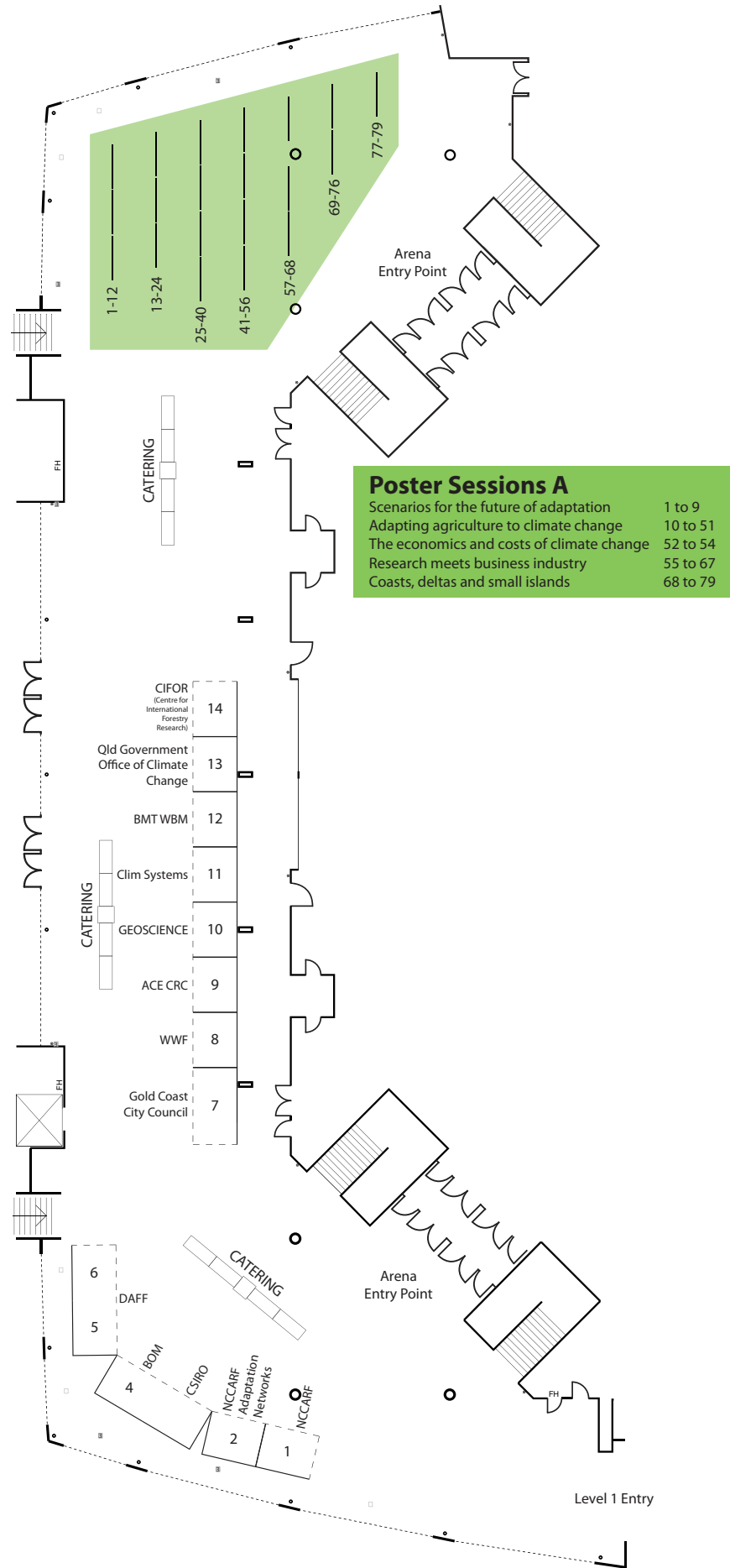
# FLOOR PLAN – POSTER DISPLAYS

## GROUND LEVEL



# FLOOR PLAN – POSTER DISPLAYS

## LEVEL ONE



# SUMMARY PROGRAM

## Day 1 – 29th June

TIME	SESSION TYPE					
8.30am – 10.30am <b>Arena 1</b>	<b>1.1</b> Opening Plenary <b>Chairs:</b> Jean Palutikof (NCCARF) and Andrew Ash (CSIRO) <ul style="list-style-type: none"> <li>• <i>Welcome to Country</i> Mr Graham Dillon, Kombumerri elder</li> <li>• <i>Introduction</i> Professor Ian O'Connor, Vice Chancellor, Griffith University</li> <li>• <i>Welcome</i> Hon. Penny Wong, Minister for Climate Change, Energy Efficiency and Water</li> <li>• Hon. Kevin Rudd, Prime Minister of Australia <i>The challenge of climate change: to Australia and the world</i> (tbc)</li> <li>• Dr R.K. Pachauri, Chair, IPCC and Dr Jean-Pascal van Ypersele, Vice Chair, IPCC <i>Climate Change, Adaptation, and IPCC</i></li> <li>• Professor Joseph Alcamo, Chief Scientist, UNEP</li> <li>• Professor Martin Parry, Imperial College, UK <i>The challenge for adaptation: the legacy from Copenhagen</i></li> <li>• Youth perspectives on climate change adaptation</li> </ul>					
10.30am – 11.00am	Morning Tea					
11.00 am – 12.40pm <b>Arena 1</b>	<b>1.2</b> Plenary: Frontiers in adaptation science <b>Chair:</b> Bryson Bates, CSIRO, Australia <ul style="list-style-type: none"> <li>• <i>Uncertainty/limits to adaptation/adapting to +4°C</i> Steve Schneider, Stanford University, USA</li> <li>• <i>Food security/natural environments</i> Mark Howden, CSIRO, Australia</li> <li>• <i>Sustainability and adaptation</i> Atiq Rahman, BCAS, Bangladesh</li> </ul>					
12.40pm – 2.00pm	Lunch					
1.00pm – 1.40pm	Open meeting: <i>Making sense of new global scenarios for adaptation research</i> <b>Room 5</b> <b>Chair:</b> Tim Carter, Finnish Environment Institute (SYKE), <b>Speaker:</b> Richard Moss, Pacific Northwest National Laboratory/ University of Maryland					
2.00pm – 3.30pm	<b>1.3</b> PARALLEL SESSIONS					
Thread 1 <i>Understanding and communicating adaptation</i>	Thread 2 <i>Adaptation by sectors</i>	Thread 3 <i>Adapting from the grass roots</i>	Thread 4 <i>Frameworks for adaptation</i>	Thread 5 <i>Adaptation at the edge</i>	Thread 6 <i>Human welfare and adaptation</i>	
<b>Parallel Session 1.3.1</b> <b>Room 6</b> Scenarios of the future for adaptation <b>Convenors:</b> Tim Carter (Finnish Environment Institute SYKE), Mark Stafford Smith (CSIRO)	<b>Parallel Session 1.3.2</b> <b>Arena 1</b> Adapting agriculture to climate change (session 1 of 2) <b>Convenors:</b> Mark Howden (CSIRO), Cynthia Rosenzweig (NASA, Goddard Institute for Space Studies)	<b>Parallel Session 1.3.3</b> <b>Room 5</b> A Climate of Uncertainty: Indigenous Land Managers, vulnerabilities and adaptation to climate change <b>Convenor:</b> Marcia Langton (University of Melbourne)	<b>Parallel Session 1.3.4</b> <b>Room 9</b> The economics and costs of adaptation <b>Convenor:</b> Frank Jotzo (ANU)	<b>Parallel Session 1.3.5</b> <b>Room 7</b> Coasts, deltas and small islands (session 1 of 2) <b>Convenors:</b> Robert Nicholls (University of Southampton), Jon Barnett (University of Melbourne), Tim Smith (USC)	<b>Parallel Session 1.3.6</b> <b>Room 8</b> Adaptation and the community (session 1 of 2) <b>Convenors:</b> Coleen Vogel (University of Witwatersrand), Lisa Schipper (Stockholm Environment Institute)	
3.30pm – 4.00pm	Afternoon Tea					
4.00pm – 5.30pm	<b>1.4</b> PANEL SESSIONS					
<b>Panel Session</b>	<b>1.4a Panel Session 1</b> <b>Arena 1</b> <i>Financing Adaptation: International transfers and global geopolitics</i> <b>Organiser:</b> Saleemul Huq, (International Institute for Environment and Development) <b>Panel members:</b> Ian Noble (World Bank), Robin Davies (AusAID), Emma Tompkins (University of Leeds), Saleemul Huq (IIED)	<b>1.4b Panel Session 2</b> <b>Room 5-6</b> <i>Is building resilience the answer?</i> <b>Organiser:</b> Terry Hughes, (James Cook University) <b>Panel members:</b> Chris Cocklin (JCU), Eddie Allison (WorldFish Center), Joshua Cinner (JCU), Nick Graham (JCU), Louisa Evans (WorldFish Center)		<b>1.4c Panel Session 3</b> <b>Room 7-8</b> <i>Measuring the effectiveness of adaptation</i> <b>Organiser:</b> Rob Kay, (Coastal Zone Management) <b>Panel members:</b> Cynthia Rosenzweig (GISS), Will Steffen (Australian National University), Andrew Haines (LSHTM), Bruce Thom (University of Sydney)		
5.45pm – 6.15pm <b>Arena 1</b>	<b>1.5</b> Welcome Reception <b>Speaker:</b> <i>Climate change: a personal view of adaptation and mitigation in the Australian context</i> <b>Tim Flannery</b> , Macquarie University, Australia					
6.15pm – 7.30pm <b>Poster Session</b> <b>Foyer</b>	<b>1.6</b> Poster presentations & refreshments <ul style="list-style-type: none"> <li>• Adapting agriculture to climate change</li> <li>• Scenarios for the future of adaptation</li> <li>• Coasts, deltas and small islands</li> <li>• The economics and costs of climate change</li> <li>• Research meets business and industry</li> </ul>					

# SUMMARY PROGRAM

## Day 2 – 30th June

TIME	SESSION TYPE					
7:30am – 8:30am <b>Poster Session Foyer</b>	<b>2.1</b> Light breakfast and poster presentations: <ul style="list-style-type: none"> <li>Climate information for users</li> <li>National and sub-national case studies of adaptation</li> <li>The interface of adaptation and mitigation</li> <li>Human security, social and equity issues</li> <li>Engineering and technology solutions for adaptation</li> <li>Risk communication and behavioural change</li> <li>Climate extremes and disaster management</li> </ul>					
8:30am – 10.30am <b>Arena 1</b>	<b>2.2</b> Plenary session: The science/policy interface <b>Chair:</b> Andrew Haines, London School of Hygiene and Tropical Medicine, UK <ul style="list-style-type: none"> <li><i>Equity and the economic impacts of adaptation</i> Neil Adger, Tyndall Centre for Climate Change Research, University of East Anglia, UK</li> <li><i>Climate change adaptation in a post-Copenhagen world: the view from Japan</i> Nobuo Mimura, Ibaraki University, Japan</li> <li><i>Bridging the science policy interface</i> Diana Liverman, University of Arizona, USA</li> <li><i>New scenarios for adaptation</i> Mark Stafford Smith, CSIRO, Australia</li> </ul>					
10.30am – 11.00am Morning Tea						
11.00am – 12.30pm <b>2.3 PARALLEL SESSIONS</b>						
Thread 1 <i>Understanding and communicating adaptation</i>	Thread 2 <i>Adaptation by sectors</i>	Thread 3 <i>Adapting from the grass roots</i>	Thread 4 <i>Frameworks for adaptation</i>	Thread 5 <i>Adaptation at the edge</i>	Thread 6 <i>Human welfare and adaptation</i>	
<b>Parallel Session 2.3.1 Room 6</b> Climate information for users <b>Convenors:</b> Chris West and Roger Street (UK CIP), Andrew Watkins (Bureau of Meteorology)	<b>Parallel Session 2.3.2 Arena 1</b> Adapting agriculture to climate change (session 2 of 2) <b>Convenors:</b> Mark Howden (CSIRO), Cynthia Rosenzweig (GISS)	<b>Parallel Session 2.3.3 Room 5</b> National and sub-national case studies of adaptation (session 1 of 2) <b>Convenors:</b> Emma Tompkins (University of Leeds), Heather McGray (World Resources Institute)	<b>Parallel Session 2.3.4 Room 9</b> The interface of adaptation and mitigation <b>Convenors:</b> Kathy Hibbard (Pacific Northwest National Laboratory), Andrew Ash (CSIRO)	<b>Parallel Session 2.3.5 Room 7</b> Coasts, deltas and small islands (session 2 of 2) <b>Convenors:</b> Robert Nicholls (University of Southampton), Jon Barnett (University of Melbourne), Tim Smith (USC)	<b>Parallel Session 2.3.6 Room 8</b> Human security, social and equity issues <b>Convenors:</b> Neil Adger (University of East Anglia), Karen O'Brien (University of Oslo)	
12.30pm – 2.00pm Lunch						
12.45pm – 1.30pm Open meeting: <i>Developing countries perspective on IAV networking</i> <b>Room 5</b>						
2.00pm – 3.30pm <b>2.4 PARALLEL SESSIONS</b>						
Thread 1 <i>Understanding and communicating adaptation</i>	Thread 2 <i>Adaptation by sectors</i>	Thread 3 <i>Adapting from the grass roots</i>	Thread 4 <i>Frameworks for adaptation</i>	Thread 5 <i>Adaptation at the edge</i>	Thread 6 <i>Human welfare and adaptation</i>	
<b>Parallel Session 2.4.1 Room 6</b> Risk communication and behavioural change <b>Convenors:</b> Jan McDonald (Griffith University), Susanne Moser (Susanne Moser Research and Consulting)	<b>Parallel Session 2.4.2 Arena 1</b> Water sector adaptation: innovations <b>Convenors:</b> Kathy Jacobs (Arizona Water Institute), Bryson Bates (CSIRO), Stuart Bunn (Griffith University)	<b>Parallel Session 2.4.3 Room 5</b> National and sub-national case studies of adaptation (session 2 of 2) <b>Convenors:</b> Emma Tompkins (University of Leeds), Heather McGray (World Resources Institute)	<b>Parallel Session 2.4.4 Room 9</b> Research meets business and industry <b>Convenors:</b> Sandra Schuster (Munich RE), Allen Kearns (CSIRO)	<b>Parallel Session 2.4.5 Room 7</b> Impacts and adaptation in the tropics <b>Convenor:</b> Suzanne Long (Reef and Rainforest Research Centre)	<b>Parallel Session 2.4.6 Room 8</b> Engineering and technology solutions for adaptation <b>Convenors:</b> Ron Cox (UNSW), Xiaoming Wang (CSIRO)	
3.30pm – 4.00pm Afternoon Tea						
<b>Panel Session</b>	<b>2.5a Panel Session 4 Arena 1</b> <i>Providing the essential information, knowledge and skills for adaptation</i> <b>Organiser:</b> Kathy Jacobs, (OTSP, Executive Office of the President, USA) <b>Panel members:</b> Chris West (UK CIP), Susanne Moser (Susanne Moser Research and Consulting), Celine Herweijer (Price Waterhouse Coopers)	<b>2.5b Panel Session 5 Room 5-6</b> <i>Vulnerability/risk assessment for extreme events</i> <b>Organiser:</b> John Schneider (Geoscience Australia) <b>Panel members:</b> Arthur Webb (SOPAC), Jennifer Rigby (Victorian Government), Roger Jones (Victoria University), Suraje Dessai (University of Exeter)	<b>2.5c Panel Session 6 Room 7-8</b> <i>Australian case studies: practical adaptation - making it happen on the ground</i> <b>Organiser:</b> Jon Barnett, (University of Melbourne) <b>Panel members:</b> Scott Smithers (JCU), Steve Dovers (ANU), John Handmer (RMIT), Ove Hoegh-Guldberg (UQ)	<b>Side Meeting Room 9</b> First Assessment Report on Climate Change and Cities (ARC3) <b>Convenor:</b> Cynthia Rosenzweig (GISS)		
5:45pm – 7:00pm <b>Poster Session Foyer</b>	<b>2.6</b> Poster presentations and pre-dinner bar <ul style="list-style-type: none"> <li>Water sector adaptation: innovations</li> <li>Adaptation and the community</li> <li>Impacts and adaptation in the tropics</li> <li>Ecosystems</li> <li>New concepts in adaptation</li> <li>Constructing and enabling local knowledge</li> </ul>					
7:00pm – 11:00pm	Conference Dinner					

# SUMMARY PROGRAM

## Day 3 – 1st July

TIME	SESSION TYPE					
7:30am – 8:30am <b>Poster Session Foyer</b>	<b>3.1</b> Light breakfast and poster presentations: <ul style="list-style-type: none"> <li>• Communication of information for adaptation</li> <li>• National and international adaptation activities</li> <li>• Adapting to climate change in cities</li> <li>• Adaptation and development</li> <li>• Public health adaptation to climate variability and change</li> </ul>					
8:30am – 10.30am <b>Arena 1</b>	<b>3.2</b> Plenary: Four case studies in adaptation <b>Chair:</b> Lesley Hughes, Macquarie University, Australia <ul style="list-style-type: none"> <li>• <i>Drought proofing rural economies in semi-arid areas: lessons from NE Brazil</i> Antonio Magalhães, Esquel Brazil Foundation, Brazil</li> <li>• <i>The urban poor in developing countries: the biggest adaptation challenge</i> David Dodman, International Institute for Environment and Development, UK</li> <li>• <i>The challenge of coastal erosion in West Africa</i> Isabelle Niang, University of Dakar, Senegal</li> <li>• <i>Towards better water security in China: the challenge of climate change</i> Jun Xia, Centre for Water Resources Research, Chinese Academy of Sciences, China</li> </ul>					
10.30 am– 11.00am Morning Tea						
11.00am – 12.30pm <b>3.3 PARALLEL SESSIONS</b>						
Thread 1 <i>Understanding and communicating adaptation</i>	Thread 2 <i>Adaptation by sectors</i>	Thread 3 <i>Adapting from the grass roots</i>	Thread 4 <i>Frameworks for adaptation</i>	Thread 5 <i>Adaptation at the edge</i>	Thread 6 <i>Human welfare and adaptation</i>	
<b>Parallel Session 3.3.1 Room 6</b> Communication of information for adaptation <b>Convenors:</b> Marie Waschka (NCCARF), Simon Torok (CSIRO)	<b>Parallel Session 3.3.2 Room 5</b> Ecosystems (session 1 of 2) <b>Convenors:</b> Rik Leemans (Wageningen University), Guy Midgley (South African National Biodiversity Institute), Alistair Hobday (CSIRO)	<b>Parallel Session 3.3.3 Room 9</b> Constructing and enabling local knowledge <b>Convenors:</b> Donovan Burton (NCCARF), Opha Pauline Dube (University of Botswana)	<b>Parallel Session 3.3.4 Room 8</b> National and international adaptation activities <b>Convenors:</b> Joseph Alcamo (UNEP), Youssef Nassef (UNFCCC)	<b>Parallel Session 3.3.5 Room 7</b> Climate extremes and disaster management (session 1 of 2) <b>Convenors:</b> Jean Palutikof (NCCARF), John Handmer (RMIT), Reid Basher (UN International Strategy for Disaster Reduction)	<b>Parallel Session 3.3.6 Arena 1</b> Adaptation and the community (session 2 of 2) <b>Convenors:</b> Coleen Vogel (University of Witwatersrand), Lisa Schipper (Stockholm Environment Institute)	
12.30pm – 2.00pm Lunch						
12.45pm – 1.30pm Open meeting: <i>Progressing an international IAV community</i> <b>Room 5</b>						
12.45pm – 1.30pm Adaptation and the community parallel session discussion <b>Arena 1</b>						
2.00pm – 3.30pm <b>3.4 PARALLEL SESSIONS</b>						
Thread 1 <i>Understanding and communicating adaptation</i>	Thread 2 <i>Adaptation by sectors</i>	Thread 3 <i>Adapting from the grass roots</i>	Thread 4 <i>Frameworks for adaptation</i>	Thread 5 <i>Adaptation at the edge</i>	Thread 6 <i>Human welfare and adaptation</i>	
<b>Parallel Session 3.4.1 Room 6</b> New concepts in adaptation <b>Convenors:</b> Ben Preston (Oak Ridge National Laboratory), Roger Jones (Victoria University)	<b>Parallel Session 3.4.2 Room 5</b> Ecosystems (session 2 of 2) <b>Convenors:</b> Rik Leemans (Wageningen University), Guy Midgley (South African National Biodiversity Institute), Alistair Hobday (CSIRO)	<b>Parallel Session 3.4.3 Room 9</b> Adaptation and development <b>Convenors:</b> Saleemul Huq (IIED), Jean-Pascal van Ypersele (Université catholique de Louvain)	<b>Parallel Session 3.4.4 Room 8</b> Adapting to climate change in cities <b>Convenors:</b> Shagun Mehrotra (Columbia University), Cynthia Rosenzweig (GISS)	<b>Parallel Session 3.4.5 Room 7</b> Climate extremes and disaster management (session 2 of 2) <b>Convenors:</b> Jean Palutikof (NCCARF), John Handmer (RMIT), Reid Basher (UN International Strategy for Disaster Reduction)	<b>Parallel Session 3.4.6 Arena 1</b> Public health adaptation to climate variability and change <b>Convenors:</b> Tony McMichael (ANU), Kristie Ebi (IPCC)	
3.30pm – 3.45pm Afternoon Tea						
3.45pm – 5.15pm <b>Arena 1</b>	<b>3.5</b> Closing Plenary: Looking forward <b>Chairs:</b> Jean Palutikof and Andrew Ash <ul style="list-style-type: none"> <li>• <i>Towards IPCC AR5:</i> Chris Field, Co-Chair, Working Group II, Intergovernmental Panel on Climate Change</li> <li>• <i>Reflection on conference</i> Tony McMichael, ANU</li> <li>• Panel discussion: <i>Future directions in adaptation: needs, barriers and actions</i> <ul style="list-style-type: none"> <li>– Chris Field, Carnegie Institute for Science, USA</li> <li>– Jean Palutikof, Director, NCCARF, Australia</li> <li>– Andrew Ash, Director, Climate Adaptation Flagship, CSIRO, Australia</li> <li>– Martin Parry, Imperial College, London, UK</li> <li>– Youth representative, to be announced</li> </ul> </li> </ul>					



## PLENARY SPEAKERS

### Tuesday 29th June

#### Welcome to country

Mr Graham Dillon, Kombumerri Elder

#### Biography

Graham Dillon is known as Uncle Graham to the Saltwater Communities and he is the Kombumerri Gold Coast clan Elder.

Uncle Graham held the position of Chairperson of Griffith University's Aboriginal and Torres Strait Islander Advisory Committee for four years until December 2008 and has actively contributed to other University forums and initiatives for over ten years. He provides consistently thoughtful and perceptive input in the full spirit of reconciliation, and to improve the participation of Aboriginal and Torres Strait Islander people in higher education. In 2009, Graham became Griffith University's Elder in Residence, to support Aboriginal and Torres Strait Islander students, and bring Indigenous culture and community into University culture. He was also awarded a Doctor of the University in July 2009 for his valued contributions.

Uncle Graham was formerly the General Manager of Kalwun Development Corporation Limited, a community-controlled service offering support across a broad range of areas including community development/consultancy, housing and crisis accommodation, health, aged care, child protection, cultural training, environmental issues, social welfare, legal support, and preventative/diversionary rehabilitation for youth. His other positions and roles include Director of the Queensland Land Tribunal, Director of Aboriginal Hostels Ltd, University of Queensland researcher and elected Aboriginal Councillor for South-east Queensland with the Aboriginal Development Commission and then ATSIC.

In 2008, Uncle Graham was invited to participate in the Australian Government 2020 Summit (and related activities in Queensland) in recognition of his community position and local contribution.



#### **The challenge of climate change: to Australia and the world**

Senator the Hon. Penny Wong, Minister for Climate Change, Energy Efficiency and Water

#### Biography

Penny Wong was born in Malaysia and moved to Australia when she was eight.

Before entering Parliament, Penny Wong was a barrister and solicitor in Adelaide and worked as an adviser to the Carr Government in New South Wales.

She was elected as a Labor Senator for South Australia in November 2001 and began her term in July 2002.

In December 2007 Penny was appointed to the Federal Cabinet in the new Rudd Labor Government as the Minister for Climate Change and Water, and in March 2010 the Prime Minister added the Energy Efficiency portfolio to her responsibilities.



#### **Climate Change, Adaptation, and IPCC**

Jean-Pascal van Ypersele, IPCC Vice-Chair, Université catholique de Louvain, Belgium

Climate warming has now been qualified by the IPCC (Intergovernmental Panel on Climate Change) as unequivocal. The main factor for the warming since 1950 has been identified: greenhouse gases (GHGs) from human activities. The habitability of the planet is at stake, with impacts felt or projected on about every ecosystem or human activity. There will be significant, often adverse, impacts on many ecological systems and socio-economic sectors, including food supply and water resources, and on human health. Mitigation, i.e. seriously reducing emissions of greenhouse gases is needed if one wants to stabilize the temperature. But that will not prevent quickly enough many negative consequences of climate change of happening. Adaptation measures are absolutely essential to complement mitigation actions, even if one can adapt only up to a point, and at a cost. For too long, adaptation has been perceived as the enemy of mitigation. Actually, both need to be integrated, in a sustainable development and climate-friendly framework. The recent controversies about the state of climate science (in the broadest sense) have only emphasized the need for an honest broker assessing the available scientific, technical, and socio-economic information, in a policy-relevant but non-prescriptive way. That is the role IPCC has filled over the last 22 years. It does not hold the truth, but, with the help of thousands of scientists and experts, it is seeking it. Without IPCC, policy-makers at all levels would be left with an extremely large mass of unusable and sometimes contradictory information, and would have much more difficulty to act. This conference will help feed some of the best new ideas on adaptation into the AR5 (IPCC fifth assessment report), to be finalized in 2014. With your help, the AR5 will be the best IPCC report ever.

#### Biography

Jean-Pascal van Ypersele (1957, Belgium), has a PhD in physics from the *Université catholique de Louvain* (Louvain-la-Neuve, Belgium), where he is professor of climatology and environmental sciences, and directs the Master programme in Science

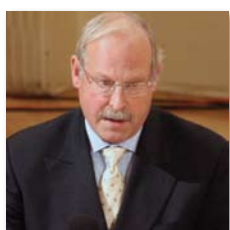
and Management of the Environment ([www.uclouvain.be/cgse](http://www.uclouvain.be/cgse)). He made his doctoral research in climatology at NCAR (National Center for Atmospheric Research, Colorado, USA). He specialized in modelling climate and the climate effects of human activities, and has recently focused his research on the impacts of climate change and on integrated assessment modelling. He chairs the Energy & Climate Working Group of the Belgian Federal Council for Sustainable Development ([www.cfdd.be](http://www.cfdd.be)). Since 2002, Jean-Pascale has been a member of the Bureau of the IPCC ([www.ipcc.ch](http://www.ipcc.ch), Intergovernmental Panel on Climate Change, which shared the 2007 Nobel Peace Prize with Al Gore), and was elected Vice-chair of IPCC in 2008. In 2009, he was elected a Member of the Belgian Royal Academy. Jean-Pascale has participated to a number of United Nations conferences on climate issues, as scientific advisor. Among other prizes, he received in 2006 the *Energy and environment award* from the International Polar Foundation, and the “Francqui Chair” from the Université libre de Bruxelles in 2007-2008.

## UNEP: UNEPs new international adaptation programme

Dr Joseph Alcamo, UNEP Chief Scientist

### Biography

Joseph Alcamo is the inaugural Chief Scientist of the United Nations Environment Programme. He has worked extensively with the IPCC and been a lead author of many of its reports. He is well known for contributions to global modelling of the environment and development of global scenarios. He is a past winner of the international Max Planck Research Prize for achievements in global change research.



### **The challenge for adaptation: The legacy from Copenhagen**

**Martin Parry**, Grantham Institute and Centre for Environmental Policy, Imperial College London, UK

How much adaptation to climate change will be needed? What resources have been made available for it? These are key questions that remain after the UNFCCC Copenhagen conference.

The pledges to reduce GHG emissions received by the end of the Copenhagen meeting, both those formally agreed and those still needing legislation (such as the US) have been estimated, if fully implemented, to lead to a mean global warming of about 3°C above pre-industrial levels. In other words the current UNFCCC emissions strategy would not meet its 2°C target.

For adaptation, the amount of funding agreed in the Copenhagen Accord is \$100 bn annually by 2020, but this is intended also to cover the costs of providing new technologies to reduce future emissions. If we assume that half of this sum was made available for adaptation, then the allocation would broadly be in line with previous UNFCCC estimates of adaptation costs (\$27-66 bn for 2030). But these costs were calculated as necessary to cover 1.5°C of warming.

The result is a 1.5°C gap between adaptation and mitigation which, if not closed in the future, could result in substantial unavoided impacts. Closing this gap in the post-Copenhagen period will require much deeper cuts in emissions, substantially greater funding for adaptation and, above all, a massive increase in our knowledge of how to adapt to climate change.

### Biography

Martin Parry is Visiting Professor at The Centre for Environmental Policy and also Visiting Research Fellow at The Grantham Institute. He was Co-Chair of Working Group II (Impacts, Adaptation and Vulnerability), of the Intergovernmental Panel on Climate Change (IPCC) for the Fourth Assessment. Previously he was Director of the Jackson Environment Institute (JEI), and Professor of Environmental Science at the University of East Anglia (1999-2002); Director of the JEI and Professor of Environmental Management at University College London (1994-99), foundation Director of the Environmental Change Institute and Professor of Geography at the University of Oxford (1991-94), and Professor of Geography at the University of Birmingham (1989-91). He has published about 150 scientific papers, mainly in the field of climate change and agriculture, including 5 books. From 1983 -2005 he was editor of the journal *Global Environmental Change*. Martin is a recipient of the Peek Award (1991) from the Royal Geographical Society (UK), and the Gerbier-Mumm International Award (1993) from the World Meteorological Organisation. He was appointed OBE in 1998 for services to the environment and to climate change.



### **Uncertainty/limits to adaptation/adapting to +4°C**

**Stephen Schneider**, Stanford University, USA

The Intergovernmental Panel on Climate Change (IPCC) stated in 2007 that global warming was “unequivocal” and that human activities were “very likely” to have created most of the warming since 1970. The institutional and political commitments to business-as-usual dependence on carbon based fuels will not easily be overcome in the short term, although vigorous research, development and deployment of more efficient systems and low carbon emitting sources is certainly feasible over the next few decades. Therefore, adaptation strategies are needed to deal with “in-the-pipeline” climate change; and mitigation activities which will dramatically lower our collective carbon footprint will be needed to deal with impacts that are difficult to adapt to. Rather than being trade offs, adaptation and mitigation are complementary strategies in coping with and reducing impacts of climate change. Is there a clustering of dangerous impacts at any particular level of anthropogenic Global Warming (AGW) that would define a dangerous threshold not to be exceeded? The Copenhagen

Accords named 2°C above preindustrial levels (about 1.2 above now) as such a threshold--but in reality no such single number is more than a value-laden aggregation of many linear and non-linear impacts as a function of AGW. While individual system thresholds of warming above which adaptation is too difficult might be known or at least knowable, their collective unacceptability-- "the dangerous threshold level"-- is an aggregation of so-called key vulnerabilities--themselves based on normative weighting of many criteria. Such criteria and aggregation methods will be explored in this presentation, and the need for a traceable account of any aggregation criteria or algorithms must be explicit in all assessments.

### Biography

Stephen Schneider is internationally recognised for research, policy analysis and outreach in climate change. His work focuses on climate change science, integrated assessment of ecological and economic impacts of human-induced climate change, and identifying viable climate policies and technological solutions. He has been an expert adviser to seven US Government administrations. He founded and edits the journal, *Climatic Change*. His books include 'The Genesis Strategy: Climate and Global Survival'; 'Laboratory Earth: The Planetary Gamble We can't Afford to Lose'; and 'Science as a Contact Sport'.



### **Food security and the natural environment**

Mark Howden, CSIRO, Australia

There is widespread and growing scientific inquiry and science-driven public debate into whether a variable and changing climate increases the challenge of maintaining global food security. Food security is a construct intrinsic to all human societies visible particularly during periods of population growth and increasing affluence. Increasing concern over climate change and its management by reducing net greenhouse gas emissions, as well as ongoing human impacts on the resource base, including biodiversity, have led to the current scientific focus on the issue. Effective adaptations to climate change will be needed across the several dimensions of food security (availability, stability, access and utilisation). Science is particularly useful for illustrating the potential interactions between climate change and food security, to inform the magnitude of the problem, and to identify appropriate investment in further information and potential solutions. Initial scientific analyses have typically been driven by the science community, technical in nature and use existing tools and methods of analysis. This approach tends to focus on incremental adaptation within the framework of existing farming systems and current management approaches. Historically, an engineering response to uncertainty has led to risk management approaches that focus on predicting and managing the negative impacts of climate change on food security. This framing of the problem tends to constrain policy options to essential but politically intractable approaches to global mitigation, rather than fostering sustainable food systems.

In this presentation we argue that adaptation is highly contextual, is usually a set of locally-specific activities integrated with other considerations and that these fundamentally require the participation of decision-makers. This means evolving practical approaches to adaptation science that realise the benefits of co-design, joint knowledge generation and power sharing. Clearly, the reported lack of belief or engagement in climate change by farmers and industry peak bodies could be seen as a major barrier to adaptation. We explore the potential basis of these attitudes, including the way science frames the problems of climate change and food security. We then compare this with the observation that some decision-makers in food systems are proactively adapting to climate change (or at least perceptions of climate change) sometimes making much more than incremental changes. The institutional and policy environment necessary to support effective adaptation and adaptation research is arguably the most critical factor for framing the scientific perspective of food security, and we describe research into adaptive governance that potentially provides a pathway forward.

### Biography

Mark Howden is Theme Leader for Adaptive Primary Industries, Enterprises and Communities with CSIRO Sustainable Ecosystems. He leads a team of researchers working with community, government and industry to enable agriculture, fisheries, forestry, and other primary industries, to prepare and adapt for the effects of climate change and variability. He developed national and international greenhouse gas inventories for Australia's agricultural sector and assessed sustainable methods of reducing greenhouse emissions from agriculture.



### **Conceptual framework for adaptation options: Learning from Bangladesh**

Atiq Rahman, BCAS, Bangladesh

A number of elements of a conceptual framework on adaptation to climate change will be presented in the paper.

The elements will compare the climate change signals with general development signals and demonstrate their asymmetry. Further the relative importance of adaptive capacity will be compared with total climate change impacts and baseline socio-economic conditions of a society or a country. Attempts will be made to show that focused investment in adaptive capacity may be the best investment for enhancing resilience to climate specific impacts. While overall investment in development creates overall capacity to withstand multifaceted challenges including climate impacts. It will also be demonstrated that the investment in adaptive capacity and development must reduce the vulnerability of a community, and ecosystem, an enterprise or an institute. The enhancement of the resilience will be one of the

important measures of climate change investment in adaptation, particularly community based adaptation.

Bangladesh will be taken as a case study to formulate the above framework.

Bangladesh is a low lying deltaic flood plain situated in the Himalayan drainage ecosystem. Due to its unique geographical location, dominance of flood plain and low elevation from mean sea level, Bangladesh is extremely vulnerable to climate induced natural hazards and sea level rise. Bangladesh is already vulnerable to many climate change related extreme events and natural disasters. It is expected that climate change will bring changes in characteristics of natural hazards and gradual changes phenomenon of the physical system. Various studies suggest that Bangladesh will have to face the following consequences due to the catastrophic collapse of the climatic system;

- Sea Level Rise
- Cyclone with higher intensity and frequency
- Deeper penetration of saline water
- Erratic rainfall
- Intense and frequent flood in the Ganges-Brahmaputra-Meghna basin
- Frequent hydrological, meteorological and agricultural drought
- River bank erosion
- Food Security, and
- Health

However, being at the forefront of adverse impacts of climate change, Bangladesh has been able to draw the attention of global community to address its sensitivity and vulnerability to climate change. Despite being one of the lowest emitters of green house gases Bangladesh is worst affected by different climate stimulus and climate induced extreme events. Historically the people of Bangladesh are coping with the extreme climatic events according to their highest ability. But the big thaw of climate change is wiping away their development efforts and eventually throwing them into the vicious circle of poverty. Hence, all of our development endeavours; from national to local level; should address planned adaptation options in order to sustain the development initiatives. Being the world's largest adaptation laboratory, Bangladesh has enormous potential to mainstream adaptation into its development initiatives.

### Biography

Atiq Rahman is Executive Director of Bangladesh Centre for Advanced Studies. He coordinates the Global Forum on Environment and Poverty, convenes the Climate Action Network South Asia and chairs the Coalition of Environmental NGOs in Bangladesh. In 2008 the United Nations Environment Programme awarded him the UN's highest environmental award 'Champion of the Earth' for outstanding and inspirational leadership in the field of environment.

## Wednesday 30th June



### *Equity and the economic impacts of adaptation*

**Neil Adger**, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK

Actions to deal with the challenge of climate change affect all parts of society, with potential gains and losses from such adjustments being fundamentally determined by the underlying structures of wealth and geography. Climate change affects economic and other dimensions of well-being. Over the coming decades it will likely transform natural landscapes, resources and the built environment that have been perceived by most people to be stable over their own experience and lifetimes.

This lecture will outline how adaptation processes may affect different individuals and communities by distinguishing between equity in outcome of adaptation decisions and equity in the process by which society spreads and shares risks. Drawing on research on societal responses to weather-related risks, I suggest that fairness in decision-making on adaptation requires specific recognition of the temporal and spatial scales of justice and that economic measures of loss and cost omit important elements of the impacts of climate change such as identity and attachment to place. I further suggest that devolving adaptation to community level makes assumptions about the coherence of communities and involves an evolution of the social contract whereby states are ultimately responsible for protection of the vulnerable. I discuss the implications of these findings for national and international action on adaptation

### Biography

Neil Adger is Professor in the School of Environmental Sciences. He has led the research programme on adaptation in the Tyndall Centre for Climate Change Research since its inception in 2000. He researches and teaches on the social sciences of global change including issues of social vulnerability, resilience and adaptation and justice and equity in decision-making. Neil is a member of the Executive Board of the Resilience Alliance, an international network of ecological and social scientists dedicated to exploring the nature of social-ecological systems as a foundation for sustainable development. He is Editor of the journal *Global Environmental Change*.



## **Climate change adaptation in a post-Copenhagen world: the view from Japan**

**Nobuo Mimura**, Ibaraki University, Japan

Japan has been experiencing effects of climate change for the past decades, such as changes in quality of agricultural products, northward movement of vector mosquitoes and other insects, and often occurrence of torrential rainfall. We would face stronger risk caused by climate change.

A comprehensive research was carried out for climate change impacts on Japan and the Asia-Pacific region to obtain a quantitative overview of the future risks. Regional and temporal distributions of impacts in various fields, such as water resources, agriculture, forests, coastal zones, and human health, were quantitatively assessed revealing how impacts on Japan and costs of damage would appear along different paths of emission stabilization paths.

The future impact is an important factor for the national and local policies. At the same time, Japan faces specific problems such as decrease in population, advancing aging society, and needs to maintain economic activities. In the mid-century, stronger impacts of climate change may appear on more aged and weaker people in many parts of Japan. This means that we need to consider climate change adaptation in a wider context of sustainability and well-being of Japan's society.

The Japan's Prime Minister declared 25% reduction of GHG emission by 2020 in the UN General Assembly in 2009 to call for collaborative efforts of other countries. Low-carbon society is an important target of the Japanese government. However, so far the policies for mitigation and adaptation have been dealt with separately, and adaptation is much behind mitigation. Given the complex situation, we should consider an integration of policies aiming at low-carbon society and climate change adaptation. This new integrated policy should also be a part of long-term economic activation by developing a green economy and environmental friendly cities that support the low-carbon and climate change adaptation society. Science and technology are expected to play a key role to realize such goal.

Impacts of climate change will more severe for the developing countries, given their geographic setting and low adaptive capacity. Strengthening capacity in these countries in terms of mitigation and adaptation is also an important aspect of Japan's policy. For this, scientific capacity building and development of network for adaptation is essential. I will also introduce the current situation of this area.

### **Biography**

Nobuo Mimura is Director of the Institute for Global Change Adaptation Science, Ibaraki University, Japan. He specialises in global environmental engineering, coastal engineering and adaptation policy to climate change. He is intensively engaged in studies on the impacts of climate change and sea-level rise on Japan, China, Thailand and small island countries such as Tuvalu, Samoa and Fiji, leading several research projects in this field. He has also served as an expert advisor to the Japanese government.



## **Science and the governance of adaptation**

**Diana Liverman**, University of Arizona, USA

The development of adaptation programs and plans at regional, national and international levels places new demands on both natural and social science that include improved monitoring and projection of regional climates, identification of baselines for climate, vulnerability, and funding, and the development of methods and information systems for assessing the additionality, sustainability and effectiveness of adaptation efforts.

Are we ready to respond to these demands? What are the challenges in providing a strong scientific basis for adaptation policies? What lessons can we learn from problems encountered in mitigation, especially the monitoring, reporting and verification of emission reductions and the design of carbon offset markets? What do social science theories on climate governance offer to our understanding of the adaptation science-policy interface?

### **Biography**

Diana Liverman is Co-Director of the Institute of the Environment at the University of Arizona. Her research interests include climate impacts, vulnerability and adaptation, and climate policy and mitigation especially in the developing world. She is an active member of many national and international advisory committees including of the National Academy of Sciences Committee on America's Climate Choices advising the US government on responses to climate change. Also, she chairs the scientific advisory committee of the Global Environmental Change and Food Systems programme and sits on the parent committee for the International Earth Systems Science Partnership.



## **Scenarios for transformative adaptation**

**Mark Stafford Smith**, CSIRO, Australia

Many different ways of using scenarios are relevant to adaptation, from local or sectoral visioning of futures through to their use to frame the IPCC Assessments. This paper will canvass three in particular, exploring what may be learned between their uses in a world that faces an increasing need for transformative thinking.

At a local scale, scenarios are an important means of opening a community or industry's eyes to the potential for dramatically different futures, which in turn may help those players to think beyond small adjustments aimed at maintaining their current way of life to transformative change. Case studies of such uses of scenarios, whether or not related to climate change, illustrate that transformative change usually requires a longer lead-time than incremental adjustments, for both technical and psychological reasons. It also often requires intervention from a higher scale of organisation in order to envisage and facilitate change (e.g. a community may help individuals face change, and government support may help communities think about this). Last, the focus needs to be clearly on the differences between a suite of alternative futures, rather than the uncertainty around the expression of any single one. As the prospects for timely mitigation become dimmer, the importance of obtaining efficiencies in transformative adaptation becomes ever greater.

Scenarios are also used at the global scale, of course, as in the Millennium Assessment and the IPCC Assessments. Yet neither the MA nor the IPCC scenarios have been very successful as yet, in terms respectively of achieving the Millennium Development Goals or strong agreements to mitigate or adapt to climate change. We suggest that this is partly explained by the degree to which these scenario exercises apply the lessons noted above. At this global scale, there is no recourse to a higher scale of organisation so that, inasmuch as the scenarios aim to aid transformative thinking, it is critical to get other aspects of their use right. Many would argue that responses in both cases are too slow compared to rates of change driven by population increase, negative effects of globalisation and the release of greenhouse gases. For the IPCC scenarios, in the past at least, we argue that scientific uncertainty around the precision with which we can project the individual scenario responses has clouded the key message about selecting the future that we want to live in. There are political and institutional reasons for this outcome, overcoming which constitute a significant global adaptation as well as having implications for how much adaptation to climate change is needed.

Scenarios of the future are also used in economics, yet usually with a far simpler presentation aimed at decision making, little clouded by uncertainty. We discuss what lessons might be learned from the mode by which economics generally contributes to policy, and how this might sharpen the messages of IPCC AR5, as well as inform support for transformative adaptation in society more widely. One key area is in the presentation of climate information for adaptation, and we explore the implications for decision-making of a proposed approach in which generalised, simple and stable regional scenarios nest more detailed and complex climate projections.

### **Biography**

Mark Stafford Smith is Science Director of the CSIRO Climate Adaptation Flagship, coordinating science undertaken across the Flagship research themes. He has been vice-chair of the Scientific Committee of the International Geosphere-Biosphere Programme (IGBP) and involved in other global research programmes associated with climate change and desertification. His past work has focused on the science of desert living and sustainable management of outback environments, as a desert researcher and past CEO of the Desert Knowledge Cooperative Research Centre. His recent work includes the book 'Dry Times: Blueprint for a Red Land'.



## **Climate change: a personal view of adaptation and mitigation in the Australian context**

**Tim Flannery**, Macquarie University, Australia

### **Biography**

Tim Flannery is one of Australia's leading thinkers and writers. A scientist, explorer, and conservationist, he has published more than 130 peer-reviewed papers and many books, including the landmark works *The Future Eaters* and *The Weather Makers*.

Currently Professor in the Faculty of Science at Macquarie University, he is Chair of the Australian Government's Coasts and Climate Change Group, represents Australasia on the National Geographic Society Research Grant Committee and is a director of the Australian Wildlife Conservancy. From 2006 to 2009 he was Chair of the Copenhagen Climate Council. In 2007 he was named Australian of the Year.



### ***Drought proofing rural economies in semi-arid areas: lessons from NE of Brazil***

Antonio Magalhães, Esquel Brasil Foundation, Brazil

What are the lessons from the experience of adaptation to past and present climate variability that can be useful for planning and implementing adaptation to climate change?

The Brazilian Northeast is an overpopulated semi-arid region that encompasses nine states and covers about 1 million square kilometers. It has a history of extreme droughts that have heavily impacted rainfed agriculture, society and the environment. In poor regions, droughts end up to being more of a social problem that imposes heavy consequences to the population.

Scenarios show that the dry regions will be the most affected by the impacts of climate change. The Brazilian Northeast will become hotter and dryer, and in some parts the water deficit may severely impact/reduce the feasibility of rainfed agriculture. These are additional challenges to be faced in the future.

The Northeast has also a history of more than one century of policies of adaptation to droughts. What are the lessons from this experience that may contribute to enhance adaptive capability under a changing climate? To what extent will the nature of the impacts differ from what has been observed in the past?

Adaptation to climate variability and change is something complex, for which there are no recipes. It has to be considered in the context of integrated sustainable development policies, because sustainable development is the most effective way to reduce vulnerability, increase adaptive capacity and promote societal adaptation to climate change.

#### **Biography**

Antonio Magalhães served as Vice-Minister of Planning for Brazil and Secretary of Planning for the State of Ceara. In 1991 he was awarded the International Mitchell Prize for his work in sustainable development. He is a founding member of the Esquel Brasil Foundation, an NGO devoted to sponsoring sustainable development in Brazil. His work and research have been devoted to regional economics, development planning and sustainable development.



### ***The urban poor in developing countries: the biggest adaptation challenge?***

David Dodman, International Institute of Environment and Development, UK

Half of the world's population now lives in urban areas, and towns and cities in low- and middle-income nations will experience most of the world's growth in population in the coming decades. Although there is no automatic link between rapid urban growth and urban problems, the concentration of poverty in many cities in the global south results in particular patterns of risk and vulnerability for many urban residents – risks that will be exacerbated as a result of climate change.

Low-income urban residents are already vulnerable to a range of shocks and stresses, including hazardous living conditions and environmental health risks which in many cases will be worsened as a result of climate change. Urban infrastructure and services are not sufficient to cope with climate variability and change, while urban authorities in many low- and middle-income nations lack the necessary adaptive capacity to cope with these shocks and stresses. In addition, existing responses to climate change may not boost the resilience of the urban poor – either by failing to take their particular needs into account, or by actively encouraging dispossession and relocation.

Adaptation that meets the needs of the urban poor therefore represents a significant challenge. This presentation explores possible strategies for addressing this challenge that focus on the capacities and capabilities of low-income groups, and that strengthen their access to land, shelter, and productive assets. It also describes the ways in which local organizations in African, Asian and Latin American cities have demonstrated their potential to strengthen adaptive capacity and build resilience in ways that can also help to meet a wider range of desirable objectives around liveability, service provision, and the reduction of disaster risk.

#### **Biography**

David Dodman is a Senior Researcher in the Climate Change and Human Settlements Groups at the International Institute for Environment and Development (IIED, UK and BNAS Bangladesh) and a Teaching Fellow at University College London. He is a geographer with a background in urban environmental management and climate change. His research interests are primarily adaptation to climate change in low-income urban centres. He recently co-edited *Global Change and Caribbean Vulnerability: environment, economy and society at risk* and *Adapting Cities to Climate Change: understanding and addressing the development challenges*.



## The challenge of coastal erosion in West Africa

Isabelle Niang, University of Dakar, Senegal

Coastal erosion is already a major threat in West Africa. Rates of coastal retreat comprised between 1 and 2 m per years have been registered. This process is increasing and induces a lot of economic and social losses linked, among other things, with demographic rate.

Climate change which will induce accelerated sea level rise will just increase this threat. Using the Bruun rule a number of West African countries (e.g. Mauritania, Senegal, The Gambia, etc.) have been able to assess the potential impacts of sea level rise on their coasts. Do nothing will certainly be more costly than trying to protect at least some parts of the coastlines.

The Adaptation to climate change in coastal zones of West Africa (ACCC) project, which covers 5 coastal countries in West Africa, is a pilot project funded by GEF which tries to address the way to respond to accelerated coastal erosion due to climate change while conserving the biodiversity of the coast. It is operating at three different levels, from local to subregional.

Despite the shortness of the project it is possible to identify few lessons from the implementation of the project. Sensitization as well as exchange of information at local level will be crucial if we want to adapt. Mainstreaming climate change issues in national and local development plans could take different ways. Not only hard engineering will be necessary to protect the coasts.

In a context where adaptation is receiving increasingly attention and funds it is very important that synergies be developed at national, sub regional and certainly continental level. The Copenhagen agreement is only one step in the fight against climate change but it doesn't give any positive sign that our societies will be able to tackle this challenge. The need for adaptation is thus still there and will remain whatever the progress made to reduce greenhouse gases emissions.

### Biography

Isabelle Niang lectures at the University of Dakar and has been involved in numerous activities related to climate change, specifically related to the coastal zone. She is a member of the regional task team for the joint IOC/UN Programme on Ocean Sciences in relation to Non-Living Resources in the Central and Eastern Atlantic. She is also a member of the UNEP task team on Implications of Climate Changes in the West and Central African Region.



## Towards better water security in China: the Challenge of Climate Change

Jun Xia, Chinese Academy of Sciences, China

The impact of climate change on water resources security is a challenging issue with widespread concern globally. It is as well the great strategic issue in the national sustainable development of China. China is one of the thirteen water-poor countries all around the world; particularly the East China monsoon area with a dense population has witnessed a more serious imbalance of water resources **between supply and demand**. In addition,

the drought and waterlogging frequently occur in East China monsoon area. Under the circumstances of the climate change, drought aggravation in the northern region, **water ecological deterioration**, and the increasing extreme **flood disaster** in the southern region severely restricted the sustainable development of the economy and society during the past 30 years. The future climate change will have great influence on the existing **pattern** of "**north drought and south flooding**" in China and the water resources distribution in the near future, and consequently exert some unexpected influence on the effects of **major engineering projects** in China, including **food increasing** project in North and Northeast China, water transfer project, flood control system planning of southern rivers etc.

This paper will focus on the major river basins in eastern monsoon region of China, and investigate the mechanism of the impact of climate change on water resources and the relevant adaptation strategies. The framework of a National Basic Research Program of China, entitled the Impact of Climate Change on Terrestrial Water Cycle, Regional Water Resources Security and the Adaptation Strategy for East Monsoon Area of China, will be introduced. **The study will focus on the impact of climate change on the water resources scarcity**, droughts and floods, food security, water security and other related issues in East China monsoon area. **The three** key scientific issues are addressed, given by follows: (1) The spatial-temporal variability and uncertainty of water cycle components under climate change; (2) **Interaction and feedback** mechanism between land surface hydrology and regional climate ;(3) Vulnerability and **sustainability** of water resources under climate change. The main research topics focus in four aspects: (1) The evolution law of the water cycle components dynamics in the past and the scenario simulations for the future; (2) Regional response and **variation** attribution of water cycle under climate change; (3)The impact of climate change on typical water resources challenges in southern and northern China; (4)Vulnerability and adaptation strategies of water resources under climate change. Through the analysis of the observed land hydrological cycle components in the past 50 years or earlier, quantifying the uncertainty of the precipitation from multi-model predictions under the future climate change and the two-way coupling and interaction between land surface hydrology and regional climate, this study is to reveal the driving factor of the hydrological process change under climate change, and to recognize and understand the impact of climate changes on the spatial-temporal



dynamics of the hydrologic cycle, the system feedback and the mechanism. Corresponding to the latest report of IPCC, this study will analyze and evaluate the climate change impact on the spatial-temporal pattern of water resources in China monsoon area, the frequency and intensity of the extremes of drought and flooding, economic and social impact of the consequences and risks in water resource vulnerable areas in the next 20-50 years, and finally establish the adaptation strategies to optimally deal with the impact of climate change and to secure the water resources security for China.

The research will address the scientific basis for the regional economic and social sustainable development, and contribute to the field of climate change and water sciences as an international front runner. The aims to meet the great strategic demands of China and is targeted at the international forefront of water sciences.

### Biography

Jun Xia is a Chair Professor on Hydrology & Water Resources, and Director, Center for Water Resources Research, Chinese Academy of Sciences (CAS), and Director, Key Lab. of Water Cycle & Related Land Surface Processes, CAS. He has ample experiences on leading water research projects on climate change impact & adaptation for water security, water sustainable management and consulting jobs in China and international activities. He now serves as the President of International Water Resources Association (IWRA), and also takes the leading role as Co-Chair, InterAcademy Council (IAC) for Water Programme (IAC-WP), Co-Director, Australia-China Center on Water Resources Research, and as a Member of Scientific Steering Committee of Global Water System Project (GWSP-SSC).



### Towards the IPCC AR5

Chris Field, Carnegie Institution for Science, USA

In its Fifth Assessment Report (AR5), scheduled for release in 2013 and 2014, the IPCC will assess the state of scientific knowledge the science of climate change and its impacts, as well as options for mitigation to reduce the amount of climate change that occurs and adaptation to help humans and ecosystems deal as effectively as possible with the climate changes that cannot be avoided. Working Group II (WGII), charged with assessing the impacts of climate change, as well as adaptation and vulnerability to climate change, will prepare, in the AR5, a report that organizes the topic in two complementary ways. One section of the report will deal with sectors, focusing on the global scale analysis. The second will consider climate change and its impacts from a regional perspective, integrating across sectors. In many ways, the WGII contribution to the AR5 will continue the successful approach of earlier reports, but with heightened emphasis on a number of increasingly important areas and with a sharpened focus on coordinating with the other working groups.

For the Fifth Assessment Report, the IPCC has lengthened the interval from the release of the report of WGI, on the physical science basis, to WGII. This will facilitate the efficient transfer of information and increase the ability of WGII to assess new impacts, adaptation, and vulnerability studies based on the new science assessed by WGI.

One key theme in the WGII contribution to the AR5 will be increased emphasis on dealing with climate change as a problem in risk management. This theme will be important throughout the volume, with the presentation structured to provide stakeholders with all of the available information on both the range of uncertainty and on the way impacts scale with the possible range of climate outcomes. This increased emphasis on managing risk will be applied to a broad range of sectors including several that are new or greatly expanded in the AR5. Oceans, ocean acidification, human security, livelihoods and poverty, key economic sectors, and urban and rural communities are among the topics receiving increased prominence.

The WGII contribution to the AR5 is also strongly increasing the emphasis on adaptation. The number of chapters dealing with adaptation will increase to four. This heightened priority will provide a rich opportunity to assess the important new work on adaptation while at the same time emphasizing the point that adaptation needs to be a key component of the broader strategy for dealing with climate change.

As in past assessments, the quality of the WGII contribution to the AR5 will depend on the commitment and integrity of the authors and editors who volunteer to contribute, on the experts who volunteer to provide review comments, and on the scientific community that provide the new research to assess. WGII taps a rich pool in all these areas, setting the stage for a durable contribution to climate change science and management.

### Biography

Chris Field is Director of the Department of Global Ecology at the Carnegie Institution for Science and Professor in the Department of Environmental Earth System Science and the Department of Biology at Stanford University. Since September 2008, he has served as co-chair of Working Group 2 of the Intergovernmental Panel on Climate Change.

His research focuses on interactions among climate, the carbon cycle, and ecosystem processes, using approaches that range from ecosystem-scale climate manipulations to global climate models. He has published over 200 peer-reviewed papers in leading scientific journals, and was a coordinating lead author on the topic "North America" for the Working Group 2 contribution to the IPCC Fourth Assessment Report. Chris is an elected member of the US National Academy of Sciences and the American Academy of Arts and Sciences, as well as an elected Fellow of the American Association for the Advancement of Science.

## PANEL DISCUSSIONS

### Panel Session 1: Financing Adaptation: International transfers and global geopolitics

**Organiser:** Saleemul Huq, International Institute for Environment and Development, UK, and Bangladesh Centre for Advanced Studies, Bangladesh

The two instruments to address climate change are adaptation and mitigation. Alone, neither is sufficient. Mitigation is essential to reduce emissions, but will take time to have an effect. Adaptation is essential to deal with the impacts of climate change that are already inevitable, and those that will occur along the pathway to stabilise emissions through mitigation. But for developing countries, many questions arise. Should we expect developing countries with currently low levels of emissions to pay for adaptation measures? If not, who will pay? And how will payment be effected? This session will engage panellists representing the aid agencies, developing countries, and the research community to explore some of the key questions around financing adaptation.

#### Biography

Dr Saleemul Huq joined the International Institute for Environment and Development (IIED, UK and BNAS Bangladesh) in London as Director of the Climate Change Programme in 2001. His interests are in the inter-linkages between climate change (both mitigation as well as adaptation) and sustainable development, from the perspective of the developing countries (with special emphasis on the least developed countries). He was the lead author of the chapter on Adaptation and Sustainable Development in the third assessment report of the Intergovernmental Panel on Climate Change (IPCC) and is a co-anchor of the cross cutting theme on Adaptation and Mitigation for the fourth assessment report.

#### Panel members:

Robin Davies (AusAid, Australia)

Ian Noble (The World Bank, USA)

Emma Tompkins (University of Leeds, UK)

### Panel Session 2: Is building resilience the answer?

**Organiser:** Terry Hughes, James Cook University and ARC Centre of Excellence for Coral Reef Studies, Australia

Resilience provides a powerful interdisciplinary concept for understanding complex systems and disturbance events such as climate change, characterised by high uncertainty, but there are no panaceas to achieving the “right” kind of resilient system. Following an introduction to the ideas, a range of empirical work from agriculture, fisheries and aquaculture, and coastal and marine social-ecological systems will demonstrate the potential and limitations of resilience thinking as an analytical and governance approach to climate change adaptation. Chris Cocklin discusses vulnerable agri-environmental landscapes and the challenge of reconciling the need to build resilience and reduce emissions at the same time as maintaining productivity in a changing climate. Eddie Allison develops a typology to facilitate policy coherence in adaptive responses in aquatic ecosystems affected by climate change. Nick Graham raises the prospect of eroding resilience to navigate away from undesirable system states that may result from climate change impacts and Joshua Cinner presents a framework that ties together resilience thinking and vulnerability to critically assess options for conservation management. Terry Hughes will conclude the session by inviting audience discussion.

#### Biography

Professor Terry Hughes is an Australian Research Council Federation Fellow (2002-2007, 2007-2012) and Director of the ARC Centre of Excellence for Coral Reef Studies (since 2005). Professor Hughes was elected a Fellow of the Australian Academy of Science in 2001, and was a member of the Expert Advisory Committee for Australian National Research Priorities in 2002. He is a Fellow and Board Member of the Beijer International Institute for Ecological Economics at the Royal Swedish Academy of Science, Stockholm, and a member of the Board of Directors of the Resilience Alliance. He has been awarded numerous prizes awards, including the Centenary Medal of Australia, the Silver Jubilee Award for Excellence of the Australian Marine Science Association in 2004, the 2007 Sherman Eureka Prize for Environmental Research, and the 2008 quadrennial Darwin Medal of the International Society for Coral Reef Studies.

#### Panel members:

Edward Allison (WorldFish Centre)

Joshua Cinner (James Cook University, Australia)

Chris Cocklin (James Cook University, Australia)

Louisa Evans (WorldFish Centre)

Nick Graham (James Cook University, Australia)

### Panel Session 3: Measuring the effectiveness of adaptation

**Organiser:** Rob Kay, Coastal Zone Management, Australia

The panel session “how effective can adaptation be?” aims to explore two key questions:

1. What are our measures of success in climate change adaptation?
2. How can we think about the design of adaptation activities to consider adaptation effectiveness?

The session will approach adaptation effectiveness from experts in different sectors, namely:

- Urban centres;
- Ecosystems;
- Human health; and
- Coastal zones.

The session is extremely timely given the extensive debate within the adaptation community on focussing resources on 'optimal' adaptation outcomes. This debate is occurring both at an international level and within Australia where regarding the optimal allocation of adaptation funding between levels of Government, the community and private sector.

#### Biography

Robert is a Principal Consultant in the Perth-based consulting company Coastal Zone Management (CZM). He has 22 years in climate change impact assessment focussing on coastal zones. He founded CZM in 2004 to provide specialist technical and management consultancy services to enhance the sustainable development of coastal zones in Australia and beyond. Robert has worked in government, academia and private sector. His consulting experience includes projects ranging from local-scale strategy development for local governments, State and National projects in Australia and a number of UN agencies including the UNFCCC, UNDP and UNEP.

#### Panel members:

Sir Andrew Haines (London School of Hygiene and Tropical Medicine, UK)

Cynthia Rosenzweig (NASA Goddard Institute for Space Studies and Columbia University, USA)

Will Steffen (Australian National University, Australia)

Bruce Thom (University of Sydney, Australia)

### Panel Session 4: Providing the essential information, knowledge and skills for adaptation

**Organiser:** Kathy Jacobs, Assistant Director, OTSP, US Executive Office of the President

There is general agreement that information, knowledge and skills are essential tools for adaptation. Beyond that very general statement, however, there is much less agreement around what the information needs are, who should supply them, and in what form. Even to formulate the questions which express the needs of end users is not straightforward. End users struggle with decision making under uncertainty, and with future projections of climate change which provide a range of potential outcomes with little or no guidance on a 'best-estimate'. Researchers offer risk assessment frameworks as an alternative, but these frameworks may not address the needs of practical decision making around adaptation.

At the international scale, these issues grow in complexity. Do developed countries have a responsibility to share information and skills with developing countries? In what form? How can, and should, intellectual property rights be protected?

In the face of these questions, governments and funding agencies may well retreat to the low-risk position of commissioning more research rather than taking practical action. But this position is only temporarily low-risk and, as climate change continues, it will become more and more of a high-risk strategy to take no adaptation action. It becomes more and more essential to provide fit-for-purpose information and knowledge to enable end users to take action to adapt to climate change.

This session brings together providers and users of information and knowledge from the developed and developing world to address some of these questions.

#### Biography

Kathy Jacobs is the Assistant Director for Climate Assessment and Adaptation at the Office of Science and Technology Policy. She is on a mobility assignment from the University of Arizona, where she is on the faculty of the Department of Soils, Water and Environmental Science. She is the Director of the National Climate Assessment and part of a team working to develop a national adaptation strategy. Jacobs recently chaired a National Research Council panel on climate change adaptation within the America's Climate Choices Project, and has served on six other Academy committees. From 2006-2009 Jacobs was the Executive Director of the Arizona Water Institute, a consortium of the three state universities focused on water-related research, education and technology transfer in support of water supply sustainability. She has 23 years of experience as a water manager for the state of Arizona, including 14 years as director of the Tucson Active Management Area, and has a master's degree in environmental planning from the University of California, Berkeley.

#### Panel members:

Celine Herweijer (Price Waterhouse Coopers, UK)

Susanne Moser, (Susanne Moser Research and Consulting, USA)

Chris West (UKCIP, UK)

### Panel Session 5: Vulnerability /risk assessment for extreme events

**Organiser:** John Schneider, Geoscience Australia

Our ability to adapt responsibly to climate change requires a strong knowledge base of climate change science Our ability to adapt responsibly to climate change requires a strong knowledge base of climate change science as well as a firm understanding

of the likely consequences of climate change on society. Hazards that must be considered include the frequency, magnitude and distribution of severe storms, bushfires, heatwaves, and drought, as well as the effects of sea-level rise and resulting implications for coastal erosion and storm surge events. In addition, changes in demographics together with population and economic growth in general are changing our exposure and vulnerability to these and other climate-change induced hazards.

Risk assessment is about combining our knowledge of these factors into estimates of likelihood and consequence. Current scientific knowledge and available data are able to provide us with an initial basis for managing these risks, but there are also significant gaps and shortcomings in our knowledge that limit its applicability. Fundamental data such as digital elevation models are lacking, and computational models to describe coastal processes in response to sea level rise are too simplistic. Moreover, our ability to estimate the physical, economic, environmental and social consequences on communities is quite limited.

This panel session will provide a range of perspectives on these issues from those who are involved in developing climate change risk assessment methods, to climate adaptation specialists who use these tools and information to inform state and regional adaptation policy. Risk assessment experts will discuss how the explicit measurement of uncertainty can be used to facilitate the decision making process, such as in defining risk tolerance thresholds for life safety or in evaluating the cost vs benefit of an adaptation decision. Adaptation specialists will discuss how their work is helping to inform our understanding of potential climate change impacts on communities and identify information and research gaps. By looking at the issues from several perspectives, the discussion will provide insights into how different approaches to measuring climate change impact and risk can be brought together to inform and promote adaptation and community resilience more broadly.

### Biography

Dr Schneider heads the Risk & Impact Analysis Group at Geoscience Australia, in Canberra, Australia. This Group develops a wide range of tools, databases and methods for assessing the risk of natural and man-made hazards in Australia and the Australasian region. Dr Schneider advises government and private industry on risk management issues including emergency preparedness, critical infrastructure protection, climate change, land-use planning, and building regulation. He has an MS (1981) and PhD (1984) in geophysics from the University of Wisconsin (USA) and has extensive experience in catastrophe risk research through subsequent work for the nuclear power and reinsurance industries in the US prior to coming to Australia in 2000.

### Panel members:

Suraje Dessai (University of Exeter, UK)  
Roger Jones (Victoria University, Australia)  
Jennifer Rigby (Victorian Government, Australia)  
Arthur Webb (SOPAC)

## Panel Session 6: Australian Case Studies: practical adaptation – making it happen on the ground

**Organiser:** Jon Barnett, University of Melbourne, Australia

Australia contains a range of social and ecological systems that are exposed to and sensitive to climate change. Many of these are experiencing changes that, if not directly attributable to climate change, are consistent with the kinds of changes that are anticipated with rising concentrations of greenhouse gases. Australia presumably has a high capacity to adapt to these changes given its stable governance institutions and high levels of wealth. Thus there are valuable lessons to be learned from Australia's experiences with climate change adaptation. To elicit these lessons, in this session four speakers will present evidence about the responses that have occurred thus far, examining their successes and limits, and the barriers to improved responses in the future. Speakers will examine responses to adapt to bushfires in Victoria, coastal change in the Torres Strait, and coral bleaching in the Great Barrier Reef, as well as the adaptation responses of local governments.

### Biography

Jon is an Australian Research Council Fellow and Reader in Geography at Melbourne University. He is a human geographer whose research investigates the impacts of and responses to environmental change on social systems. This includes research on climate change, environmental security, water, and food. He has been conducting research on the social and institutional dimensions of vulnerability and adaptation to climate change since 2000. This has included field based research in the South Pacific, China, and Timor-Leste. Jon is host convenor of the research network on the social, economic and institutional dimensions of climate change, which is part of the National Climate Change Adaptation Research Facility. He is a member of the Scientific Steering Committee of the Global Environmental Change and Human Security Project, which is a core project of the International Human Dimensions Programme (IHDP). Jon is the Executive Editor of the adaptation domain of Wiley Interdisciplinary Reviews Climate Change, and on the editorial boards of Global Environmental Change, and Geography Compass.

### Panel Members:

Steve Dovers (Australian National University, Australia)  
John Handmer (RMIT University, Australia)  
Ove Hoegh-Guldberg (University of Queensland, Australia)  
Scott Smithers (James Cook University, Australia)

## PARALLEL SESSIONS

### Scenarios for the future of adaptation

Convened by Tim Carter (Finnish Environment Institute SYKE, Finland) and Mark Stafford Smith (CSIRO, Australia)

### Climate information for users

Convened by Chris West and Roger Street (UKCIP, UK), and Andrew Watkins (Bureau of Meteorology, Australia)

### Risk communication and behavioural change

Convened by Jan McDonald (Griffith University, Australia) and Susanne Moser (Susanne Moser Research and Consulting, USA)

### Communication of information for adaptation

Convened by Marie Waschka (NCCARF, Australia) and Simon Torok (CSIRO, Australia)

### New concepts in adaptation

Convened by Ben Preston (Oak Ridge National Laboratory, USA) and Roger Jones (Victoria University, Australia)

### Adapting agriculture to climate change

Convened by Mark Howden (CSIRO, Australia), Cynthia Rosenzweig (NASA Goddard Institute for Space Studies and Columbia University, USA)

### Water sector adaptation: innovations

Convened by Kathy Jacobs (US Executive Office of the President, USA), Bryson Bates (CSIRO, Australia), Stuart Bunn (Griffith University, Australia)

### Ecosystems

Convened by Rik Leemans (Wageningen University, The Netherlands), Guy Midgley (South African National Biodiversity Institute), Alistair Hobday (CSIRO, Australia)

### A Climate of Uncertainty: Indigenous Land Managers, vulnerabilities and adaptation to climate change

Convened by Marcia Langton (University of Melbourne, Australia)

### National and sub-national case studies of adaptation (2 sessions)

Convened by Emma Tompkins (University of Leeds, UK), Heather McGray (World Resources Institute, USA)

### Constructing and enabling local knowledge

Convened by Donovan Burton (NCCARF, Australia), Opha Pauline Dube (University of Botswana)

### Adaptation and development

Convened by Saleemul Huq (IIED, UK, and BCAS, Bangladesh), Jean-Pascal van Ypersele (Université catholique de Louvain, Belgium)

### The economics and costs of adaptation

Convened by Frank Jotzo (Australian National University, Australia)

### The interface of adaptation and mitigation

Convened by Kathy Hibbard (Pacific Northwest National Laboratory, USA), Andrew Ash (CSIRO, Australia)

### Research meets business and industry

Convened by Sandra Schuster (Munich RE, Australia), Allen Kearns (CSIRO, Australia)

### National and international adaptation activities

Convened by Joseph Alcamo (UNEP) Youssef Nassef (UNFCCC)

### Adapting to climate change in cities

Convened by Shagun Mehrotra (Columbia University, USA), Cynthia Rosenzweig (NASA Goddard Institute for Space Studies and Columbia University, USA)

### Coasts, deltas and small islands

Convened by Robert Nicholls (University of Southampton, UK), Jon Barnett (University of Melbourne, Australia), Tim Smith (University of the Sunshine Coast, Australia)

### Impacts and adaptation in the tropics

Convened by Suzanne Long (Reef and Rainforest Research Centre, Australia)

### Climate extremes and disaster management

Convened by Jean Palutikof (NCCARF, Australia), John Handmer (RMIT University, Australia), Reid Basher (UN International Strategy for Disaster Reduction)

### Adaptation and the community

Convened by Coleen Vogel (University of Witwatersrand, South Africa), Lisa Schipper (Stockholm Environment Institute, Sweden)

### Human security, social and equity issues

Convened by Neil Adger (University of East Anglia, UK), Karen O'Brien (University of Oslo, Norway)

### Engineering and technology solutions for adaptation

Convened by Ron Cox (UNSW, Australia), Xiaoming Wang (CSIRO, Australia)

### Public health adaptation to climate variability and change

Convened by Tony McMichael (ANU, Australia), Kristie Ebi (IPCC Working Group II Technical Support Unit, USA)

## GUIDE TO THE PARALLEL SESSIONS

For the convenience of conference participants, we have organized the parallel sessions into areas of common interest, or 'threads'. In deciding which parallel session to attend, it may help you to follow a thread. But this is only provided as a guide – there is no requirement to stay with a single thread throughout the conference.

### Thread 1 – *Understanding and communicating adaptation*

This thread will focus on information needed to support climate change adaptation both now and in the future, and how that information can be communicated, made available and best used. Sessions will cover: the use of scenarios to inform thinking about the future and decision-making under uncertainty; the provision of climate information; the communication of information for adaptation, including challenges and barriers to communication of information; and, the importance of the communication of climate change risks to facilitate behavioural change. This thread will also reflect on the developing field of climate change adaptation, ranging from the conduct of scientific assessments to community-based adaptation and the study of institutions and governance.

### Thread 2 – *Adaptation by sectors*

This thread explores themes around our natural environment and primary industries.

A session on Water explores innovations for climate change adaptation in water sector. There is significant focus on managing the impacts of seasonality of surface flows, extreme events (including higher peak flows, longer and perhaps deeper droughts), seawater intrusion into coastal aquifers, changes in overall amounts of precipitation, and changes in demand that are related to increased temperatures.

Two sessions on Ecosystems will address questions around:

- What constitutes a dangerous level of climate change for species and ecosystems and how should ecosystem vulnerability be communicated to policy makers and the broader public?
- Can human action decrease the vulnerability of ecosystems (including costs, benefits, barriers and limits)?
- Is enhancing resilience of ecosystems the most appropriate approach?

Two sessions on 'Adapting agriculture to climate change: implications for food producers and food security' look at the wide range of adaptations that are implemented to offset risks and use opportunities arising from climate change. Climate is a major driver of agriculture and requires adaptation responses from farm-level adjustments to maintain production and sustainability to large-scale policy changes related to the nature of farming in Australia and food security challenges.

### Thread 3 – *Adapting from the grass roots*

Ultimately much adaptation will occur locally, albeit in the context of national and international policy and action. In times of increasingly rapid change, understanding how people will act locally and what knowledge will support them in this action becomes increasingly vital. This thread explores a variety of national and sub-national case studies of adaptation, as well as specifically how Indigenous people are starting to respond to the challenge in Australia, and how local knowledge around the world is mobilised in support of adaptation. We need to move 'beyond lists' in terms of understanding how to generalise from many excellent individual studies on these matters.

### Thread 4 – *Frameworks for adaptation*

Adaptation at local or regional scales or across sectors needs to be underpinned by well thought through concepts and frameworks to ensure appropriate and effective responses. For example, better understanding the costs and benefits of adaptation, developing opportunities to better integrate adaptation and mitigation responses or bringing together research, policy and industry groups will allow scarce resources to be better targeted to key adaptation needs. This thread will examine ways in which we can develop and apply frameworks so that bottom-up adaptation responses are better informed and more effectively implemented.

### Thread 5 – *Adaptation at the edge*

This thread takes up three themes: first, that some areas are more vulnerable to climate change; second, that climate change has the greatest impacts through changing occurrence of extreme events and third, that adaptation takes place principally in response to these extreme events.

The IPCC Fourth Assessment pinpointed those locations most at risk from climate change: the Arctic, Africa, Asian megadeltas, and small islands. In this thread, we look at responses for a sub-set of these: adaptation in the Tropics (1 session), along coasts, in deltas and on small islands (2 sessions). These regions are at the forefront of attempts to adapt to climate change, and many of the experiences in these locations today will inform adaptation planning in future.































The two sessions on Climate extremes and disaster management explore the interface between the disaster management and climate change adaptation community, for floods, droughts and wind storm. Amongst the themes covered, we will look at trade-offs and synergies between short-term responses and long-term adaptation, tool kits and interrelationships between vulnerability, adaptive capacity and action.

## Thread 6 – Human welfare and adaptation

Climate change threatens human welfare, through impacts on our living environment, livelihoods and physical and mental health. Adaptation, by responding to these impacts, seeks to maintain or improve quality of life. For these responses to be sustainable, it may not be possible to maintain the present forms and patterns of our existence. Change is an inevitable part of adaptation if we are to live in equilibrium with our changing climate.

This theme explores some of these issues. There are two sessions on 'Adaptation and the community', which will test the widely-held view that adaptation should take place locally and be integrated into development activities. The success of community-based adaptation (CBA) will be explored through case studies, and the interactions between CBA and other, more 'top-down', approaches to adaptation, will be explored.

This theme will explore adaptation to address climate change impacts on human health, wellbeing and welfare through two sessions, one around 'Human security, social and equity issues' and one on 'Human health'. A session on 'Engineering solutions for adaptation' completes this theme.

THREAD 1	THREAD 2	THREAD 3	THREAD 4	THREAD 5	THREAD 6
<i>Understanding &amp; communicating adaptation</i>	<i>Adaptation by sectors</i>	<i>Adapting from the grass roots</i>	<i>Frameworks for adaptation</i>	<i>Adaptation at the edge</i>	<i>Human welfare &amp; adaptation</i>
 Scenarios of the future for adaption	 Adapting agriculture to climate change	 A climate of uncertainty: Indigenous Land Managers, vulnerabilities & adaptation to climate change	 The economics and costs of adaptation	 Coasts, deltas and small islands	 Adaptation and the community
 Climate nformation for users	 Adapting agriculture to climate change	 National and sub-national case studies of adaptation	 The interface of adaptation and mitigation	 Coasts, deltas and small islands	 Human security, social and equity issues
 Risk communication & behavioural change	 Water sector adaptation: innovations	 National and sub-national case studies of adaptation	 Research meets business and industry	 Impacts and adaptation in the tropics	 Engineering and technology solutions for adaptation
 Communication of information for adaptation	 Ecosystems	 Constructing and enabling local knowledge	 National and international adaptation activities	 Climate extremes and disaster management	 Adaptation and the community
 New concepts in adaptation	 Ecosystems	 Adaptation and development	 Adapting to climate change in cities	 Climate extremes and disaster management	 Human Health

## DETAILED PARALLEL SESSION PROGRAM

The format of parallel sessions, and the scheduling of individual presentations within these sessions, will vary. The format of sessions, including the length and nature of individual presentations and the manner in which the sessions will be run, has been determined by individual session convenors.

### Thread 1 – Understanding and communicating adaptation

<b>Scenarios for the future of adaptation</b>	
Convened by Tim Carter (Finnish Environment Institute, SYKE, Finland), Mark Stafford Smith (CSIRO, Australia)	
ORAL PRESENTATIONS – DAY 1 (2:00PM-3:30PM) – PARALLEL SESSION 1.3.1	
<i>Systematic and transparent exploration of scenario spaces: Socio-economic scenarios for local climate change adaptation</i> , <b>Henrik Carlsen</b> , Swedish Defence Research Agency, Sweden	
<i>Using Scenarios to Explore the Complexities and Adaptation Strategies of Future Arctic Marine Navigation</i> , <b>Lawson Brigham</b> , University of Alaska Fairbanks, United States	
<i>Future makers or future takers? A scenario analysis of climate change and the Great Barrier Reef</i> , <b>Erin Bohensky</b> , CSIRO Sustainable Ecosystems, Australia <b>(Presented by James Butler)</b>	
<i>Mapping Population and Climate Change Vulnerabilities: Challenges of Reaching Policy Audiences</i> , <b>Sean Finnegan</b> , Population Action International, United States	
<i>Looking ahead and adapting? Comparative analysis of future scenarios for the fisheries sectors in Peru, Senegal, Ghana, Mauritania, and Vietnam</i> , <b>Marie-Caroline Badjeck</b> , The WorldFish Center, Malaysia	
<i>Understanding Design for planning alternative landscape futures to adapt to Climate Change: Learning from Temporal inconsistencies in vulnerability and adaptation studies</i> , <b>David Brunckhorst</b> , Institute for Rural Futures, Australia	
POSTER PRESENTATIONS – DAY 1 (6:15PM-7:30PM) – POSTER SESSION 1.6	
	REF #
<i>Climate change - the limits of adaptation</i> , <b>Clive Attwater</b> , SGS Economics and Planning, Australia	A1
<i>Adapting to the Confluence of Impacts in Australian Cities: One Shock Away from Disaster and the Benefit of Resilience Planning</i> , <b>Donovan Burton</b> , NCARF, Australia	A2
<i>Towards systemic and adaptive governance: understanding framings and relational dynamics of climate change adaptation</i> , <b>Andrea Grant</b> , Monash University, Australia	A3
<i>Modelling Scenarios of Future Adaptation using an Agent Based Simulation Framework</i> , <b>Cecily Maller</b> , RMIT University, Australia <b>(Presented by Sarah Hickmott)</b>	A4
<i>Perverse Adaptation Strategies: Four Scenarios</i> , <b>Earl Saxon</b> , United States	A5
<i>Scenario Planning for Climate Change Adaptation</i> , <b>Silvia Serrao-Neumann</b> , Griffith University, Australia	A6
<i>Scenarios, stakeholders and systemic planning</i> , <b>Leon Soste</b> , Future Farming Systems Research Division, Department of Primary Industries Victoria, Australia	A7
<i>Scenario Planning for a resilient irrigated agribusiness community in Sunraysia</i> , <b>Caroline Welsh</b> , Department of Primary Industries Victoria, Australia	A8



### Climate information for users

Convened by Chris West and Roger Street (UK Climate Impacts Programme, UK), Andrew Watkins (Bureau of Meteorology, Australia)

#### ORAL PRESENTATIONS – DAY 2 (11:00AM-12:30PM) – PARALLEL SESSION 1.3.1

- Rapid assessment of the impacts of climate change (RAICC)*, **Adam Fenech**, Environment Canada, Canada
- Development of high resolution integrated climatologies for Marine Protected Areas*, **Karsten Shein**, NOAA National Climatic Data Center, United States
- Pacific Island Climate Forecasts for late 2009; a canary in the mine? The importance of climate services for users*, **Andrew Watkins**, Bureau of Meteorology, Australia
- Potential benefits of a storyline approach to the provision of regional climate projection information*, **Penny Whetton**, CSIRO Atmospheric Research, Australia
- Delivering Useful Climate Information in the UK: Continuing to learn lessons*, **Roger Street**, UKCIP, United Kingdom **(Presented by Chris West)**
- Pacific Storms Climatologies: Products and Applications*, **John Marra**, NOAA NCDC IDEA Center, United States

#### POSTER PRESENTATIONS – DAY 2 (7:30AM-8.30AM) – POSTER SESSION 2.1

REF #

<i>Towards climate change urban adaptation in Indonesia: climate change vulnerability assessment for cities in Java Region</i> , <b>Febi Dwirahmadi</b> , International Federation of Red Cross and Red Crescent Societies (IFRC), Indonesia	B1
<i>Probability ensembles of 21st century range changes among micro-hylid frogs of Australia's Wet Tropics</i> , <b>Linda Beaumont</b> , Macquarie University, Australia	B2
<i>Information overload and risks in climate adaptation for local government authorities</i> , <b>Peter Best</b> , NCARF, Australia <b>(Presented by Donovan Burton)</b>	B3
<i>A new climate change monitoring website for the South Pacific</i> , <b>Dean Collins</b> , Bureau of Meteorology, Australia	B4
<i>Modelling and Simulation of Consumption Behaviour Dynamics to Support Climate Adaptation</i> , <b>Lan Ding</b> , CSIRO, Australia	B5
<i>The Canadian Climate Change Scenarios Network: Linking Global Climate Models to Local Decision-Making</i> , <b>Adam Fenech</b> , Environment Canada, Canada	B6
<i>Development, Dissemination, and Application of Drought Indices for Monitoring and Forecasting Drought in the Southeast USA</i> , <b>Keith Ingram</b> , Southeast Climate Consortium/University of Florida, United States	B7
<i>Economic predictions of flood damages with respect to the extreme rainfall in Japan</i> , <b>So Kazama</b> , Tohoku University, Japan	B8
<i>Dealing with uncertainty in forest management under climate change</i> , <b>Emina Krcmar</b> , University of British Columbia, Canada	B9
<i>A stochastic downscaling method for generating future climate projections across New South Wales</i> , <b>De Li Liu</b> , Industry & Investment NSW, Australia	B10
<i>Assessing the impacts of climate change on the water resources in the Nile Basin using a regional climate model ensemble</i> , <b>Met Office Consulting Team</b> , UK	B11
<i>Impacts of climate change on the UK energy industry</i> , <b>Met Office Consulting Team</b> , UK	B12
<i>Investment Decisions for Climate Change Adaptation</i> , <b>Michael Nolan</b> , AECOM, Australia	B13
<i>Scenarios vs probabilistic futures: towards a risk-based understanding of climate change and adaptation priorities</i> , <b>Andy Reisinger</b> , Victoria University of Wellington, New Zealand	B14
<i>Adapting in a worst case climate change world</i> , <b>Rob Swart</b> , Alterra, Netherlands	B15
<i>Projections of future drought in Australia using AR4 climate models</i> , <b>Jozef Syktus</b> , Queensland Climate Change Centre of Excellence	B16
<i>The threat of climate change and adaptation behaviours: Studies of the New South Wales population in 2007 and 2010</i> , <b>Melanie Taylor</b> , University of Western Sydney, Australia	B17
<i>Beyond fluffy findings. Making qualitative research on climate change useful for decision making</i> , <b>Elissa Waters</b> , Department of Planning and Community Development Victoria, Australia	B18
<i>Local Climate Impacts Profile - a way to help adapters ask better questions of climate science</i> , <b>Chris West</b> , UKCIP, United Kingdom	B19
<i>Modelling Extreme Events in a Changing Climate using Regional Dynamically-Downscaled Climate Projections</i> , <b>Chris White</b> , Antarctic Climate & Ecosystems Cooperative Research Centre, Australia	B20
<i>Applicability of Ensemble Pattern Scaling Method on Climate Change Information Construction: A Case Study of South East Queensland Climate Change Mapping</i> , <b>Wei Ye</b> , CLIMSystems Ltd, New Zealand	B21

## Risk communication and behavioural change

Convened by Jan McDonald (Griffith University, Australia) and Susanne Moser, (Susanne Moser Research and Consulting, USA)

### ORAL PRESENTATIONS – DAY 2 (2:00PM-3:30PM) – PARALLEL SESSION 2.4.1

*Communication strategies to support successful implementation of managed retreat from coastal margins and floodplains: Examples from New Zealand*, **Anna Carter**, Ministry for the Environment, New Zealand

*Risk Perception and Adaptation to Climate Change: Comparative Case Studies*, **Chris Button**, The University of Adelaide, Australia

*Understanding Perceptions of Future Climate Change to Inform Adaptation Needs: A Case Study of the Rewa Delta, Viti Levu Island, Fiji*, **Shalini Lata**, University of The South Pacific, Fiji

*Transforming domestic consumption patterns in urban water supply in South East Queensland*, **Jan McDonald**, Griffith University, Australia **(Presented by Michelle Maloney)**

*Interviewing sceptical farmers about climate change adaptations*, **Geoff Kuehne**, CSIRO, Australia

*Enabling Climate Adaptation: Navigating Communication Pathways*, **Anna Taylor**, Stockholm Environmental Institute, Oxford, United Kingdom **(Presented by Tahia Devisscher)**

### POSTER PRESENTATIONS – DAY 2 (7:30AM-8:30AM) – POSTER SESSION 2.1

REF #

*Adaptigators: Addressing climate change through building social capital*, **Peta Ashworth**, CSIRO, Australia

B22

*Challenges to adaptation in the WA farming community*, **David Beard**, Department of Agriculture & Food Western Australia, Australia **(Presented by David Gray)**

B23

*Could non-cash rewards change behaviour and motivate homeowners to respond to the risk of flooding caused by dangerous climate change?* **Erik Bichard**, University of Salford, United Kingdom

B24

*'Facts' and values in climate change science and adaptation policy*, **Jacqueline De Chazal**, Australian National University, Australia

B25

*Survey of Consumers and Industrial Sectors on Food Safety According to Climate Change*, **Myung-Sub Chung**, Duksung Women's University, South Korea **(Presented by Gun-Hee Kim)**

B26

*Linking up with opinion leaders and adaptive capacity to climate change in the Sunshine Coast Region*, **Noni Keys**, University of the Sunshine Coast, Australia

B27

*Fear, Hope and Action: Facilitating positive behavioural and social change through exploring, visualising and communicating alternative futures and pathways*, **John Wiseman**, University of Melbourne, Australia **(Presented by Taegen Edwards)**

B28

## Communication of information for adaptation

Convened by Marie Waschka (NCCARF, Australia), Simon Torok (CSIRO, Australia)

### ORAL PRESENTATIONS – DAY 3 (11:00AM-12:30PM) – PARALLEL SESSION 3.3.1

*Climate adaptation strategies and cultural engagements in Mumbai, India: exploring paths to more effective climate governance via mass media communications*, **Maxwell Boykoff**, University of Colorado-Boulder, United States

*The Weakest Link: The uptake of knowledge on vulnerability into decision making*, **Lisa Dilling**, University of Colorado, United States

*Enabling climate adaptation: moving from information provision to knowledge integration*, **Ben Smith**, Stockholm Environment Institute, Oxford, United Kingdom

*Designer guidance: climate change information for New Zealand users*, **Julie King**, Ministry for the Environment, New Zealand

*Indigenous people and climate change adaptation: Facilitating equitable access to information*, **Emma Woodward**, CSIRO, Australia

*Communication and the resilient community*, **Susan Nicholls**, University of Canberra, Australia

*Communicating climate risks and adaptation strategies across stakeholders using video*, **Sabrina McCormick**, AAAS/U.S. Environmental Protection Agency, United States

POSTER PRESENTATIONS – DAY 3 (7:30AM-8:30PM) – POSTER SESSION 3.1	REF #
<i>Transitions Town Websites: technologies of communication and power relations</i> , <b>Sarah Adams</b> , University of the Sunshine Coast, Australia	D1
<i>Near Real-Time Agrometeorological Information for Mexican Agriculture: Dissemination and Application</i> , <b>Alma Delia Baez-Gonzalez</b> , INIFAP, Mexico	D2
<i>Prominence given to Climate Change Phenomenon by the Media in sub-Sahara Africa in the Millennium Decade</i> , <b>Olufemi Bolarin</b> , Department of Agricultural Extension and Rural Development, University of Ilorin, Ilorin Kwara State, Nigeria., Nigeria	D3
<i>Communication for acceptance, information access and vulnerability awareness of climate adaptation</i> , <b>Liese Coulter</b> , CSIRO, Australia	D4
<i>Supporting adaptation network through knowledge sharing – a business model</i> , <b>Susanne Etti</b> , Environmental Resources Management, Australia	D5
<i>Hawaii Island Climate Adaptation and Policy- Regional Initiatives</i> , <b>Dolan Eversole</b> , University of Hawaii, United States	D6
<i>Print Media and Climate Change in Bangladesh: the missing health issue</i> , <b>Md Aminul Haque</b> , Institute of Public Health, Heidelberg University, Germany	D7
<i>Is adaptation getting a guernsey in the media and online? Examining a case study of the discourse around the 2009 bushfires in Victoria</i> , <b>Claire Harris</b> , CSIRO, Australia	D8
<i>Waves of change: Community discourse on a local policy of ‘planned retreat’</i> , <b>Anne Leitch</b> , ARC CoE Coral Reef Studies/JCU/CSIRO, Australia	D9
<i>Successfully managing climate change scepticism in adaptation planning group processes</i> , <b>Scott Losee</b> , AECOM, Australia	D10
<i>Can we save the Great Barrier Reef? An exploratory investigation of climate change communication in Australia</i> , <b>Catherine Naum</b> , James Cook University, Australia	D11
<i>(HOPE) Householder’s options to protect the Environment Inc at 21: an environmental history perspective on the community capacity building work of a voluntary Australian NGO</i> , <b>Andrew Nicholson</b> , Householders’ Options to Protect the Environment Inc., Australia	D12
<i>Sharing and Communicating Climate Change Adaptation Research in Victoria through an online collaborative platform</i> , <b>Christopher Pettit</b> , Department of Primary Industries Victoria, Australia	D13
<i>A Report Card of Marine Climate Change Impacts and Adaptation for Australia</i> , <b>Elvira Poloczanska</b> , Climate Adaptation Flagship, CSIRO, Australia	D14
<i>Regional Climate Change Adaptation Knowledge Platform for Asia</i> , <b>Roopa Rakshit</b> , AIT/UNEP Regional Resource Center for Asia & the Pacific, Thailand	D15
<i>CARAVAN: A tool for visualizing vulnerability to climate change in the Nordic region</i> , <b>Lynn Rosentrater</b> , University of Oslo, Norway	D16
<i>Rapid Information Delivery: Ten Top Tips For Climate Change Adaptation</i> , <b>Caroline Sullivan</b> , Southern Cross University, Australia	D17
<i>Where is high impact learning for adaptation in schools?</i> , <b>Hilary Whitehouse</b> , James Cook University, Australia	D18
<i>Prepare the next generation for changes – education programs of climate change adaptation at the University of Southern Queensland</i> , <b>Chengyuan Xu</b> , University of Southern Queensland, Australia	D19

### **New concepts in adaptation**

Convened by Ben Preston (Oak Ridge National Laboratory, USA), Roger Jones (Victoria University, Australia)

### ORAL PRESENTATIONS – DAY 3 (2:00PM-3:30PM) – PARALLEL SESSION 3.4.1

<i>Circling from Virtuous to Vicious: How the IPCC stopped helping and began hindering adaptive behaviour</i> , <b>Ann Henderson-Sellers</b> , Macquarie University, Australia
<i>Linking Population, Fertility and Family Planning with Adaptation to Climate Change: Views from Ethiopia</i> , <b>Karen Hardee</b> , Population Action International, United States
<i>National climate policy and local adaptation planning: Comparisons across two continents</i> , <b>Elisabeth Hamin</b> , University of Massachusetts, United States
<i>The role of decentralized community-based renewable energy systems for climate change adaptation</i> , <b>Debora Ley</b> , Oxford University Centre for the Environment, United Kingdom
<i>Current concepts of adaptive capacity and its utility for decision making</i> , <b>Phillip Daffara</b> , University of the Sunshine Coast, Australia ( <b>Presented by Tim Smith</b> )
<i>Disciplines and post-disciplinarity in climate change and coastal planning</i> , <b>Bob Pokrant</b> , Curtin University, Australia

POSTER PRESENTATIONS – DAY 2 (5:45PM-7:00PM) – POSTER SESSION 2.6	REF #
<i>Assessing resilience of the marine social-ecological system in the Australian region</i> , <b>Julie Davidson</b> , School of Geography and Environmental Studies, University of Tasmania, Australia	C1
<i>Dealing with uncertainty in climate change adaptation planning and developing triggers for future action</i> , <b>Greg Fisk</b> , BMT WBM, Australia	C2
<i>Institutional Adaptation: A framework for climate change adaptation</i> , <b>Patricia Fitzsimons</b> , Department of Primary Industries Victoria, Australia	C3
<i>Planning for climate change: a case study of mainstreaming and integrating adaptation within the Department of Sustainability and Environment</i> , <b>Connie Hughes</b> , Department of Sustainability And Environment Victoria, Australia	C4
<i>Opportunities for Climate Adaptation Learning &amp; Action at the Urban Local Level: The Case of Lahore, Pakistan</i> , <b>Saleem Janjua</b> , RMIT University, Australia	C5
<i>Adaption strategies for changing fish production as a result of global warming</i> , <b>Ian Jones</b> , University of Sydney, Australia	C6
<i>Development of a Strategic Decision Support System to Support Local Governments Decision Making Processes under the Impact of Climate Change</i> , <b>Hamid Mirfenderesk</b> , Gold Coast City Council, Australia	C7
<i>New York City's Unwitting Climate Change Adaptive Technology</i> , <b>Jason Ornstein</b> , New York University, United States	C8
<i>Design Challenge: Climate Change. The Water Atlas. WaterLand Topologies of Hamburg's Elbe River Island</i> , <b>Julia Werner</b> , RMIT University, Australia	C9

## Thread 2 – Adaptation by sectors

### **Adapting agriculture to climate change (2 sessions)**

Convened by Mark Howden (CSIRO, Australia), Cynthia Rosenzweig (NASA Goddard Institute for Space Studies & Columbia University, USA)

#### ORAL PRESENTATIONS – SESSION 1: DAY 1 (2:00PM-3:30PM) – PARALLEL SESSION 1.3.2

*Adjusting risk management for a changing climate: Experiences with policy makers, dryland farmers and the wine grape industry in South Australia*, **Peter Hayman**, SARDI, Australia

*Climate Change Adaptation & Mitigation in Agricultural Societies – A case study in Bundala village, Hambantota, Sri Lanka*, **Prabhath Patabendi**, Centre for Disaster Risk Reduction, Sri Lanka

*Farmers' Perceptions and Adaptation Measures towards Climate Change in South India*, **Ravi Shankar Kuntamukkala**, Central Research Institute for Dryland Agriculture, India

*Sustainable adaptation in English agriculture*, **Nicholas Macgregor**, Natural England, United Kingdom

*Using general systems theory to understand how farmers manage variability*, **Lisa Cowan**, Department of Primary Industries Victoria, Australia

*Adaptation to and impacts of climate change on UK agricultural sectors*, **Peter Mills**, University of Warwick, United Kingdom

*Learning from case studies of Australian agriculture adapting to climate change: understanding transformation and transition dynamics*, **Emma Jakku**, CSIRO Sustainable Ecosystems, Australia

#### ORAL PRESENTATIONS – SESSION 2: DAY 2 (11:00AM-12:30PM) – PARALLEL SESSION 2.3.2

*The challenges of agricultural production in a future variable and changing climate*, **Steven Crimp**, CSIRO, Australia

*Traits and technologies to design crop breeding systems for climate change*, **Scott Chapman & Fernanda Dreccer**, CSIRO Plant Industry, Australia

*Climate Change Impacts on Chilean Agriculture: Estimating sectoral adaptation based on changes of productivity and land allocation, under two Climate Change scenarios*, **Oscar Melo**, Pontificia Universidad Católica de Chile, Chile (**Presented by Francisco Meza**)

<i>Adapting to climate change in broad-acre irrigated farming systems – Case studies from the Riverina region of South East Australia, <b>Donald Gaydon</b>, CSIRO Sustainable Ecosystems, Australia</i>	
<i>A risk management framework for assessing climate change impacts, adaptation and vulnerability, <b>Grant Stone</b>, Queensland Climate Change Centre of Excellence, Australia</i>	
<i>Adaptation Measures to Climate Change, <b>Batimaa Punsalmaa</b>, Water Authority, Mongolia</i>	
<b>POSTER PRESENTATIONS – DAY 1 (6:15PM-7:30PM) – POSTER SESSION 1.6</b>	<b>REF #</b>
<i>CO<sub>2</sub>/heat fluxes: Comparative assessment of flooded and aerobic fields in the Philippines, <b>Ma. Carmelita Alberto</b>, International Rice Research Institute, Philippines</i>	A10
<i>GrassGro indicates that erosion risk drives adaptation of southern tablelands grazing farms to projected climate change, <b>Douglas Alcock</b>, NSW Industry and Investment, Australia <b>(Presented by Andrew Moore)</b></i>	A11
<i>The value of extension in adaptation: a Victorian case study, <b>Graeme Anderson</b>, Department of Primary Industries Victoria, Australia <b>(Presented by Chris Gerbing)</b></i>	A12
<i>A Synthesis of Practice and Theory: Enhancing Agriculture's Capacity to Adapt to Climate Change, <b>Meghan Bond</b>, Department of Primary Industries, Australia</i>	A13
<i>Response to elevated CO<sub>2</sub> of various genotypes differing in tillering, wsc accumulation, transpiration efficiency and early vigour, <b>Maryse Bourgault</b>, CSIRO Climate Adaptation Flagship, Australia</i>	A14
<i>Assessing the adaptive capacity of Tasmanian producers to climate change, <b>Kerry Bridle</b>, TIAR/CSE, Australia</i>	A15
<i>Limits and opportunities for adaptation of forest and livestock-based livelihoods in Northern Mali: Perceptions, Levels, and Strategies, <b>Maria Brockhaus</b>, CIFOR, Indonesia</i>	A16
<i>Predicting climate change impacts on the toxicity and yield of a tropical root crop: cassava, <b>Anna Burns</b>, Monash University, Australia</i>	A17
<i>Protection from crop diseases for food security in future climates, <b>Sukumar Chakraborty</b>, CSIRO Plant Industry, Australia <b>(Presented by Jo Luck)</b></i>	A18
<i>Developing and implementing grains best management practices for managing climate variability and climate change, <b>Jeff Clewett</b>, Agroclim Australia, Australia</i>	A19
<i>Australian Agriculture : adaptations to climate change, <b>Ian Craig</b>, University of Southern Queensland, Australia</i>	A20
<i>Adapting pasture-based dairy systems to future climates, <b>Brendan Cullen</b>, University of Melbourne, Australia</i>	A21
<i>Historical trends in fruit tree chilling in Australia, <b>Rebecca Darbyshire</b>, University of Melbourne, Australia</i>	A22
<i>Impact of climate change on wheat yields in Western Australia. Will wheat production be more risky in the future? <b>Imma Farre</b>, Department of Agriculture and Food Western Australia, Australia</i>	A23
<i>Food security in the future may be compromised by lower nutritional value and increased toxicity of crop plants, <b>Roslyn Gleadow</b>, Monash University, Australia</i>	A24
<i>A New Paddy Planting System to Mitigate Methane Gas Emission, <b>Eri Hadyansyah</b>, Brawijaya University, Indonesia</i>	A25
<i>Opinions about climate change and adaptation: A study using Q methodology to investigate the views of stakeholders in the livestock industry, <b>Clare Hall</b>, Scottish Agricultural College, United Kingdom</i>	A26
<i>Modeling interannual variation of crop productivity: Towards global crop forecasting, <b>Toshichika Iizumi</b>, National Institute for Agro-Environmental Sciences, Japan</i>	A27
<i>Modeling rice cropping schedules in the Vietnam Mekong Delta for adapting to changes in flooding, salinity intrusion and monsoon rains, <b>Akihiko Kotera</b>, National Institute for Agro-Environmental Sciences, Japan <b>(Presented by Masayuki Yokozama)</b></i>	A28
<i>Facilitated social learning experiences are important for sustainable land-use practice change, <b>Allyson Lankester</b>, CSIRO &amp; James Cook University, Australia</i>	A29

POSTER PRESENTATIONS – DAY 1 (6:15PM-7:30PM) – POSTER SESSION 1.6	REF #
<i>Toward the synthesis of implications of climate change for regional food security: modelling approach and a case study</i> , <b>Yinpeng Li</b> , International Global Change Centre, The University of Waikato, New Zealand	A30
<i>An integrative approach to understanding the pest and disease threats to agricultural biosecurity under future climates</i> , <b>Jo Luck</b> , Department of Primary Industries Victoria, Australia	A31
<i>Climate change effects on winter chill for temperate fruit and nut trees around the world</i> , <b>Eike Luedeling</b> , World Agroforestry Center (ICRAF), Kenya	A32
<i>Comparison of the Potential Impacts of Changes in Mean and in Climate Variability on Wheat Production Systems</i> , <b>Qunying Luo</b> , The University of Technology, Sydney, Australia	A33
<i>Development of a model for predicting the damages of typhoons on paddy rice in Japan</i> , <b>Yuji Masutomi</b> , Center for Environmental Science in Saitama, Japan	A34
<i>Impacts of ENSO on rice production in China</i> , <b>Zhaosu Meng</b> , University of New South Wales, Australia	A35
<i>Enhancement of the GRAZPLAN grazing systems models for climate change adaptation studies</i> , <b>Andrew Moore</b> , CSIRO Climate Adaptation Flagship, Australia	A36
<i>Assessing potential impacts of climate change on berry quality for major wine grape varieties</i> , <b>Nyamdoj Namjildorj</b> , Curtin University, Australia	A37
<i>Trees on farms: Tackling the triple challenge of mitigation, adaptation and food security</i> , <b>Henry Neufeldt</b> , World Agroforestry Centre, Kenya <b>(Presented by Eike Luedeling)</b>	A38
<i>Optimal phenological development for spring wheat across Victoria under present and possible future climates</i> , <b>Garry O'Leary</b> , Department of Primary Industries, Victoria, Australia	A39
<i>Climate change impacts and adaptation strategies for the mixed crop-livestock farming systems of Tasmania</i> , <b>David Parsons</b> , Tasmanian Institute of Agricultural Research, Australia	A40
<i>A modelling framework to project future pathogenic disease scenarios in wheat cropping systems under climate change</i> , <b>Hazel Parry</b> , CSIRO Entomology, Canberra, Australia <b>(Presented by Jo Luck)</b>	A41
<i>Applying the farm scale system model APSFarm to explore adaptation options available to irrigated grain-cotton farming systems</i> , <b>Brendan Power</b> , Department of Employment, Economic Development and Innovation Queensland, Australia	A42
<i>Adapting Rainfed Agriculture to Impacts of the Climate Change in the Semi-Arid Tropics of India</i> , <b>Bharat Sharma</b> , International Water Management Institute, India	A43
<i>Transforming Australia's peanut value chains to adapt to future climates</i> , <b>Peter Thorburn</b> , CSIRO, Australia <b>(Presented by Nadine Marshall and Emma Jakku)</b>	A44
<i>Climate change and irrigated agriculture: impacts and adaptation strategies in the Rio Segundo basin, Argentina</i> , <b>María Isabel Travasso</b> , INTA, Argentina	A45
<i>Impact of climate change on partitioning efficiency of pigeon pea (Cajanus cajan), a grain legume for semi arid rainfed ecosystems of the tropics</i> , <b>Maddi Vanaja</b> , Central Research Institute for Dryland Agriculture, India <b>(Presented by Ravi Shankar Kuntamukkala)</b>	A46
<i>Climate change and response measures for developing Agriculture in Vietnam</i> , <b>Ngyen Van Viet</b> , National Institute of Meteorology, Hydrology and Environment, Vietnam	A47
<i>Attribution of earlier winegrape ripening in the Southern hemisphere: analysis of vintage records</i> , <b>Leanne Webb</b> , University of Melbourne/CSIRO, Australia	A48
<i>Rapid assessment of climate change uncertainty in evaluations of adaptation options</i> , <b>Nicholas Webb</b> , CSIRO Sustainable Ecosystems, Australia	A48
<i>Greater use of kangaroos to produce low-emission meat and adapt to climate change on the rangelands</i> , <b>George Wilson</b> , Australian Wildlife Services, Australia	A49

### **Water sector adaptation: innovations**

Convened by Kathy Jacobs (OTSP, Executive Office of the President, USA), Bryson Bates (CSIRO, Australia), Stuart Bunn (Griffith University, Australia)

#### **ORAL PRESENTATIONS – DAY 2 (2:00PM-3:30PM) – PARALLEL SESSION 2.4.2**

*Managing Water Resources under Climate Uncertainty: Challenges and Opportunities*, **Bryson Bates**, CSIRO Climate Adaptation Flagship, Australia

*Adaptive strategies to Mitigate the Impacts of Climate Change on European Freshwater Ecosystems*, **Martin Kernan**, Environmental Change Research Centre, United Kingdom

*Assessment of the challenges in adapting water resources and water infrastructure to climate change—a review*, **Eytan Rocheta**, Australian Climate Change Adaptation Research Network for Settlements and Infrastructure, Australia

*Effective water planning to maintain water supply at acceptable levels of risk*, **Mark Summerton**, Umgeni Water, South Africa

*Changing Monsoon Pattern and its Impact on Water Resources in Himalaya: Responses & Adaptation*, **Prakash Chandra Tiwari**, Kumaun University, India

*Water Planning and adapting to Climate Change in Australia: Policy, Law and Practice*, **Poh-Ling Tan**, Griffith Law School, Australia

#### **POSTER PRESENTATIONS – DAY 2 (5:45PM-7:00PM) – POSTER SESSION 2.6**

REF #

*Adaptation Strategies for Safe Water Supply in the Coastal Region of Bangladesh*, **Mehdi Azam**, Institute of Forest and Environmental Policy, Germany (**Presented by Tapan Sarker**)

C10

*Zambia Climate Change Risk Case Study*, **Bill Bohn**, Tetra Tech Inc., United States

C11

*Climate change impacts on the water resources of the river basins*, **Guillermo Cardoso-Landa**, Instituto Tecnológico de Chilpancingo, Mexico

C12

*WINDSCREEN: A visualisation tool for engaging the community about water allocation decisions*, **Michelle Graymore**, Deakin University, Australia

C13

*Climate Change Impacts and Adaptation in the Berg Water Management Area of South Africa*, **Trevor Lumsden**, University of KwaZulu-Natal, South Africa

C14

*Building adaptive capacity in the water sector through scenarios and simulations: examples from Phoenix, Arizona*, **Christy Mercer**, Arizona State University, United States

C15

*Reducing drought vulnerability by drought characterizing using meteorological data and spatial soil moisture modelling*, **Budi Hadi Narendra**, Forestry Research Institute of Mataram, Indonesia

C16

*Design flood estimation under Climate Change: the need for Continuous Simulation*, **Sahani Pathiraja**, University of New South Wales, Australia

C17

*Challenges and issues in managing water resources with global climatic changes – How vulnerable Sri Lanka as a small island country in the Southern Hemisphere*, **Prabhath Patabendi**, Centre for Disaster Risk Reduction, Sri Lanka

C18

*Determining the impacts of climate change on water availability across south eastern Australia: the SEACI initiative*, **David Post**, CSIRO Land and Water, Australia

C19

*Urban Water Supply in an Energy Constrained Australia: the water-energy nexus*, **Eytan Rocheta**, ACCARNSI (NCCARF, Australia), Australia

C20

*Determination of the Effectiveness of Chemical Film Monolayers under Wind and Wave Conditions*, **Peter Schouten**, Griffith University, Australia

C21

*A roadmap for climate change adaptation process on a multipurpose hydropower and agriculture basin in central Chile*, **Sebastian Vicuna**, Centro Interdisciplinario de Cambio Global. Pontificia Universidad Catolica de Chile., Chile

C22

## Ecosystems (2 Sessions)

Convened by Rik Leemans (Wageningen University, The Netherlands), Guy Midgley (South African National Biodiversity Institute), Alistair Hobday (CSIRO, Australia)

### ORAL PRESENTATIONS – SESSION 1: DAY 3 (11:00AM-12:30PM) – PARALLEL SESSION 3.3.2

*Marine Climate Change Impacts & Adaptation Report Card: Seabirds*, **Lynda Chambers**, Centre for Australian Weather and Climate Research, Bureau of Meteorology, Australia

*When should we stop learning about climate impacts on biodiversity and act?* **Eve McDonald-Madden**, CSIRO Sustainable Ecosystems, Australia **(Presented by Tara Martin)**

*Conservation planning for adaptation to climate change: an operational framework*, **Bob Pressey**, James Cook University, Australia **(Presented by Stephen Williams)**

*An integrated framework for assessing the vulnerability of biodiversity to climate change: prioritising research and adaptation strategies*, **Stephen Williams**, James Cook University, Australia

*Understanding Climate Change Impacts and Adaptation for Ecosystems Using Qualitative Models*, **Jonathan Rhodes**, The University of Queensland, Australia

*Ecosystem Services for Adaptation to Climate Change: Case Studies from Semi-Arid Botswana, Africa*, **Mogodisheng B.M. Sekhwela**, University of Botswana, Botswana

*An integrated regional approach to climate adaptation – the Great Barrier Reef Climate Change Action Plan*, **Paul Marshall**, Great Barrier Reef Marine Park Authority, Australia

*A biome comparison of forest ecosystem dynamics, biodiversity and climate change impacts*, **Brendan Mackey**, The Australian National University, Australia

### ORAL PRESENTATIONS – SESSION 2: DAY 3 (2:00PM-3:30PM) – PARALLEL SESSION 3.4.2

*Marine climate change impacts: Out of sight but not out of mind*, **Anthony Richardson**, University of Queensland, Australia

*Coral arks: a triage model for marine resource management based on coral resilience*, **Alison Jones**, Centre for Environmental Management, Central Queensland University, Australia

*Assessing and managing extinction risk under climate change*, **Tracey Regan**, The University of Melbourne, Australia

*Minimising conflicts in a changing climate: integrating biodiversity conservation, urban growth and climate change adaptation*, **Lochran Trill**, The University of Queensland, Australia

*Nature's Technology: An ecosystem-based approach to adaptation*, **Caroline Cowan**, United Kingdom

*More than CO2: the role of native vegetation in climate change mitigation and adaptation*, **Clive McAlpine**, The University of Queensland, Australia

*Plant invasions in Mediterranean climate "hotspots" of Australia and South Africa: do past invasions inform us about plant responses to future climate change?* **Bruce Webber**, CSIRO Climate Adaptation National Research Flagship, Australia

*Vegetation change and migration in protected areas and biological corridors under climate change scenarios in Mesoamerica*, **Bruno Locatelli**, CIRAD-CIFOR, Indonesia

### POSTER PRESENTATIONS – DAY 2 (5:45PM-7:00PM) – POSTER SESSION 2.6

REF #

*Species distribution modelling for climate change adaptation: a koala case study*, **Christine Adams-Hosking**, The University of Queensland, Australia

C23

*Multiple Ecosystem stable states and Desertification*, **David Anokye Asamoah**, International Assistance for Community Development (INACOD), Ghana

C24

*Effect of different plant functional groups on methane emissions from wetland ecosystems*, **Gurbir Singh Bhullar**, Institute of Integrative Biology, ETH, Zurich, Switzerland

C25

*The east coast Tasmanian rock lobster fishery: vulnerability to climate change impacts and adaptation response options*, **Stewart Frusher**, University of Tasmania, Australia

C26

*Tree rings trends of pine and fir trees growing on the treeline zone in central Mexico*, **Armando Gomez**, Colegio de Postgraduados, Mexico

C27



POSTER PRESENTATIONS – DAY 2 (5:45PM-7:00PM) – POSTER SESSION 2.6	REF #
<i>Observed and anticipated impacts in response to climate change on aquifer temperature</i> , <b>Luminda Gunawardhana</b> , Tohoku University, Japan	C28
<i>An ocean acidification overview: effects on marine organisms and implications for the future</i> , <b>Vanessa Hernaman</b> , Queensland Climate Change Centre of Excellence, Queensland State Government, Australia	C29
<i>Measuring and monitoring climate change adaptation: developing a system for long-term biodiversity and ecosystem research</i> , <b>Jean-Marc Hero</b> , Environmental Futures Centre, Australia	C30
<i>Assessing stress to ecosystems caused by future climate change to inform broad adaptation policy and planning at a continental scale</i> , <b>David Hilbert</b> , CSIRO, Australia	C31
<i>Networking across global marine 'hotspots'</i> , <b>Alistair Hobday</b> , CSIRO, Australia	C32
<i>Using climate change scenarios to direct habitat restoration</i> , <b>Tina Lawson</b> , CSIRO Sustainable Ecosystems, Australia ( <b>Presented by Helen Murphy</b> )	C33
<i>Assessing the vulnerability of the terrestrial natural environment at a landscape scale</i> , <b>Nicholas Macgregor</b> , Natural England, United Kingdom	C34
<i>Interacting Effects between Climate Change and Habitat Loss on Biodiversity: A Systematic Review and Meta-Analysis</i> , <b>Chrystal Mantyka-Pringle</b> , University of Queensland, Australia	C35
<i>Increasing The Resilience Of The Cape Floristic Region To The Impacts Of Climate Change Through The Wise Design And Implementation Of Systematic Biodiversity Plans</i> , <b>Kerry Maree</b> , CapeNature, Kirstenbosch National Botanical Gardens, South Africa	C36
<i>Altitudinal associations of Springatil assemblages in an Australian subtropical rainforest: implications for future climate change</i> , <b>Sarah Maunsell</b> , Griffith University, Australia	C37
<i>Assessing uncertainty in projections of future climate change in cool temperate rainforest biota of south-eastern Australia</i> , <b>Verity Miles</b> , Museum Victoria, Australia	C38
<i>Australia's EPBC Act, with reference to a case study from Australia's largest river system</i> , <b>Gina Newton</b> , Department of the Environment, Water, Heritage and the Arts, Australia	C39
<i>Assessment of vulnerability and adaptation to climate change in Rio de la Plata artisanal fisheries through a participatory methodology</i> , <b>Alvaro Ponce</b> , Ministry of Environment, Uruguay	C40
<i>Modelling coastal saltmarsh response to sea-level rise to predict vulnerability and resilience</i> , <b>Kerrylee Rogers</b> , NSW Department of Environment, Climate Change and Water, Australia	C41
<i>Climate-adaptive National Conservation Planning in Papua New Guinea</i> , <b>Earl Saxon</b> , United States	C42
<i>Present-day variability in Great Barrier Reef carbonate chemistry and implications for future ocean acidification</i> , <b>Emily Shaw</b> , The University of New South Wales, Australia	C43
<i>The Great Barrier Reef adapting to climate change: identifying options for intervention</i> , <b>Judith Stewart</b> , Great Barrier Reef Foundation, Australia	C44
<i>Deer impact on subalpine forest ecosystem in Japan: Indirect effect of climate change?</i> <b>Toru Takeuchi</b> , Central Research Institute of Electric Power Industry, Japan	C45
<i>Developing an integrated approach to climate change refugia in Old, Climatically Buffered, Infertile Landscapes (OCBILs)</i> , <b>Grant Wardell-Johnson</b> , Curtin University, Australia	C46
<i>How do you define a native species in a rapidly changing climate?</i> <b>Bruce Webber</b> , CSIRO Climate Adaptation Flagship, Australia	C47
<i>Role of rainfall change on the patterns and processes of terrestrial ecosystems</i> , <b>Wei Wei</b> , State Key Laboratory of Urban and Regional Ecology, RCEES,CAS, China	C48
<i>Modelling the Impact of Climate Change on Peatlands in the Bogong High Plains, Victoria, Australia</i> , <b>Andrea White</b> , University of Melbourne, Australia	C49
<i>The potential impacts of climate change and land transformation on biodiversity in Mediterranean climate south-west Western Australia – a global biodiversity hotspot</i> , <b>Colin Yates</b> , Western Australian Department of Environment and Conservation, Australia	C50

### Thread 3 – Adapting from the grass roots

#### **A Climate of Uncertainty: Indigenous Land Managers, vulnerabilities and adaptation to climate change**

Convened by Marcia Langton (University of Melbourne, Australia)

##### ORAL PRESENTATIONS – DAY 1 (2:00PM-3:30PM) – PARALLEL SESSION 1.3.3

**Nolan Hunter** and **Sonia Leonard**, Kimberley Land Council

Gunditj Mirring Traditional Owners Aboriginal Corporation, speaker to be announced

**Viv Sinnamon** and **Philip Mango**, Kowanyama Land and Natural Resource Management Office

Torres Strait Regional Authority, speaker to be announced

#### **National and sub-national case studies of adaptation (2 sessions)**

Convened by Emma Tompkins (University of Leeds, UK), Heather McGray (World Resources Institute, USA)

##### ORAL PRESENTATIONS – SESSION 1: DAY 2 (11:00AM-12:30PM) – PARALLEL SESSION 2.3.3

*What is next for Australian local government? - Moving from Local Adaptation Pathways to integrated adaptation planning and decision making*, **Zafi Bachar**, AECOM, Australia

*Adaptation policy in Germany and multi-level governance*, **Achim Daschkeit**, Federal Environment Agency, Germany

*Adapting to Climate Change at Multiple Governance Levels: Insights from Australia*, **Pedro Fidelman**, Australian Research Council Centre of Excellence for Coral Reefs Studies, James Cook University, Australia

*Local and large-scale approaches to adaptation in Canada*, **Pamela Kertland**, Natural Resources Canada, Canada

*The Adaptation Atlas: A Case Study in Managing Complex Information Needs for Adaptation*, **Nisha Krishnan**

*Climate change action planning workshop package*, **Amy Lovesey**, Australia

##### ORAL PRESENTATIONS – SESSION 2: DAY 2 (2:00PM-3:30PM) – PARALLEL SESSION 2.4.3

*From climate change science to adaptation planning and decision making: The Ouranos experience.*, **Alain Bourque**, Ouranos, Canada

*Measuring the Unmeasurable: The development of adaptation indicators in England*, **Caroline Cowan**, United Kingdom

*Effectiveness of adaptation to climate change in the Netherlands. A sub-national case study at six meters below sea level*, **Karianne De Bruin**, Wageningen University, Netherlands

*Adaptation challenges facing the State of Victoria, Australia: an exploration of the evolving institutional response*, **Darryn McEvoy**, RMIT University, Australia

*Defining and Assessing Maladaptation*, **Saffron O'Neill**, University of Melbourne, Australia

*Observed adaptation to climate change: UK evidence of social transition*, **Emma Tompkins**, SRI, Leeds University, United Kingdom

##### POSTER PRESENTATIONS – DAY 2 (7:30AM-8.30AM) – POSTER SESSION 2.1

*Regional Adaptation to Climate Change in Germany (the KLIMZUG research projects)*, **Hubertus Bardt**, Cologne Institute for Economic Research, Germany

REF #

B29

*Exploring the adaptation research challenge: a state government perspective*, **Jennifer Cane**, Department of Sustainability & Environment Victoria, Australia

B30

POSTER PRESENTATIONS – DAY 2 (7:30AM-8.30AM) – POSTER SESSION 2.1	REF #
<i>Adaptation to climate change and development cooperation in North Africa</i> , <b>Benjamin Garnaud</b> , IDDRI, France	B31
<i>Adapting to climate change in the UK: UKCIP's Adaptation Framework</i> , <b>Megan Gawith</b> , UK Climate Impacts Programme (UKCIP), United Kingdom <b>(Presented by Chris West)</b>	B32
<i>Assessments of Impacts and Adaptations to Climate Change in Japan using an integrated assessment model, AIM/Impact[Policy]</i> , <b>Yasuaki Hijioka</b> , National Institute for Environmental Studies, Japan	B33
<i>Recent rapid climate change in south-eastern Australia and its impacts: important lessons for adaptation</i> , <b>Roger Jones</b> , Centre for Strategic Economic Studies, Victoria University, Australia	B34
<i>Developing An Integrated Regional Vulnerability Assessment - A Pilot Project in South Eastern NSW</i> , <b>Christopher Lee</b> , NSW Dept of Environment, Climate Change and Water, Australia	B35
<i>Monitoring, evaluating and reporting climate change adaptation in local governments in Sydney, Australia</i> , <b>Timo Leiter</b> , University of New South Wales, Australia	B36
<i>Adapting England's landscapes to a changing climate</i> , <b>Nicholas Macgregor</b> , Natural England, United Kingdom	B37
<i>Impact assessment of climate change on irrigation and adaptation by a distributed water circulation model</i> , <b>Takao Masumoto</b> , National Institute for Rural Engineering (NIRE), NARO, Japan	B38
<i>Understanding adaptation perceptions through policy frameworks: a case study from South East Queensland, Australia</i> , <b>Johanna Mustelin</b> , Griffith Centre for Coastal Management and Urban Research Program, SEQCARI, Griffith University, Australia	B39
<i>Climate change, land use policies, and adaptation in Alxa region, Inner Mongolia, China</i> , <b>Henry Neufeldt</b> , Tyndall Centre for Climate Change Research, United Kingdom	B40
<i>Community-based adaptation, vulnerability and poverty</i> , <b>Julie Webb</b> , CARE Australia, Australia	B41
<i>The role of legislation in enabling climate change adaptation at the local government level</i> , <b>Jacqui Yeates</b> , Ministry for the Environment, New Zealand, New Zealand	B42
<i>Vulnerability Assessments as a platform for social learning</i> , <b>Emma Yuen</b> , CSIRO, Australia	B43
<i>Research on climate change adaptation selection in underdeveloped areas of northwest China</i> , <b>Jingjing Zeng</b> , CAS, China	B44

### Constructing and enabling local knowledge

Convened by Donovan Burton (NCCARF, Australia), Opha Pauline Dube (University of Botswana)

### ORAL PRESENTATIONS – DAY 3 (11:00AM-12:30PM) – PARALLEL SESSION 3.3.3

<i>Partner or Perish: Regional Governance for Local Adaptation</i> , <b>Benjamin Preston</b> , Oak Ridge National Laboratory, United States
<i>Shared Learning on Adapting to Climate Change: Experiences from the Columbia Basin Trust Initiative - Communities Adapting to Climate Change</i> , <b>Stewart Cohen</b> , Environment Canada and University of British Columbia, Canada
<i>Effective Community Engagement to Reach Agreement over Climate Adaptation: Utilising Consensus Building and Joint Fact-Finding Strategies</i> , <b>Julian Prior</b> , University of New England, Australia
<i>Adapting through local planning: barriers and opportunities for climate adaptation</i> , <b>Thomas Measham</b> , CSIRO, Australia
<i>Lessons learnt from Fiji rural climate change adaptation project</i> , <b>Leone Limalevu</b> , University of the South Pacific, Fiji
<i>Developing citizen science as a communication and research tool for monitoring ecological change in the marine environment</i> , <b>Gretta Pecl</b> , University of Tasmania, Australia <b>(Presented by Stewart Frusher)</b>
<i>Building Resilience to Climate Change through Community Based Development Planning: Lessons from Addressing Climate Impacts in a Rural Coastal Community in Hawaii</i> , <b>Adam Stein</b> , National Oceanic and Atmospheric Administration, United States

POSTER PRESENTATIONS – DAY 2 (5.45PM-7:00PM) – POSTER SESSION 2.6	REF #
<i>Communities dealing with transformational change: Insights from a social network approach</i> , <b>Anne-Maree Dowd</b> , CSIRO, Australia	C51
<i>Victorian farmers take positive action and stay informed about climate change and emissions</i> , <b>Chris Gerbing</b> , Victorian Department of Primary Industries, Australia	C52
<i>Learning from experience: deriving lessons from the local level climate adaptation actions in three urban areas of Asia &amp; Africa</i> , <b>Saleem Janjua</b> , RMIT University, Australia	C53
<i>Optimising information use in adaptation planning: Examples from Kiribati</i> , <b>Rob Kay</b> , Coastal Zone Management Pty Ltd, Australia <b>(Presented by Carmen Elrick)</b>	C54
<i>Climate change risk responses through common interests and collective action behaviour: The case of Sydney Bushcare volunteers</i> , <b>Justus Kithiia</b> , Macquarie University, Australia	C55
<i>Local government as knowledge brokers for effective climate change adaptation</i> , <b>Anne Leitch</b> , ARC CoE Coral Reef Studies/JCU/CSIRO, Australia	C56
<i>Building agricultural adaptation through understanding farmer attitudes, knowledge and responses to a changing climate</i> , <b>Pamela McRae-Williams</b> , University of Ballarat, Australia <b>(Presented by Michelle Graymore)</b>	C57
<i>Adaptation to climate change. Case studies of two rural Australian communities</i> , <b>Emily Mendham</b> , CSIRO, Australia	C58
<i>Talking climate change with the bush</i> , <b>Clare Mullen</b> , Bureau of Meteorology, Australia	C59
<i>Building the Climate Change Response Capability of Local Governments Units in the Philippines</i> , <b>Linda Peñalba</b> , University of the Philippines Los Baños, Philippines <b>(Presented Dulce Elazegui)</b>	C60
<i>Community Landcare Networks, Social Capital and Adaptation Strategies: Lesson Learned for Community Adaptation to Climate Change</i> , <b>Julian Prior</b> , University of New England, Australia	C61
<i>A problem- oriented approach to adaptation in a business community: lessons learnt from Alpine Shire, Victoria Australia</i> , <b>Carolina Roman</b> , Monash University, Australia	C62
<i>Me &amp; My Community</i> , <b>Tim Saal</b> , Centre for Rural and Remote Mental Health Queensland, Australia	C63
<i>Island Adaptation: Linking Knowledge, Management and Communities in American Samoa</i> , <b>Clare Shelton</b> , American Samoa Coral Reef Advisory Group, American Samoa	C64
<i>Developing Policy for Adaptation to Climate Change at the Indonesian Local Government Levels</i> , <b>Rahayu Yoseph</b> , Griffith University, Australia	C65

### **Adaptation and development**

Convened by Saleemul Huq (IIED, UK and BNAS Bangladesh), Jean-Pascal van Ypersele (IPCC Vice-Chair, Université catholique de Louvain, Belgium)

### ORAL PRESENTATIONS – DAY 3 (2:00PM-3:30PM) – PARALLEL SESSION 3.4.3

<i>Reconciling Climate Resilience and Sustainable Urban Development: Perspectives from Vietnam</i> , <b>Iftekhar Ahmed</b> , RMIT University, Australia
<i>Climate Change and sustainable development in Botswana</i> , <b>Opha Pauline Dube</b> , University of Botswana, Botswana
<i>Adaptation to drought – learning from Africa</i> , <b>Simon Batterbury</b> , University of Melbourne, Australia
<i>3 (influential but) misleading ideas about adaptation to climate change</i> , <b>Benjamin Garnaud</b> , IDDRI, France
<i>A framework for assessing and monitoring vulnerability and adaptive capacity</i> , <b>Sarah Park</b> , CSIRO Sustainable Ecosystems, Australia
<i>Identifying problems and finding solutions: using the Climate Vulnerability Index to prioritise adaptation responses</i> , <b>Caroline Sullivan</b> , Southern Cross University, Australia

POSTER PRESENTATIONS – DAY 3 (7:30AM-8:30AM) – POSTER SESSION 3.1	REF #
<i>Pacific Island responses to Australian and Japanese governments' assistance in dealing with problems of adaptation to climate change</i> , <b>Yumiko Asayama</b> , Australia	D19
<i>Institutional Challenges to Climate Change Adaptation in NSW, Australia</i> , <b>Alicia Bergonia</b> , Institute of Environmental Studies, University of New South Wales, Australia	D20
<i>Adaptation to climate change in Africa: Challenges and Opportunities identified from Ethiopia</i> , <b>Declan Conway</b> , University of East Anglia, United Kingdom	D21
<i>Evolving sustainability supportive ecosystem approach to climate policy in Guyana: Rising above the gathering storm of the political ecology of climate change adaptation</i> , <b>John Carthey Caesar</b> , University of Guyana, Guyana	D22
<i>Strengthening the Link Between Climate Change Adaptation and National Development Plans: Lessons from the Case of Population in NAPAs</i> , <b>Karen Hardee</b> , Population Action International, United States	D23
<i>Adaptation by the Australian mining industry in response to climate change</i> , <b>Jane Hodgkinson</b> , CSIRO, Australia	D24
<i>Sustainability Assessment of a Climate Change Adaptive Urban Development: Coolum Ridges, Sunshine Coast, Australia; as a Demonstration Project</i> , <b>Greg Laves</b> , University of the Sunshine Coast, Australia	D25
<i>Planning for the Coast: Sea Level Rise, Significant Coastal Events and Preserving Land and Development – an Analysis of Site-Specific New South Wales Case Studies</i> , <b>Tayanah O'Donnell</b> , Urban Research Centre, University of Western Sydney, Australia	D26
<i>Formulating a Implementable Climate Change Adaptation Policy for Sri Lanka</i> , <b>Chandani Panditharatne</b> , Griffith University, Australia	D27
<i>Demography, Vulnerability and Climate Change Adaptation</i> , <b>Benjamin Preston</b> , Oak Ridge National Laboratory, United States	D28
<i>Methods for assessing vulnerability of sustainable forest management to climate change</i> , <b>Tim Williamson</b> , Canadian Forest Service, Canada	D29

#### Thread 4 – Frameworks for adaptation

<b>The economics and costs of adaptation</b> Convened by Frank Jotzo (Australian National University, Australia)
ORAL PRESENTATIONS – DAY 1 (2:00PM-3:30PM) – PARALLEL SESSION 1.3.4
<i>Decision Making in a Changing Climate: Responding to Uncertainty, Surprise and the Lag of Impacts</i> , <b>Kelly Levin</b> , World Resources Institute, United States
<i>Adapting economics to climate change adaptation</i> , <b>Amar Breckenridge</b> , Frontier Economics, Australia
<i>A HECS on all your houses. Financing climate-induced retreat from coastal inundation</i> , <b>Leo Dobes</b> , Crawford School of Economics and Government, Australia
<i>Shaping Climate Resilient Development - a framework for decision making</i> , <b>David Bresch</b> , Swiss Reinsurance Company, Australia <b>(Presented by Reto Schnarwiler)</b>
<i>Adding climate impacts and adaptation possibilities to an economic computable general equilibrium model</i> , <b>Philippe Thalmann</b> , EPFL Ecole Polytechnique Fédérale de Lausanne, Switzerland
<i>Adaptation responses and costs for Australia's critical energy network infrastructure – a case study</i> , <b>John Dyer</b> , Parsons Brinckerhoff, Australia <b>(Presented by Justin Harding)</b>
<i>Impacts of Climate Change to Asian Coastal Areas: The case of Metro Manila</i> , <b>Megumi Muto</b> , Japan International Cooperation Agency, Japan
<i>Implementing information on the costs and benefits of adaptation in a portfolio –based decision framework</i> , <b>Alistair Hunt</b> , University of Bath, United Kingdom

POSTER PRESENTATIONS – DAY 1 (5:45PM-7:30PM) – POSTER SESSION 1.6	REF #
<i>Weather Extremes: Assessment of Impacts and Hazards for European Regions</i> , <b>Claus Doll</b> , Fraunhofer-Institute Systems and Innovation Research (ISI), Germany ( <b>Presented by Andreas Küster</b> )	A52
<i>Equity in the financing of adaptation: a perspective from distributive justice</i> , <b>Francois Gemenne</b> , Sciences Po Paris - Institute for Sustainable Development and International Relations (IDDRI), France	A53
<i>How should we share the global burden of adaptation costs now ... and in future?</i> <b>Kiyoshi Takahashi</b> , National Institute for Environmental Studies, Japan	A54

### **The interface of adaptation and mitigation**

Convened by Kathy Hibbard (Pacific Northwest National Laboratory, USA), Andrew Ash (CSIRO, Australia)

#### ORAL PRESENTATIONS – DAY 2 (11:00AM-12:30PM) – PARALLEL SESSION 2.3.4

*Wetland Assimilation: A Case Study of Climate Change Mitigation and Adaptation in New Orleans*, **Sarah Mack**, Tierra Resources LLC, United States

*Linkages between adaptation and mitigation in forests: landscapes, communities and policies*, **Bruno Locatelli**, CIRAD-CIFOR, Indonesia

*Managing bushfire risk using an integrated assessment of the sustainability of a planned neighbourhood*, **Melissa James**, CSIRO, Australia

*Carbon sequestration potential of agroforestry in the African Sahel*, **Eike Luedeling**, World Agroforestry Center (ICRAF), Kenya

*Adaptation-Mitigation Interactions in Agriculture – Identifying Synergies and Conflicts*, **Chris Stokes**, CSIRO, Climate Adaptation Flagship, Australia

*Potential Consequences of Climate Mitigation for Land Use Change in the 21st Century*, **Allison Thomson**, Pacific Northwest National Laboratory, United States

*Implications of Climate Change Impact on Building Energy Efficiency and Mitigation Effectiveness*, **Xiaoming Wang**, CSIRO Climate Adaptation Flagship/CSIRO Sustainable Ecosystems, Australia

#### POSTER PRESENTATIONS – DAY 2 (7.30AM-8:30AM) – POSTER SESSION 2.1

*Policy for sustainable forest development for increasing carbon sink and mitigating climate change*, **David Anokye Asamoah**, International Assistance for Community Development (INACOD), Ghana

*Characteristics of Environmental Performance and Carbon Emission of a Korean Traditional Residential Building - focused on the case study by LCA*, **Chang-U Chae**, Korea Institute of Construction Technology, South Korea

*Carbon accounting and climate change risks for public lands*, **Mark Conlon**, NSW Department of Environment, Climate Change and Water, Australia (**Presented by Chris Lee**)

*Expectations and experiences of keeping cool in the Illawarra*, **Carol Farbotko**, Australian Centre for Cultural Environmental Research, Australia

*Adaptation and mitigation: developing a tool to achieve an integrated climate change response*, **Nicole Moffatt**, AECOM, Australia

*Adaptation with grace: Searching for stability in the non-linear Earth system*, **Liam Phelan**, Macquarie University, Australia

*How the combination of adaptation strategies and mitigation options, leading to a net CO<sub>2</sub>-sink, enhances the regeneration of the Peat Colonies, the Netherlands*, **Rob Roggema**, Wageningen University and Research Centre, Netherlands

*Towards enabling mitigation of climate change through green technology investment and innovation: an empirical investigation into the Australian offshore oil and gas industry*, **Tapan Sarker**, Asia Pacific Centre for Sustainable Enterprise, Griffith University, Australia

*Socio-agrarian adaptation restore and conserve tropical forest carbon sinks?* **Sean Sloan**, The University of Melbourne/CSIRO, Australia

## Research meets business and industry

Convened by Sandra Schuster (Munich RE, Australia), Allen Kearns (CSIRO, Australia)

### ORAL PRESENTATIONS – DAY 2 (2:00PM-3:30PM) – PARALLEL SESSION 2.4.4

*Moving beyond impacts: Placing adaptation and resilience at the forefront of tourism development strategies*, **Emma Calgaro**, Centre of Tourism and Services Research, Victoria University, Australia

*Tourism, Climate Change and Adaptation: New South Wales Local Government Responses*, **Nadine White**, Regional Futures Institute, Southern Cross University, Australia

*Adaptation of the Australian electricity sector*, **Jenny Riesz**, ROAM Consulting, Australia

*A Reliability Assessment of Railway Track Performance in Extreme Heatwave Events*, **Minh Nguyen**, CSIRO Land and Water, Australia

*Adapting the industry to climate change: the role of climate services*, **Benjamin Garnaud**, IDDRI, France

*Vulnerability of the aquaculture sector to climate change in Vietnam*, **Marie-Caroline Badjeck**, The WorldFish Center, Malaysia

**Panel member: Barbara Norman**, University of Canberra, Australia; Simone Gigli, Allen Consulting; Nicole Nelson, Sydney Water; Peter Young, Councillor Gold Coast City Council; Sandra Schuster, Munich RE

### POSTER PRESENTATIONS – DAY 1 (6:15PM-7:30PM) – POSTER SESSION 1.6

REF #

*Lifestyle identity drives reef tourism enterprise resilience and propensity to conserve the Great Barrier Reef*, **Duan Biggs**, ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia

A55

*Climate and weather impacts on tourism in New Zealand*, **Susanne Becken**, Lincoln University, New Zealand

A56

*Climate Change: Employment and social policy adaptation implications*, **Peter Glynn**, International Climate Change Consultants, France

A57

*Future electricity demand projections for fast growing metropolitan regions in the context of climate change*, **George Grozev**, CSIRO Sustainable Ecosystems, Australia

A58

*Developing climate change adaptation strategies for urban infrastructure* **Donna Lorenz**, AECOM, Australia

A59

*Tourism and Adaptation to Climate Change in Switzerland : an example of public participation in the Aletsch region*, **Cecilia Matasci**, EPFL Swiss Federal Institute of Technology, Switzerland

A60

*Unique Responses by the Sheraton Fiji Resort to the Impacts of Climate Change*, **Gayle Mayes**, University of the Sunshine Coast, Australia

A61

*Effective climate change adaptation process for business*, **Risa Morimoto**, Toulouse Business School France, France

A62

*Climate change and its impacts on coastal tourism: A Case of Bagamoyo District*, **Roland Mushi**, University of Dar-es-salaam, Tanzania

A63

*Feasibility Study for Combining Adaptation Aspect in to the Long Planning Project of the Rail Transportation Sector*, **Phirada Pruittichaiwiboon**, Korea Railroad Research Institute, South Korea

A64

*Cooling energy impact of climate change in South East Queensland*, **Seongwon Seo**, CSIRO Sustainable Ecosystems, Australia

A65

*Dependency of Electricity Demand on Temperature and Economic Growth for South East Queensland, Australia*, **Chi-Hsiang Wang**, CSIRO Sustainable Ecosystems, Australia

A66

*Managing Climate Change Adaptation with Knowledge-based Risk Management Approach*, **Mingwei Zhou**, CSIRO Sustainable Ecosystems, Australia

A67

## National and international adaptation activities

Convened by Joseph Alcamo (UNEP), Youssef Nassef (UNFCCC)

### ORAL PRESENTATIONS – DAY 3 (11:00AM-12:30PM) – PARALLEL SESSION 3.3.4

*International Co-operation on Adaptation to Global Environmental Change: the Past, Present and Future of the Earth System Science Partnership (ESSP)*, **Martin Rice**, Earth System Science Partnership (ESSP), France

*Supporting Adaptation in Least Developing Countries: The International Geosphere-Biosphere Programme (IGBP) Synthesis, Integration, and Exploration (SIE) Activity*, **Opha Pauline Dube**, University of Botswana, Botswana

*Ecosystem-based Adaptation in the National Adaptation Programmes of Action (NAPAs)*, **Emilia Pramova**, Center for International Forestry Research (CIFOR) and Technical University of Munich (TUM), Indonesia

*How Europe adapts to climate change*, **Rob Swart**, Alterra, Netherlands

*Climate change adaptation and associated policy challenges: an international and national perspective*, **Greg Picker**, AECOM, Australia

*The German Adaptation Strategy: good practices and lessons learnt*, **Petra Mahrenholz**, Federal Environment Agency, Germany

*Climate Change Adaptation: The Approaches and Issues in India*, **Shailendra Kumar Mandal**, National Institute of Technology Patna, India

*Benchmarking the level of adaptation planning in Australian organisations*, **John Gardner**, CSIRO, Australia

### POSTER PRESENTATIONS – DAY 3 (7.30AM-8:30AM) – POSTER SESSION 3.1

REF #

*Climate Change and Coastal Adaptation Challenges in Albania*, **Eglantina Bruçi**, UNDP Climate Change Programme, Albania (**Presented by Robert Kay**)

D31

*Adaptation to climate change in the transport sector*, **Klaus Eisenack**, University of Oldenburg, Germany

D32

*Mainstreaming Climate Change Issue in Bangladesh*, **Md Aminul Haque**, Institute of Public Health, Heidelberg University, Germany

D33

*Hotspots and consortia joining forces for national and regional adaptation strategies for The Netherlands*, **Kim Van Nieuwaal**, Knowledge for Climate - Utrecht University, Netherlands

D34

*What is Successful Adaptation Research? Science policy challenges for an emerging outcomes-focused discipline*, **Ryan Meyer**, Australian-American Fulbright Commission, Australia

D35

*Criteria for fair allocation of international adaptation finance*, **Jonathan Pickering**, The Australian National University, Australia

D36

*Climate change adaptation and Australia's managed forests*, **Libby Pinkard**, CSIRO, Australia

D37

*Synthesis of APN Adaptation Activities in the Asia-Pacific Region*, **Linda Anne Stevenson**, Asia-Pacific Network for Global Change Research (APN), Japan

D38

*Developing ENSO-based irrigation water forecast system in a region with limited hydro-meteorological observations to mitigate the impacts of climate variability: a case study in Lombok, Indonesia*, **Xike Zhang**, Queensland Climate Change Centre of Excellence, Department of Environment and Resource Management, Australia

D39



## Adapting to climate change in cities

Convened by Shagun Mehrotra (Columbia University, USA), Cynthia Rosenzweig (NASA Goddard Institute for Space Studies & Columbia University, USA)

### ORAL PRESENTATIONS – DAY 3 (2:00PM-3:30PM) – PARALLEL SESSION 3.4.4

*Variations in Urban Climate Adaptation Planning: Implications for Action*, **Joann Carmin**, Massachusetts Institute of Technology, United States

*Better understanding the risks of climate change to the City of Toronto*, **Adam Fenech**, Environment Canada, Canada

*Strategic local government planning and decision-making on climate change adaptation: experiences from local councils in Australia*, **Hartmut Fuenfgeld**, ICLEI - Local Governments for Sustainability, Australia

*Flood risk and climate change: Main challenges to reduce vulnerability in Tunisia*, **Yadh Labane**, Tunisian Association on Climate change and sustainable development (2C2D), Tunisia

*Financing climate resilient urban infrastructure development to climate change in developing cities*, **Jun Li**, Wuhan University/IDDRI Sciences Po, China

*What is the capacity of local councils in Australia to adapt to climate change impacts in coastal urban areas?* **Frank Thomalla**, Macquarie University, Sydney, Australia

*Anticipative planning for future circumstances: The Groningen experience and the development of the swarm planning concept*, **Rob Roggema**, Wageningen University and Research Centre, Netherlands

### POSTER PRESENTATIONS – DAY 3 (7.30AM-8:30AM) – POSTER SESSION 3.1

REF #

*Adapting Cities to Climate Change: Lessons from Local Practices in Australia*, **Xuemei Bai**, CSIRO Sustainable Ecosystems, Australia **(Presented by Hitomi Nakanishi)**

D40

*Bimimicry and Urban Resilience*, **Donovan Burton**, NCCARF, Australia

D41

*Adaptation to sea level rise in Wellington, New Zealand*, **Chris Cameron**, Wellington City Council, New Zealand

D42

*Soft Infrastructure for Urban Resilience and Adaptive Capacity in Australia's Coastal Zones—the Role of the Development Control Plans (DCPs)*, **Nan Chen**, UNSW/CSIRO, Australia

D43

*Adaptation strategies to alleviate the climatic impacts of the “Melbourne 2030” planning strategy*, **Nadine Marie Josephe D’argent**, Monash University, Australia

D44

*Toward Climate Change Urban Adaptation in Indonesia : Climate Change Vulnerability Assessment in Jakarta and Java Region*, **Febi Dwirahmadi**, IESR, Indonesia

D45

*Designing reserve networks to facilitate species’ adaptations to climate change: an urban biodiversity case study*, **Jenni Garden**, Griffith University, Australia

D46

*Rapid Resilience: A systems based approach to addressing Urban Climate Change Resilience*, **Sam Kernaghan**, Ove Arup and Partners, Thailand **(Presented by Cathy Crawley)**

D47

*Boonah 2 and Gold Coast 2 – Ecologies of Climate Change*, **Nora Kinnunen**, Postgraduate Student - Griffith University QCA, Australia

D48

*A differential vulnerability assessment of Darwin, Australia: towards a better understanding of adaptive needs in urban settlements*, **Geraldine Li**, Northern Territory Government Department of Natural Resources, Environment, The Arts and Sport, Australia

D49

*Poor, Urban Planning and Adaptation to Climate Change: Tales of Indian Megacities*, **Shailendra Kumar Mandal**, National Institute of Technology Patna, India, India

D50

*Planning for resilience through effective governance: improving climate change adaptation in subtropical coastal cities*, **Johanna Mustelin**, Griffith University, Australia

D51

*Exploring the distributional effects of adding carbon charges to the New Zealand household energy sector*, **Kimberley O’Sullivan**, New Zealand Centre for Sustainable Cities, New Zealand

D52

*Climate change impacts on energy consumption and GHG emissions in Australian housing*, **Zhengen Ren**, CSE, Australia

D53

*Adapting cities to climate change: a spatial approach to decision making*, **Arvind Varshney**, Hassell, Australia

D54

## Thread 5 – Adaptation at the edge

### Coasts, deltas and small islands (2 sessions)

Convened by Robert Nicholls (University of Southampton, UK), Jon Barnett (University of Melbourne, Australia), Tim Smith (University of the Sunshine Coast, Australia)

#### ORAL PRESENTATIONS – SESSION 1: DAY 1 (2:00PM-3:30PM) – PARALLEL SESSION 1.3.5

*Heading for the walls: rising sea and declining options in South East Queensland*, **Nick Abel**, CSIRO, Australia

*Retreat: designing policies and pathways for resilient coastal development*, **Russell Gorddard**, CSIRO, Australia

*From coping to managed retreat – a transition approach for adapting to sea level rise and increased flood frequency*, **Judy Lawrence**, NZ Climate Change Research Institute, School of Government, Victoria University of Wellington, New Zealand

*The devil and the deep blue sea: legal responses to climate change risks in Australian coastal communities*, **Jan McDonald**, Griffith University, Australia

*Adapting coastal policies and instruments to climate change: a case study from South East Queensland, Australia*, **Marcello Sano**, Griffith Centre for Coastal Management - Griffith University, Australia

*Coastal Governance in Western Australia: Mapping response capacity to climate adaptation*, **Laura Stocker**, Curtin University Sustainability Policy Institute, Australia

#### ORAL PRESENTATIONS – SESSION 2: DAY 2 (11:00AM-12:30PM)

*Household level adaptation: saline intrusion and migration in the Mekong Delta, Vietnam*, **Olivia Dun**, School of Geosciences, University of Sydney, Australia

*Climate Change Adaptation in Mangrove Systems*, **Joanna Ellison**, University of Tasmania, Australia

*Integrating Climate Change Adaptation and Coastal Zone Management: A Capacity Driven approach for the Republic of Kiribati*, **Carmen Elrick**, Coastal Zone Management Pty Ltd, Australia

*Environmental migration from small island states: why islanders should not be seen as ‘canaries in the coalmine’.*, **Francois Gemenne**, Sciences Po Paris - Institute for Sustainable Development and International Relations (IDDRI), France

*Barriers to effective climate-change adaptation on islands*, **Patrick Nunn**, The University of the South Pacific, Fiji

*Climate change, coastal change, and adaptation on a low-lying coral cay: a case study from Masig, Torres Strait, Australia*, **Scott Smithers**, School of Earth and Environmental Sciences, James Cook University, Australia

#### POSTER PRESENTATIONS – DAY 1 (6:15PM-7:30PM) – POSTER SESSION 1.6

REF #

*Coastal retreat contribution to carbon cycle of Arctic Ocean on example of Yamal coast, Kara Sea.*, **Nataliya Belova**, Lomonosov Moscow State University, Faculty of Geogaphy, Russia

A68

*Climate change and adaptation in coastal zone: case study south western region Bangladesh*, **Md. Bhuiyan**, Monash University, Australia

A69

*National wind risk assessment - an overview of research activities*, **Robert Cechet**, Geoscience Australia, Australia

A70

*Managing Sea Level Rise and Coastal Hazards in an Era of Climate Change, Wellington Region, New Zealand*, **Iain Dawe**, Greater Wellington Regional Council, New Zealand

A71

*Climate Smart Sanctuary: Bridging the Gap between Scientists and Communities in American Samoa*, **Emily Gaskin**, Fagatele Bay National Marine Sanctuary/National Oceanic and Atmospheric Administration, American Samoa

A72

*Three Things to Consider When Estimating Allowances for Sea-Level Rise*, **John Hunter**, Antarctic Climate & Ecosystems Cooperative Research Centre, Australia

A73

*The value of time-series data to track climate-driven changes in coastal systems and use in the provision of policy-relevant evidence and advice*, **Nova Mieszkowska**, Marine Biological Association of the UK, United Kingdom **(Presented by Elvira Poloczanska)**

A74

*Effects of Changing Climate and Sea Ice Extent on Dynamics of Russian Arctic Coasts*, **Stanislav Ogorodov**, Lomonosov Moscow State University, Russia

A75

*Dynamic Assessment of Coastal Vulnerability to Sea-level Rise: When and Where to Adapt?* **Oz Sahin**, Griffith University, Australia

A76

*Adaptation Strategies arising from Clarence City Council’s Climate Change Impacts on Clarence Coastal Areas Report*, **John Stevens**, Clarence City Council

A77

<i>Climate adaptation information from Digital Elevation Models (DEM)</i> , <b>Benton Wecker</b> , Queensland Government, Australia	A78
<i>Data in support of climate change adaptation in the Pacific</i> , <b>William Wright</b> , Australian Bureau of Meteorology, Australia	A79

### **Impacts and adaptation in the tropics**

Convened by Suzanne Long (Reef and Rainforest Research Centre, Australia)

#### **ORAL PRESENTATIONS – DAY 2 (2:00PM-3:30PM) – PARALLEL SESSION 2.4.5**

*Climate change and multiple impact assessment for marine management in Melanesia*, **Timothy Skewes**, CSIRO, Australia **(Presented by James Butler)**

*A systematic vulnerability assesment: analysing the vulnerability of sea turtle nesting grounds to climate change*, **Mariana Fuentes**, James Cook University, Australia

*Criteria and Indicators for assessing vulnerability to climate change and developing participatory adaptation measures: Javan Rhino conservation, Ujung Kulon National Park, Indonesia*, **Hety Herawati**, Center for International Forestry Research (CIFOR), Indonesia

*Knowledge of climate refugia (past and present) to inform conservation in a changing world*, **Jeremy Vanderwal**, Centre for Tropical Biodiversity and Climate Change, James Cook University, Australia

*Vulnerability of coastal island and adaptation measures for cyclonic storm surge and climate change in the coastal area of Bangladesh*, **Md. Mobassarul Hasan**, Institute of Water Modelling, Bangladesh

*Responding to Community Vulnerability in the Pacific Islands*, **Nicholas Maclellan**, Australia

*A Balancing Act: How Small Island Developing States are balancing climate change and development*, **Caitlin Dix**, Saint Mary's University, Canada

*Impacts of Climate Change to the Straits of Malacca: The 'Three Major Effects' and Its Policy Remedy*, **Syed Mohazri Syed Hazari**, Maritime Institute of Malaysia (MIMA), Malaysia

*Management of coastal environment and sustaining its resource-dependent communities: options for coastal communities in Nigeria*, **Yemi Akegbejo-Samsons**, University of Agriculture, Nigeria

#### **POSTER PRESENTATIONS – DAY 2 (5:45PM-7:00PM) – POSTER SESSION 2.6**

REF #

*Impacts of climate on water-use and water-use efficiency of woodlands in the Sudanese Sahel region: a modelling study*, **Syed Ashraf Al Alam**, Viikki Tropical Resources Institute (VITRI), Department of Forest Sciences, University of Helsinki, Finland

C67

*Observing insects: Traditional entomological knowledge, climate change and adaptive responses in tropical rainforests*, **Edmond Dounias**, IRD/CIFOR/UMR 5175 CEFE, France **(Presented by Bruno Locatelli)**

C68

*Assessment of climate change impacts and development of adaptation options in Kakadu National Park*, **Greg Fisk**, BMT WBM Pty Ltd, Australia

C69

*Vulnerability, Impacts and Adaptation to Climate Change in the Semi-arid Region of Northeast Brazil*, **Jose A. Marengo**, CCCST-INPE, Brazil

C70

*Exploring vulnerability and local adaptation options to climate change using participatory-action research of a forest community in Lekié, Cameroon*, **Youssoufa Bele Mekou**, Center for International Forestry Research (CIFOR), Cameroon

C71

*Potential impacts of an increasing frequency of intense cyclones on plant communities in the Australian Wet Tropics*, **Helen Murphy**, CSIRO Climate Adaptation Flagship, Australia

C72

*Climate change adaptation: amphibian physiological response, including immune function and chytrid intensity, along altitudinal and temporal gradients in South-east Queensland, Australia.*, **Edward Narayan**, Environmental Futures Centre, Griffith University, Australia

C73

*Adapting to change – exploring the response of the GBR coral reef fin fish fishery to a major environmental event*, **Ann Penny**, Fishing and Fisheries Research Centre, James Cook University, Australia

C74

*Development of climate change projections for southeast Asia and Pacific islands*, **John McGregor**, CSIRO/Centre for Australian Weather and Climate Research, Australia

C75

## Climate extremes and disaster management (2 sessions)

Convened by Jean Palutikof (NCCARF, Australia), John Handmer (RMIT University, Australia), Reid Basher (UN International Strategy for Disaster Reduction)

### ORAL PRESENTATIONS - SESSION 1: DAY 3 (11:00AM-12:30PM) – PARALLEL SESSION 3.3.5 - THE DISASTER-ADAPTATION INTERFACE

*Livelihoods, vulnerability and disasters*, **Joshua Whittaker**, RMIT University, Australia

*Does 'drought' exist anymore in Australia? The challenge of adapting to a normalised climate extreme*, **Lauren Rickards**, University of Melbourne, Australia

*Adapting to climate change: development of an integrated decision support tool for disaster and evacuation planning in regional areas*, **Michael Taylor**, University of South Australia, Australia

*Climate Change Adaptation and Disaster Risks Reduction - A Continuum: Philippine Case*, **Rosa Perez**, Manila Observatory, Philippines

*Linking Disaster Risk Reduction and Climate Change Adaptation: Best practices of the Red Cross societies in delivering its assistance to support the flood prone areas in Indonesia*, **Febi Dwirahmadi**, International Federation of Red Cross Red Crescent Societies (IFRC), Indonesia

*The Role of Disaster Relief in Pacific Island Countries: A Cause of Increasing Vulnerability?*, **John Campbell**, Department of Geography, Tourism and Environmental Planning, University of Waikato, New Zealand

### ORAL PRESENTATIONS SESSION 2 – DAY 3 (1.30PM-3:00PM) – PARALLEL SESSION 3.4.5 - CHANGING EXTREMES AND ADAPTION

*Developing a typology of adaptive learning strategies within coastal institutions affected by extreme events related to climate change*, **Craig Stephenson**, Sustainability Research Centre, University of the Sunshine Coast, Australia

*Cyclone Tracy: A case study on adapting building regulations to minimise the impact of extreme wind events*, **Matthew Mason**, Risk Frontiers, Australia

*Institutional Factors in Climate Change Adaptation: The Example of Flood Risk Management in Cape Town's Informal Settlements, South Africa*, **Felix Olorunfemi**, Nigerian Institute of Social and Economic Research, Nigeria

*Vulnerability of and adaptation in energy systems to climate change and extreme events*, **Ferenc Toth**, IAEA, Austria

*Adaptive Capacity of a Flood Vulnerable Community in Rural Bangladesh*, **Ashish Sarker**, Environment Canada, Canada **(Presented by Monirul Mirza)**

*Linking institutional and agricultural adaptation to extreme dry conditions in the Canadian Prairies: The case of the South Saskatchewan River Basin*, **Monica Hadarits**, Canadian Plains Research Center, University of Regina, Canada

### POSTER PRESENTATIONS – DAY 2 (7:30AM-8:30AM) – POSTER SESSION 2.1

REF #

*Early Warning and Emergency Telecommunications Plan for Chittagong, Bangladesh*, **Iftekhar Ahmed**, RMIT University, Australia

B54

*Adaptation in the fires management sector, what role for bureaucratic networks and institutions?*  
**Karyn Bosomworth**, RMIT University, Australia

B55

*Flood Risk in Australia: A Review*, **Pamela Box**, Macquarie University, Australia

B56

*Critical review of resilience definitions in theory and practice: towards measurable definitions of resilience to disasters and climate change impacts*, **Riyanti Djalante**, Macquarie University, Australia

B57

*Linking Disaster Risk Reduction and Climate Change Adapatation in Indonesia*, **Riyanti Djalante**, Macquarie University, Australia

B58

*Community adaptation to heatwave: equitable policy responses to extreme weather in Victoria, Australia*, **Jess Fritze**, Victorian Council of Social Service, Australia

B59

POSTER PRESENTATIONS – DAY 2 (7:30AM-8:30AM) – POSTER SESSION 2.1	REF #
<i>From Disaster Management to Disaster Resilience: An Agenda for Change</i> , <b>Gary Mahon</b> , Department of Community Safety, Queensland, Australia	B60
<i>Proving the Adaptation Pudding: Prioritising Local Government Climate Change Investments</i> , <b>Supriya Mathew</b> , Macquarie University, Australia	B61
<i>Characterising tropical cyclone seasons and understanding past variations in cyclone activity</i> , <b>Kendal McGuffie</b> , University of Technology Sydney, Australia	B62
<i>Climate Adaptation within Risk- and Vulnerability Analyses in Swedish Municipalities</i> , <b>Karin Mossberg Sonnek</b> , FOI, Sweden	B63
<i>Transboundary Cooperation in the context of the Murray-Darling Basin</i> , <b>Jane Mullett</b> , RMIT University, Australia	B64
<i>Exposure of Settlements and Infrastructure for Climate Change Adaptation Research and Decision Making</i> , <b>Krishna Nadimpalli</b> , Geoscience Australia, Australia	B65
<i>Empowering communities to adapt fire management practices locally in a changing change</i> , <b>Waminda Parker</b> , Hotspots Fire Project (Nature Conservation Council of NSW), Australia	B66
<i>Opportunities for an Ecosystem-based Disaster Risk Reduction Framework: Lessons from a Doubly Exposed Coastal Social-ecological System in Orissa, India</i> , <b>Jyotiraj Patra</b> , Center for the Environment and Public Policy (CEPP), India	B67
<i>The Influence of Model Skill on Regional Projections of Extreme Temperatures over Australia</i> , <b>Sarah Perkins</b> , CSIRO Marine and Atmospheric Research, Australia	B68
<i>Estimating Design Floods For Gauged Urban Catchments Under Climate Change Conditions</i> , <b>P Rahman</b> , University of New South Wales, Australia	B69
<i>A Micro-Foundation of Direct and Indirect Damage of Extreme Weather</i> , <b>J. Micha Steinhäuser</b> , University of Oldenburg, Germany ( <b>Presented by Klaus Eisenack</b> )	B70
<i>Long-term persistence in future climate simulations: An investigation from a water resources management point of view</i> , <b>M Sugiyanto</b> , University of New South Wales, Australia	B71
<i>The Adaptive Capacity of urban coastal cities Vulnerable to Climate Change impacts: A case study of Social Networks from the 2008 disaster flood event in Mackay, Queensland, Australia</i> , <b>Melanie Thomas</b> , James Cook University, Australia	B72
<i>Enhancing Resilience to Coastal Hazards in Asia-Pacific: The Role of Early Warning Systems in linking Disaster Risk Reduction and Climate Change Adaptation</i> , <b>Natasha Udu-Gama</b> , Macquarie University, Australia	B73
<i>Reliability model for adaptation strategies for housing in cyclonic regions</i> , <b>Chi-Hsiang Wang</b> , CSIRO Sustainable Ecosystems, Australia	B74
<i>Using Value-at-Risk (VaR) to assess natural impacts on coastal Infrastructure under climate change scenarios</i> , <b>Kwok Yum</b> , CSIRO Sustainable Ecosystems, Australia	B75

## Thread 6 – Human welfare and adaptation

### Adaptation and the community (2 sessions)

Convened by Coleen Vogel (University of Witwatersrand, South Africa), Lisa Schipper (Stockholm Environment Institute, Sweden)

#### ORAL PRESENTATIONS – SESSION 1: DAY 1 (2:00PM-3:30PM) – PARALLEL SESSION 1.3.6

##### Session A: Theory and practice in community adaptation

###### Full presentations

*Guiding principles for good practice in adaptation to climate change – Results of a European survey with 250 adaptation experts*, **Torsten Grothmann**, Potsdam Institute for Climate Impact Research, Germany

*Impacts of climate change on coastal recreation and public safety*, **Norman Farmer**, Surf Life Saving Australia, Australia

*Adaptation to climate change: a longitudinal media study of an Australian rural community*, **Yasmin Van Kasteren**, CSIRO, Australia

*Processes of adaptation – lessons learned from three case studies of community-based adaptation in Limpopo province, South Africa*, **Florence Crick**, Griffith University, Australia

*Adaptation Challenges to Climate Change Disasters in the Karamoja Cluster (Cattle Corridor) in Uganda*, **Jamiat Nanteza**, Makerere University, Uganda

###### Panel: 3 minute presentations

*Policy processes, institutional systems, and adaptation*, **Stephen Dovers**, Fenner School, Australian National University, Australia

*A conceptual framework for understanding adaptive capacity to climate change*, **Alexandre Magnan**, IDDRI - Institute for Sustainable Development and International Relations, France

*Using science to articulate an uncertain future for strategic climate change decision-making*, **Douglas Bardsley**, University of Adelaide, Australia **(Presented by Susan Sweeney)**

*The Sustainable Livelihoods Approach: a useful conceptual framework for participatory community-driven processes for the identification of climate change impacts and community adaptation strategies*, **Julian Prior**, University of New England, Australia

*How to enable the public to participate more effectively in adaptation policy and practice*, **Paul Burton**, Griffith University, Australia

*Planning for climate change in New South Wales: do planning laws and climate change litigation hinder or help?*, **Nicole Rogers**, Southern Cross University, Australia

*Adaptation Decision Making in New Orleans: Wetland Assimilation Feasibility Planning*, **Sarah Mack**, Tierra Resources LLC, United States

#### ORAL PRESENTATIONS – SESSION 2: DAY 3 (11:00AM-12:30PM) – PARALLEL SESSION 3.3.6

##### Session B: Case studies of community adaptation

###### Full presentations

*Adaptation Strategies of Coffee Producers in Coatepec, Veracruz, Mexico to Climate Variability and Change*, **Cecilia Conde**, Centro de Ciencias de la Atmósfera, UNAM, Mexico

*Vulnerability and adaptive capacity to climate change of the guagua community in central Luzon, Philippines*, **Rogelio Cosio**, Pampanga Agricultural College, Philippines

*Rural livelihoods, vulnerability and adaptation to climate hazards: Reflections on a case study in Ningxia, Northwest China*, **Yue Li**, University of East Anglia, United Kingdom **(Presented by Declan Conway)**

*Extreme events preparedness planning in indigenous communities in Canada*, **Jeremy Pittman**, Saskatchewan Watershed Authority, Canada

###### Panel: 3 minute presentations

*Climate Change and Indigenous Peoples: Community Adaptation and Sustainability of Biocultural Diversity in Eastern Himalaya, Arunachal Pradesh*, **Dr. Ranjay K. Singh**, Central Soil Salinity Research Institute, India

*Climate change, an issue of the elites?: Rethinking adaptation through the eyes of the most vulnerable in Nepal*, **Philip Ireland**, Macquarie University, Australia

*The Louisiana United Houma Nation Case Study of Native American Adaptation and Mitigation*, **Ann Yoachim**, Tulane University; CBR, United States

*Adaptive Pathways for the Future: Indigenous Peoples, Traditional Knowledge and Climate Change*, **Kirsty Galloway-McLean**, United Nations University - Traditional Knowledge Initiative, Australia

*The forgotten islands: climate change in the Torres Strait*, **Donna Green**, UNSW, Australia

*Summary of a presentation of the work of HOPE in the area of community education on adaptation/mitigation to anthropogenic climate change*, **Frank Ondrus**, Householder's Options to Protect the Environment Inc, Australia

POSTER PRESENTATIONS – DAY 2 (5:45PM-7:00PM) – POSTER SESSION 2.6	REF #
<i>Resilience and Water Security in Two Australian Inland Towns, Kalgoorlie and Broken Hill,</i> <b>Helen Allison</b> , Murdoch University, Australia	C76
<i>Adaptation to climate change in communities affected by tropical glacier retreat in Bolivia,</i> <b>Juan Carlos Alurralde Tejada</b> , Agua Sustentable, Bolivia	C78
<i>Climate Change Adaptation: Sharing Experience of Coastal Bangladesh,</i> <b>Mehdi Azam</b> , Institute of Forest and Environmental Policy, Germany <b>(Presented by Tapan Sarker)</b>	C78
<i>Eyre Peninsula Climate Change Vulnerability Assessment,</i> <b>Jacqueline Balston</b> , Jacqueline Balston & Associates, Australia	C79
<i>Engaging agricultural stakeholders to discuss climate variability and change: lessons on participatory process design from the southeastern USA,</i> <b>Wendy-Lin Bartels</b> , University of Florida, United States	C80
<i>Climate Proofing Bribie and Coochiemudlo Islands, South East Qld: Moving beyond the ‘case study’,</i> <b>Susie Chapman</b> , SEQ Catchments Ltd, Australia	C81
<i>Building Climate Change Resilience and Adaptive Capacity in Australia’s Community Sector Using Social Media and Technology Innovation,</i> <b>Marcus Foth</b> , Queensland University of Technology, Australia	C82
<i>Informing the climate change adaptation challenge,</i> <b>Steve Hilly</b> , Australian Bureau of Statistics, Australia	C83
<i>Vulnerability assessment to Sea Level Rise- Arriving at a systems perspective through the Integration of quantitative and qualitative approaches,</i> <b>Vijai Joseph</b> , University of New South Wales, Australian Defence Force Academy, Australia	C84
<i>Adaptation and Limiting Factors: Issues and Perspectives from Grass Root Level in Tungabhadra Basin,</i> <b>Lenin Babu Kamepalli</b> , Institute for Social and Economic Change, India	C85
<i>Resilience, Vulnerability and Adaptive Capacity of an Inland Rural Town Prone to Flooding: A Climate Change Adaptation Case Study of Charleville, Queensland, Australia,</i> <b>Diane Keogh</b> , Australian Centre for Sustainable Catchments, University of Southern Queensland, Australia	C86
<i>Networked resilience – a role for Health Promotion in regional responses to climate change,</i> <b>Anne Kia</b> , North Coast Area Health Service, Australia	C87
<i>Assessing the impacts of climate variability and change on community projects; approach for local adaptation strategies,</i> <b>Pamela Levira</b> , University of the Sunshine Coast, Australia	C88
<i>Adaptation options for mining communities,</i> <b>Barton Loechel</b> , CSIRO, Australia	C89
<i>The drying of Lake Boga – what it tells us about community responses to climate change,</i> <b>Fiona McKenzie</b> , Department of Planning and Community Development Victoria, Australia	C90
<i>Adaptation Measures in Zapata face to climate change,</i> <b>Barbaro Moya</b> , Meteorological Center of Matanzas, Cuba	C91
<i>Bayesian Networks as a novel tool for identifying barriers to community-based adaptive capacity,</i> <b>Russell Richards</b> , Sustainability Research Centre, University of the Sunshine Coast, Australia	C92
<i>Socio-economic trends and implications for community based adaptive capacity,</i> <b>Anne Roiko</b> , University of the Sunshine Coast, Sustainability Research Centre, Australia	C93
<i>Climate Proofing the UNESCO-MAB Noosa Biosphere Reserve,</i> <b>Neil Tindale</b> , University of the Sunshine Coast, Australia	C94
<i>An Environmental Regulator Adapting To Climate Change - Journey so far for EPA Victoria,</i> <b>Barry Warwick</b> , EPA Victoria, Australia	C95

## Human security, social and equity issues

Convened by Neil Adger (University of East Anglia, UK), Karen O'Brien (University of Oslo, Norway)

### ORAL PRESENTATIONS – DAY 2 (11:00AM-12:30PM) - PARALLEL 2.3.6

*Adaptation and Development: Whose Goals and Priorities Count?* **Thomas Heyd**, University of Victoria, Canada  
(Presented by **Johanna Mustelin**)

*What people care about: focusing effort on highly effective adaptations*, **Timothy Lynam**, CSIRO, Australia

*Migration doesn't have to be a failure of adaptation. An escape from environmental determinism*, **Francois Gemenne**, Sciences Po Paris - Institute for Sustainable Development and International Relations (IDDRI), France

*Understanding social resilience to climate variability in primary enterprises and industries*, **Nadine Marshall**, CSIRO, Australia

*Small in a small island state: implications of climate change adaptation on human security in the Solomon Islands*, **Thomas Birk**, Department of Geography and Geology, University of Copenhagen, Denmark

*Will diversity assist adaptability? A case study contrasting diverse and specialized fishing sectors in the Queensland Inshore Fishery, Australia*, **Renae Tobin**, Fishing and Fisheries Research Centre, Australia

*The absolute homeless and increasing climate variability: insights from Waterloo Region, Canada*, **Johanna Wandel**, University of Waterloo, Canada

### POSTER PRESENTATIONS – DAY 2 (7:30AM-8:30AM) – POSTER SESSION 2.1

REF #

*Assessing the Destination Hubs: the Relocation Suitability Index*, **Anamaria Bukvic**, Virginia Tech, United States

B77

*The role of place attachment in understanding and managing community adaptation to climate change*, **Patrick Devine-Wright**, University of Exeter, United Kingdom

B78

*"Ground-truthing" adaptation research: a collective reflection on contextual adaptation issues*, **Carolina Roman**, Monash University, Australia

B79

*Securing the city in a climate-constrained future*, **Wendy Steele**, Griffith University, Australia

B80

*Four propositions for developing socially just adaptation to global change in Australian Indigenous communities*, **Siri Veland**, Macquarie University, Australia

B81

## Engineering and technology solutions for adaptation

Convened by Ron Cox (UNSW, Australia), Xiaoming Wang (CSIRO, Australia)

### ORAL PRESENTATIONS – DAY 2 (2:00-3:30PM) – PARALLEL SESSION 2.4.6

*Key barriers and potential solutions for developing climate change adaptation strategies for transport infrastructure*, **Adam Davis**, Manindis Roberts, Australia

*Why are Utilities Reluctant to Adapt to Climate Change? - A Survey in the German Energy and Transportation Sectors*, **Klaus Eisenack**, University of Oldenburg, Department of Economics and Statistics, Germany

*Water Pipe Failure Predictions under Different Climate Change Scenarios*, **Fanny Boulaire**, CSIRO, Australia  
(Presented by **Scott Gould**)

*Framework Models for Adaptation Strategies for Buildings*, **Stephanie Wake**, Australian Building Codes Board, Australia

*Deterioration of Concrete Structures under Changing Climate in Australian Coastal Cities*, **Xiaoming Wang**, CSIRO Climate Adaptation Flagship and CSIRO Sustainable Ecosystems, Australia

*Spatial Information Technologies for Climate Change Impact on Ecosystem: Detecting and Mapping Invasive Weeds in the Rio Grande River System, South Texas*, **Shobha Sriharan**, Virginia State



POSTER PRESENTATIONS – DAY 2 (7:30AM-8:30AM) – POSTER SESSION 2.1	REF #
<i>Using degradable polymer film to mitigate the impacts of climate variability and change on agricultural production</i> , <b>Shaun Lisson</b> , CSIRO, Australia	B82
<i>Climate Change Impact and Adaptation on Concrete Infrastructure Deterioration</i> , <b>Mark Stewart</b> , University of Newcastle, Australia	B83
<i>Regional Assessment of Coastal Inundation in Southeast Queensland under Changing Climate</i> , <b>Xiaoming Wang</b> , CSIRO Climate Adaptation Flagship and CSIRO Sustainable Ecosystems, Australia	B84
<i>Spatial risk-based assessments of impacts and adaptation: a case study of domestic water harvesting systems in Queensland using the SimCLIM modelling system</i> , <b>Richard Warrick</b> , University of the Sunshine Coast, Australia	B85
<i>IC Tag Sensing Technology Used for Climate-Change Adaptation Strategies</i> , <b>Kazuya Yasuhara</b> , Ibaraki University, Japan	B86

### Public health adaptation to climate variability and change

Convened by Tony McMichael (ANU, Australia), Kristie Ebi (Working Group II Technical Support Unit)

### ORAL PRESENTATIONS – DAY 3 (2:00PM-3:30PM) – PARALLEL SESSION 3.4.6

<i>Adaptation to extreme heat in Australian cities</i> , <b>Matthew Beaty</b> , CSIRO Climate Adaptation National Research Flagship, Australia
<i>Victorian Adaptation Responses to Climate Change and Human Health</i> , <b>Julie Hoy</b> , Victorian Department of Health, Australia
<i>Climate change and extreme weather events: Adaptation to protect the health of our protection workforce</i> , <b>Liz Hanna</b> , NCEPH Australian National University, Australia
<i>Climate Change Environmental Health Indicators: devising a tool to measure and monitor human health vulnerability and the effectiveness of interventions for climate variability and change</i> , <b>Tammy Hambling</b> , Institute of Environmental Science and Research, New Zealand
<i>The value of improved weather forecasts and socioeconomic information for preventing meningitis outbreaks in sub-Saharan Africa--A decision analytic tool to allocate meningitis vaccine in the face of uncertainty</i> , <b>Jennie Rice</b> , Pacific Northwest National Laboratory, United States
<i>Hop, skip and...: Moving beyond the analytical drivers of public health related climate change adaptation to explore the impact of knowledge, culture and risk perception</i> , <b>Ursula King</b> , Australian National University, Australia
<i>Climate change and human health in the Northern Territory: The road to adaptation</i> , <b>James Smith</b> , NT Department of Health and Families, Australia

### POSTER PRESENTATIONS – DAY 3 (7:30AM-8:30AM) – POSTER SESSION 3.1

	REF #
<i>A PhD Thesis Proposal: Statistical modelling of malaria incidence cases in Ghana</i> , <b>Simon Appiah</b> , School of Engineering, Edith Cowan University, Australia	D56
<i>Identifying key health adaptation opportunities in greater western Sydney</i> , <b>Hilary Bambrick</b> , School of Medicine, University of Western Sydney, Australia	D57
<i>Resilience and vulnerability among older Australians: Adaptive responses to heat</i> , <b>Hilary Bambrick</b> , School of Medicine, University of Western Sydney Australia	D58
<i>Impact of climate change and socio-environmental factors on dengue transmission in the Asia-pacific region</i> , <b>Shahera Banu</b> , School of Public Health, QUT, Australia	D59
<i>Climate and child health in rural areas of low and middle income countries: a review of the epidemiological evidence</i> , <b>Angela Baschieri</b> , Ishtm, United Kingdom	D60
<i>Mosquitoes and Climate Change in Australasia</i> , <b>Nigel Beebe</b> , University of Queensland & CSIRO Entomology, Australia	D61
<i>The best heat wave index for local climate adaptation: associations between measures of temperature and mortality in Victoria, Australia, 1990-2000</i> , <b>Charmian Bennett</b> , The Australian National University, Australia	D62
<i>The association between meteorological factors and hospital visits of allergic patients with sensitization to tree pollen</i> , <b>Si Heon Kim</b> , Department of Preventive Medicine and Public Health, Ajou University, South Korea	D63

POSTER PRESENTATIONS – DAY 3 (7:30AM-8:30AM) – POSTER SESSION 3.1	REF #
<i>Assessment of constraints and barriers to public health adaptation to climate change</i> , <b>Cunrui Huang</b> , School of Public Health & Institute of Health and Biomedical Innovation, Queensland University of Technology, Australia	D64
<i>The role of parks and nature in human health during a time of climate change</i> , <b>Peter Livitsanis</b> , Parks Victoria, Australia	D65
<i>Tailoring mental health promotion in rural and remote areas in the context of climate change: a non-government organisation perspective</i> , <b>Alexandra McEwan</b> , Centre for Rural and Remote Mental Health Queensland, Australia <b>(Presented by Jennifer Bowers and Tim Saal)</b>	D66
<i>Climate, public space and public health: the influence of heat on people’s use of public space and implications for public health – a Western Sydney case study</i> , <b>Louise McKenzie</b> , Faculty of the Built Environment, University of New South Wales, Australia	D67
<i>Enhancing cooperation between the health and climate sectors for adaptation to climate change</i> , <b>Clive Mutunga</b> , Population Action International, United States <b>(Presented by Karen Hardee)</b>	D68
<i>Causes of Death and Demographic Characteristics of Victims of Meteorological Disasters in Korea, 1990-2008</i> , <b>Hyung-Nam Myungh</b> , Department of Preventive Medicine and Public Health, Ajou University, South Korea	D69
<i>The unfolding story of heatwaves in Adelaide</i> , <b>Monika Nitschke</b> , Department of Health, Australia	D70
<i>Health sector challenges to climatic variability and change: A case study of the South East Queensland, Australia</i> , <b>Redwan Rahman</b> , Griffith University, Australia	D71
<i>Heat Stress, Urban Health and Labour Productivity: Adaptation Strategy for a megacity in India</i> , <b>Joyashee Roy</b> , Global Change Programme-Jadavpur University, India	D72
<i>Impact of High Temperatures on Emergency Admissions in 6 Cities of Korea</i> , <b>Jo Soo-Nam</b> , Department of Preventive Medicine & Public Health, South Korea	D73
<i>Scoping of Climate Change Impacts on Human Health and Vulnerable Populations</i> , <b>Robert Turk</b> , Arup, Australia	D74
<i>Climate Change and Primary Health Care Intervention Framework</i> , <b>Rae Walker</b> , La Trobe University, Australia	D75

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## Heading for the walls: rising sea and declining options in South East Queensland

N Abel<sup>1</sup>, R Gorddard<sup>1</sup> and B Harman<sup>1</sup>

<sup>1</sup> CSIRO

A sea level rise of up to a metre or more around Australia by 2100 is plausible, and the frequency and intensity of storms may increase. Almost 9000 residential buildings are already estimated by the Department of Climate Change and Energy Efficiency to be within 110 m of erodible shore in South East Queensland (SEQ).

The draft Queensland Coastal Plan, and draft SEQ Climate Change Management Plan seek to protect people and property from the hazards of sea level rise and storm surges. The plans aim to maintain natural physical coastal processes, preserve areas of high ecological significance, conserve terrestrial, wetland and marine ecological values, preserve coastal scenery, and enhance public coastal access. This is in tune with international shifts in policy away from costly built defences and towards the maintenance of natural processes for their ecological and recreational values, the defence they provide against storm surges, and their adaptability to changing sea levels. However, Federal and State governments favour population increase. If population growth in Queensland increases along with climatic change, the future adaptability of the coast will depend on precluding or removing development from low lying land to provide space for the future spread of dunes, beaches and wetland vegetation as the sea rises.

An array of problems make it difficult for the coastal and regional planning system to implement the aspirations of the Queensland Coastal Plan and the SEQ Climate Change Management Plan. The net private benefits from houses on low-lying sites at the coast are realisable now, but the net social benefits of excluding it are in the future, so State and local governments are pressured by public demand and development lobbyists to increase the area zoned for urban development. The planning minister can and does rezone undeveloped land to allow urban development against the objections of councils, and against the population policies of some councils. The local government development approval process meanwhile allows incremental occupation of land that could be set aside for sea level rise because: 1.) biophysical thresholds of potential concern (e.g. the balance between erosion and deposition of sand) are not specified in Local Government Planning Schemes, so each approval is unrelated to changes in proximity to thresholds; 2.) councils that refuse technically valid development applications can be taken to court by applicants; and 3.) councils can be liable for the consequent decrease in property values if they re-zone land, even if risks to properties have increased.

Different sections of the Queensland coast are at different stages of development, the less urbanised having more intact coastal ecosystems, therefore more options and greater adaptability, but the trend is towards declining options and adaptability as incremental development proceeds. As the number of people living in vulnerable places increases, and the value of property there grows, so governments will be increasingly likely to succumb to political pressure and build defences against storm surges regardless of the net public benefit of doing so. If land is not set aside for colonisation by coastal ecosystems in anticipation of sea level rise, therefore, built defences will become the dominant strategy.

We propose that measures to enable the regional and coastal planning system to respond pro-actively to sea level rise should:

1. allow for irreducible uncertainties including rates and amounts of sea level rise, storm intensity, erosion rates and population changes e.g. property rights, development approvals, zoning could be linked to pre-specified sea level heights;
2. redistribute the benefits, costs, risks and uncertainties of coastal development, residence and governance. Measures that place the risks on the property owner or developer would clarify uncertainties about the responsibilities of local and State governments and reduce the attractiveness of lower lying land;
3. be developed in consultation with the banking and insurance industries. Banks will be reluctant to provide mortgages for properties that will be at risk during the repayment period. High insurance costs or refusal of cover would be a significant disincentive for coastal development, not least because banks would become less willing to provide mortgages for properties at risk;
4. operate as negative feedbacks, so that the closer the system approaches an unwanted threshold, the stronger the feedback becomes e.g. zoning that changes with sea level.

## Study of Climate Change Impacts on the Agriculture Production System in Rasuwa District: Case Study of Ramche and Bhorle VDCs

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<sup>1</sup>Resource Identification and Management Society Nepal (RIMS-Nepal)

Climate induced disaster is one of the major issues in Rasuwa district. WWF Nepal has initiated a pilot project on promoting climate resilience of communities residing in Ramche and Bhorle village Development committees (VDCs) of Rasuwa district. The major interventions are targeted at exploring impact of climate change on agriculture; piloting some innovative agriculture practices for enhancing adaptive capacity and building resilience of communities. A study was carried out by RIMS-Nepal to assess climate change impacts on agriculture and livelihoods options; and to identify adaptation measures in reducing peoples' vulnerability in those VDCs. The assessment used "impacts, vulnerability and adaptation matrix" in assessing the climate change vulnerability context, types of agriculture assets affected, total impacts, types of agriculture system and assets available to cope with impacts and total capacity to cope. Participatory tools like historical timeline, hazard mapping, vulnerability mapping, and focus group discussion were used for the study taking into account gender,



age, social position and income. In addition, total 30 household interviews (15 each in studied VDC) were conducted. The findings suggest that agriculture is one of the most impacted sectors in the study sites. Climate induced risk and hazards (landslide, drought, pest, diseases and hailstone) have tremendous impact on the livelihoods of communities in both VDCs. Those impacts have caused considerable destruction to agriculture, forest and pasturelands. Landslides have washed away productive landscape ruining and degrading the landscapes; damaged hundreds of houses, livestock, and animal sheds; destroyed thousands of hectares of crop fields; and dismantled traditional terrace farming in the study areas. Similarly, drought has impacted crop yield negatively and brought about water stress. With changing climate locals have experienced spread of invasive species and emergence of new pest and diseases. Farmers have been forced to switch to new but high cost hybrid varieties and new input based intensive farming. This has added economic burden to sustain their livelihoods. The drought and landslides have increased vulnerability of more than 65% of communities who produce food for less than six months with decline in food production. Thus these VDCs are facing acute shortage of food and water leading to malnutrition and outbreak of diseases aftermath of stress and shocks. The coping and adaptation strategies are not sufficient to deal with the severity of impact. Communities and project team jointly analyzed the agriculture magnitude of impact and identified adaptation measures. The group recommended the practices to save seeds, shift to organic and conservation agriculture, use of appropriate local species to tolerate environment stresses and capacity building.

## **Transitions Town Websites: technologies of communication and power relations**

**S Adams<sup>1</sup>, C Corpé<sup>1</sup> and J Matthews<sup>1</sup>**

<sup>1</sup>Sustainability Research Centre, University of the Sunshine Coast, Australia

Societies are coordinating efforts across multiple scales – international, national, regional, community, and individual – to adapt to the changes precipitated by climate change and large-scale problems like peak oil, pollution, and food and water security.

High-level initiatives set targets, enact legislation, and establish frameworks for action, and are led by governments and supra-national organizations such as the United Nations. Regional and community initiatives inform and/or develop policy and legislation, and translate policies into actions that encourage (and/or compel) governments, businesses, communities and individuals to modify behavior. The challenges facing societies are heavily entwined in their economic, social and cultural fabric, and require a holistic approach.

The 'Transition Towns' initiative is a grassroots movement that espouses a holistic adaptation strategy to address the changes arising from climate change and peak oil. This initiative considers the key areas of a community - food, energy, transport, health, and economics - and aims to inform and engage motivated individuals and small groups to develop creative solutions to building sustainable communities. Conceived in 2005, Transition Towns have spread throughout the United Kingdom and into twelve countries by word of mouth, traditional media, and the Internet.

Websites can be an effective and low-cost way for individuals, groups, businesses and governments to provide information to global audiences 24 hours a day, 7 days a week. Web-based communication has evolved rapidly as the Internet has grown in sophistication and importance, and now supports interactivity and user-generated content through blogs, wikis, established and viral media, file sharing, and social networking applications. The proliferation of inexpensive web design and publishing tools means the cost of 'getting on the web' is relatively low compared to traditional media like newspapers or television.

However, it is no longer sufficient to have a simple website that displays static information. Instead, organizations strive to create a web presence that engages people, and motivates them to participate in the organization's activities, whether commercial, recreational, social, and/or political. While visual design is important, usability, content quality, and interactivity are important factors in successfully establishing and maintaining a web presence.

The main TransitionTowns.org website provides information such as guiding principles for community groups, criteria for becoming a transition town, and a registry of transition towns. As of 4 February 2010, there are 277 officially registered transition towns. Twenty-eight are in Australia, the third largest concentration of Transition Towns after the United Kingdom and the United States.

While the main website acts as a hub, each Town's website is designed and maintained separately by individuals or community organizations, creating a highly distributed web presence. This poster presents an evaluation of the Transition Towns web presence and highlights successes and challenges in the initiative's web-based communications. The analysis uses a stratified sample of websites drawn from the Transition Towns registry, and evaluates the appearance and function using criteria drawn from best practices in web communications. Informed by Foucauldian analysis the poster identifies discourses and power dynamics relating to jurisdictional and organizational overlap, resourcing, credibility and legitimacy.

## **Species distribution modelling for climate change adaptation: a koala case study**

**C Adams-Hosking<sup>1</sup>, PT Moss<sup>1</sup>, R Rhodes<sup>1,2</sup>, HS Grantham<sup>2</sup> and C McAlpine<sup>1,2</sup>**

<sup>1</sup> Centre for Spatial Environmental Research, School of Geography, Planning, and Environmental Management, The University of Queensland Australia.

<sup>2</sup> The Ecology Centre, The University of Queensland, Australia.

It is well recognized that planning for the conservation of species and biodiversity requires a systematic approach if optimal management strategies are to be identified. The synergistic anthropogenic impacts of habitat loss and fragmentation and climate change now threaten many species and assessing how a species may adapt to these threats through the identification of future suitable habitats is essential.

Australia's endemic folivorous marsupial, the koala (*Phascolarctos cinereus*), is a wide-ranging species whose diet is solely dependent on specific species of Eucalyptus, Corymbia and Angophora trees. Koalas are threatened by ongoing land clearing and urbanisation and a changing climate, in particular more days of drought and extreme heat. This is leading to population declines and climate-driven contractions from their western range limit in the two stronghold Australian states for this species, Queensland and New South Wales. On the Koala Coast in southeast Queensland where rapid urban expansion is occurring, the koala population has declined by 51% in less than three years.

Species distribution modelling is a predictive tool that has become an essential component of biodiversity conservation and management. We developed a climate envelope model using Bioclim and then predicted current and future koala distributions using Biomap, based on known koala locality records and future CSIRO climate change projections. We also conducted a sensitivity analysis to assess changes in these predictions in response to increases in temperature and decreases in rainfall. We then used maximum entropy modelling (Maxent) to characterize the probability distributions of koalas in Queensland currently and under future climate change projections. In addition to climatic parameters, we incorporated biologically meaningful environmental variables such as eucalypt vegetation, soil and elevation. Finally, using our Maxent models as raw habitat layers we implemented Zonation, a reserve selection framework for large-scale conservation planning, to develop a network of priority koala conservation areas in Queensland.

Both Bioclim and Maxent indicated a significant eastward contraction in the koala's western range limit in Queensland and New South Wales with increasing warming and decreasing rainfall and both models indicated that koalas are most sensitive to temperature.

Proactive systematic conservation planning that implements decision support tools such as those we have demonstrated in this koala study, will assist in facilitating the adaptation of species to future climate change. The results of this koala case study suggest that national and regional koala conservation policies urgently need to address future climatic threats and develop strategies that aim to reduce the contemporary land use pressures on extant koala populations and help buffer against the projected impacts of climate change.

## Reconciling Climate Resilience and Sustainable Urban Development: Perspectives from Vietnam

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As a consequence of being coastal and low-lying, Vietnam has historically had to develop coping and recovery mechanisms for a range of climate-related extreme events - especially floods and wind storms. However, the country has also recently been highlighted by the IPCC as one of the countries most at risk from future climate change impacts, with the predicted increase in sea level of particular concern. Estimates suggest that 43% of the land area of Ho Chi Minh City (HCMC), the largest city in Vietnam, would be inundated with a rise of 1 meter. Such an impact, combined with an increase in the frequency and intensity of extreme weather events, would undoubtedly have devastating and wide-ranging social and economic consequences. The challenges facing urban areas are further exacerbated by the presence of other stressors. In the Vietnamese context, economic reform in the late 1980s has led to rapid urbanisation and unintended outcomes such as the migration of urban poor into marginal land; often these 'informal' settlements are established near waterways directly increasing exposure to floods. Risks are further compounded by a lack of adequate drainage which causes localised water-logging and as a consequence disruptive impacts to the local economy, enterprises and livelihoods.

Responding to these complex and interlinked issues, this paper analyses the potential role of strategic urban planning to reconcile climate resilience and sustainable urban development for the two largest cities in Vietnam, Hanoi and HCMC. Framed by an institutional perspective, the paper will provide a critical analysis of how current day planning structures and processes are responding to the combined challenges of rapid urbanisation, sustainable development and weather-related extreme events. As such, the paper will progress discussion beyond merely considering the physical impacts of climate change to attempt to better understand the social implications of a range of multiple stressors influencing future risk and adaptation, as well as the barriers and opportunities facing those responsible for managing the development of the urban system. For instance, urban planning is currently developed under the direction of three main types of national level plans, though are criticised for lack of coordination between implementing bodies as well as overlap in scope of the plans. Furthermore, the planning mechanisms also tend to focus on more immediate environmental management problems, with agencies grappling with existing problems arising from the pace of urban growth as represented by traffic, waste, pollution, uncontrolled informal growth, etc. Of particular significance is the widespread proliferation of informal settlements - not only a key challenge for the planning community, but also acutely vulnerable to the impacts of a changing climate.

However, despite these constraints, the authors will argue that there is also potential to inform urban planning in Vietnam's cities as they look to the future through the development of strategic frameworks that explicitly address climate resilience and sustainable urban development. Vietnam has the advantage of being a late-comer to adaptation and is therefore able to learn from the experience of others, opening up the possibility to leapfrog into a sustainable paradigm and avoiding the worst mistakes of Western development. This paper concludes with a set of recommendations that can guide the development of a strategic urban planning framework that positions urban development in Vietnam on a sustainable track and takes in account future climate change risks.

## Early Warning and Emergency Telecommunications Plan for Chittagong, Bangladesh

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Bangladesh is among the countries most seriously at risk from climate change impacts, with its coastal areas particularly vulnerable. Climate change induced hydro-meteorological hazards such as cyclones and floods as well as secondary hazards such as rain-induced landslides are expected to increase in frequency, intensity and extent of impact. Therefore developing a robust early warning system (EWS) should be a priority climate change adaptation strategy. This paper focuses on that concern based on the case study of Chittagong, which could be a model for wider replication in other coastal areas within the country and elsewhere. Chittagong is an important region and Chittagong city is the second largest city in Bangladesh. It has many commercial and industrial facilities associated with its seaport. Chittagong's coastal and estuarine location in a context of rapid urbanisation represents a multi-hazard context. Located in a cyclone risk zone Chittagong is frequently affected by cyclonic storms and storm surges. Efforts after the devastating 1991 Cyclone have reduced risk to some extent, but many coastal communities still remain vulnerable. Urban flood and water-logging is a serious hazard in Chittagong city and recently caused great damage. There is no national or local flood EWS for Chittagong. Landslide is another serious hazard in the hilly terrain of Chittagong, aggravated by densification of human settlements. Landslide events combined with urban flood cause great devastation. Chittagong also faces earthquake and tsunami risk. Present technology does not allow early warning of earthquake; a tsunami EWS has been developed, but perception of tsunami risk is generally low. Despite a variety of hazards in Chittagong, the only EWS is for cyclone and the challenge remains in developing a multi-hazard EWS backed by emergency telecommunications for this important national region.

The paper draws on a detailed report prepared for the International Telecommunications Union. Key national and city level institutions, NGOs and at-risk communities were identified and their EWS networks were mapped. Preparation of an institutional map and tracing on it existing and potential links between the main EWS and telecommunications institutions, organizations and stakeholders allowed developing a master network for EWS and emergency telecommunications planning. The master network allowed formulating summary Standard Operating Procedures (SOPs) and equipment requirements corresponding to the identified links, a possible basis for development of a national EWS and emergency telecommunication plan with detailed SOPs relevant to individual institutions and fitting into the overall plan. Development of the proposed improvement framework reveals that although in Bangladesh there is an institutional structure in place for disaster management, early warning and emergency telecommunications, it requires strengthening and improvement. For Chittagong, it is necessary to develop a local end-to-end multi-hazard EWS, which has to be linked to the national network. Institution-community relationship remains a challenging area offering possibility of improvement by supporting local networks. The paper concludes with a set of recommendations to institutionalise a nation-wide end-to-end multi-hazard EWS and emergency telecommunications plan based on the Chittagong case study.

## Management of coastal environment and sustaining its resource-dependent communities: options for coastal communities in Nigeria

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Large-scale degradation has occurred in South west Nigeria, especially the Niger Delta area as a result of past unsuccessful land use policies and land-use decree and traditional land-title deeds. Resource utilization has been based on a policy that restricts the access of local communities to the forests except with permits. People generally had to illegally enter the forest for farming, wood collection, grazing and charcoal burning.

The land system, including freshwater, is a critical land component within the earth system. Both terrestrial and aquatic land ecosystem provide a multiplicity of ecosystem services. Intensification and diversification of land use and advances in technology have led to rapid changes in landscape dynamics. Nigeria, the most populous country in Africa, is a maritime country, with most of the oil and gas resources coming from the coastal areas. Our coasts are important and present an opportunity to make a greater contribution to our well-being and to benefit from the protection of critical marine environments. This has not being the case over the years. Area-based planning has been a popular and important coastal management especially in the developed countries, being used to address persistent conflicts over land and water use, declines in water quality, protection of habitat and endangered species and the accommodation of ever-growing human population. Today the scenario is more precarious courtesy the impulse of global climate change phenomenon. The coastal area can be a potential zone for increasing crop and fish production through better management of land and water resources. Climate change is projected to impact broadly across ecosystems, societies and economies, increasing pressure on all livelihoods and food supplies, including those in the fisheries and aquaculture sector. Food quality will have a more pivotal role as food resources come under greater pressure, and the availability and access to fish supplies will become an increasingly critical development issue.

This paper examines the three primary determinants of use patterns in coastal zone areas in Nigeria: environmental factors, social factors and economic factors. Evaluating the degree to which conflict exists and the impact of such on the environment formed the research questions of this paper. The study analysed the multiple use problems such as fisheries, crop farming, oil and gas production and tourism, and proposed a management approach that will integrate comprehensive climate risk management into development planning, programs, and projects in the coastal zone of Nigeria.

## Impacts of climate on water-use and water-use efficiency of woodlands in the Sudanese Sahel region: a modelling study

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The Sahel belt of Africa has been identified as a “hot spot” of global environmental change. However, the response of this semi-arid region to climate change, particularly in relation to woodland vegetation cover and water-use, remains unclear. Climate change could cause major ecological disruption and conflict in the region. We have modelled the impact of various climate change and emission scenarios on the water-use and water-use efficiency of woodlands across the Sudanese Sahel region for the 2080s.

Modelled monthly mean scenarios of climate variables (temperature, precipitation and cloud cover) for the period 2070–2099 were derived using five GCMs (CGCM2, CISRO2, ECHam4, HadCM3 and PCM) run with A1FI (greatest climate forcing caused by fossil fuel usage) and B1 (least climate forcing caused by fossil fuel usage) SERS emission scenarios. The climate data were generated for nine grids (1.0° latitude x 1.5° longitude), covering 11.5–17.5 °N by 24–36 °E, were selected so as to cover the current climate conditions of Sudanese Sahel region. Climate data from TYN SC 2.0 dataset were extracted. Baseline (1961–1990) observed monthly mean values of same climate variables were extracted from the CRU TS 2.1 dataset. The climate data were calculated as the average of the resulting six TYN/CRU grids per study grid. A simple water balance model, WATBAL, was parameterized for woodland vegetation and two soil types, arenosols (AR) and vertisols (VR) using HWSO soil data, to give monthly water-use (ETc\_adj) values for the baseline data and each climate change scenario dataset. Water-use efficiency (WUE, g C m<sup>-2</sup> mm<sup>-1</sup>) for each study grid was calculated as mean above-ground biomass C density (g C m<sup>-2</sup>) divided by ETc\_adj (mm).

Grid baseline annual rainfall ranged from 5 to 55 mm and temperature from 23.3 to 29.2 °C. Mean annual air temperature increased under all 10 climate change and SERS scenarios and for all nine grids (+1.2 to +8.3 °C), while rainfall either increased (+1 to +30 mm) or decreased (-1 to -16 mm), depending on scenario and study grid. Grid baseline ETc\_adj varied from 56 to 595 mm and WUE from 0.106 to 0.462 g C m<sup>-2</sup> mm<sup>-1</sup>, depending on grid and soil type. Compared to AR soils, VR soils had equal or greater water-use and equal or less WUE. Depending on climate change scenario and grid, the relative water-use (scenario/baseline) of woodlands varied from 0.54 to 6.79 for VR soils and from 0.61 to 4.33 for AR soils while that of WUE varied from 0.50 to 2.44 for VR soils and from 0.46 to 2.22 for AR soils. The largest relative changes in water-use were associated with the drier grids. WUE decreased for the drier grids, but either decreased or increased for the wetter grids, depending on SRES.

Our results indicate that the water-use in the Sahel region will strongly depend on the degree and nature of climate change and adaptation of woodlands.

## CO<sub>2</sub>/ heat fluxes in rice fields: Comparative assessment of flooded and non-flooded fields in the Philippines

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The microclimates and seasonal fluxes of heat, moisture and CO<sub>2</sub> were investigated under two different rice environments: flooded and aerobic soil conditions, using the eddy covariance technique during 2008 dry season. The fluxes were correlated with the microclimate prevalent in each location. This study was intended to monitor the environmental impact, in terms of C budget and heat exchange, of shifting from lowland rice production to aerobic rice cultivation as an alternative to maintain crop productivity under water scarcity.

The declining availability and increasing costs of water threaten the traditional way of growing rice under irrigated conditions. Therefore, several water-saving techniques are currently developed to lower the water requirements of the rice crop. One of the promising water-saving technologies comprises shifting from lowland rice production to aerobic rice cultivation. However, large uncertainties exist in predicting the outcomes of these changes with regard to soil health, long-term sustainability and environmental impacts of rice production systems.

Results from 2008 dry season investigation showed that in the aerobic rice field, the mean air temperature in the canopy was about 1% higher while the relative humidity and vapor pressure were about 3.9% and 2.6%, respectively, lower than in the flooded rice field. This accounted for about 15.6% higher vapor pressure deficit in the aerobic rice field over the growing season.

Likewise, the aerobic rice fields had higher sensible heat flux (H) and lower latent heat flux (LE) compared to flooded fields. On seasonal average, aerobic rice fields had 48% more sensible heat flux while flooded rice fields had 20% more latent heat flux. Consequently, the aerobic rice fields had significantly higher Bowen ratio (0.25) than flooded fields (0.14), indicating that a larger proportion of the available net radiation was used for sensible heat transfer or for warming the surrounding air.

The total C budget integrated over the cropping period (113 days) showed that the net ecosystem CO<sub>2</sub> exchange (NEE) in flooded rice fields was about three times higher than in aerobic fields while gross primary production (GPP) and ecosystem respiration (Re) were 1.5 and 1.2 times higher, respectively. The high GPP of flooded rice ecosystem was very evident because the photosynthetic capacity of lowland rice is naturally large and it is free from environmental stresses from dry air and soil. The Re of flooded rice fields was also relatively high because it was enhanced by the high photosynthetic activities of lowland rice as manifested by larger above-ground plant biomass. The NEE, GPP, and Re values for flooded rice fields were -258, 778, and 521 gC m<sup>-2</sup> respectively. For aerobic rice fields, values were -85, 515, and 430 gC m<sup>-2</sup> for NEE, GPP, and Re, respectively. The ratio of Re/GPP in flooded fields was 0.67 while it was 0.83 for aerobic rice fields.

The results of this investigation will contribute to a thorough evaluation of alternative water-saving technologies by providing a unique opportunity to understand their environmental impact in terms of C budget and heat exchanges in different rice production systems.

## GrassGro indicates that erosion risk drives adaptation of southern tablelands grazing farms to projected climate change

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The extent of future climate change cannot be directly measured using conventional observational research methods. Rather the current understanding of climate systems must be embodied in mathematical models in order to project forward on the basis of known trends in climate forcings. Similarly it is impossible to test in the field the impact of climate change on the productivity of grazing systems at a farm scale without also using appropriate pasture growth and grazing systems models. To date impact assessments of climate change on grazing farms have been limited to either specific statements about components of the system or generic interpretations of production trends and associated risks without seeking to quantify the full impact at a farm scale.

The GrassGro grazing system simulation model was used to quantify the impact of climate change on two specific grazing systems located at Bookham and Goulburn on the southern tablelands of NSW. GrassGro uses daily time step weather data as input to a soil water budget and pasture growth model in concert with a grazing animal model. Modelled pasture growth is responsive to atmospheric CO<sub>2</sub> concentration. In order to determine the impact of climate change the grazing systems were simulated for the historical weather data from 1970 to 2000 and compared with a simulation of the same system using projected daily weather for thirty years centred on 2030. The projected daily weather data were generated using a novel technique that used comparisons of average projected and historical outputs for a range of Global Circulation Models (GCMs) to estimate the basic parameters of a stochastic weather generator.

Results for the localities studied show that although there was considerable variation between the GCMs, growing season lengths were consistently shorter with the greatest truncation occurring in autumn. Winter pasture growth was enhanced by higher temperatures. Overall these changes in feed supply led to considerable reductions in carrying capacity and profit per hectare. This impact was largely driven by the inability of the system to maintain target ground cover at present-day stocking rates.

Three SRES emissions scenarios were tested (A1B, A2 and B1). For 2030, there was little difference between scenarios in the impact on the grazing system. The seven years from 2001 to 2007 were also simulated, and it was found that several of these years are analogous to the worst years in the projected 2030 climate. Climate projections suggest, however, that severe drought years such as 2004 may become more frequent with less likelihood of a sequence of higher rainfall years to aid in recovery between them.

## Resilience and Water Security in Two Australian Inland Towns, Kalgoorlie and Broken Hill

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The concept of resilience is now appearing in policy documents as a normative goal. Resilience as we refer to it means the capacity of a social-ecological system both to withstand perturbations from for instance climate or economic shocks and to rebuild and renew itself afterwards. Loss of resilience can cause loss of valuable ecosystem services, and may even lead to rapid transitions or shifts into qualitatively different situations and configurations, evident in, for instance people, ecosystems, knowledge systems, or whole cultures. It is, however, an emergent property, one that is not easily measured. Recent attention has increasingly focussed on the likelihood that environmental and social shocks will push some regional systems, but not others, beyond their historical bounds. We suggest that some regions are pre-adapted to absorbing these shocks and will continue to be resilient while others will succumb either to disasters or gradual deterioration. Australia is already experiencing the impacts of climate change with communities facing increasing frequency and severity of weather events (drought, dust storms, fires and flood). Our research addresses four areas of research priority for Australia, understanding risk, community and organisational resilience, adaptive strategies and regional implications.

We have developed a Resilient Regional Assessment Process (RRAP) to discover the common issues that foster or create resilience and alternatively those issues that create barriers and perverse resilience in a number of case studies across Australia. Using the RRAP we examine the existing levels of risk awareness and felt levels of resilience in the face of unfolding knowledge of the risks to infrastructure and human safety. The risks and threats include climate change, water security and land use change.

We demonstrate the usefulness of the RRAP by exploring the adaptive capacity of two regional inland towns facing different challenges relating to climate change and water supply on opposite sides of the Australian continent, Kalgoorlie in Western Australia and Broken Hill in New South Wales. Each has a rich history based on mineral resources and a developing tourist industry. However, they face different resilience problems. Kalgoorlie is reliant on transported surface water through a 560km long pipeline from a dam situated in a coastal catchment near Perth. Kalgoorlie has no alternative water source other than a possible desalination plant and another pipeline from Esperance 350 km on the south coast of Western Australia. The Perth water catchment is under intense pressure with desalination already supplementing declining rainfall and aquifer extraction. On the other hand, Broken Hill has a much diminished mining industry but a strong social base and a new economy as an 'outback' tourism destination. With ongoing requirements for potable water Broken Hill is, however, totally reliant on limited local ground water supply or a possible desalination plant 350 km away on the coast of South Australia. Without a full understanding of the likely impacts of climate change, extreme variability and the increased technical difficulties and economic costs of providing potable water in remote communities, the future resilience of Kalgoorlie and Broken Hill is not secure. Regional resilience under severe economic, demographic and environmental pressures is a nationally important issue. As a consequence, the resilience of Australia's largest inland cities is under threat. The RRAP is shown to be new way to assess resilience at a regional scale and a vital new methodological tool in planning and management.

## **Adaptation to climate change in communities affected by tropical glacier retreat in Bolivia**

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By 2008 supported by DANIDA, Agua Sustentable began developing a strategy to adapt to Climate Change from the needs of indigenous communities in the basin of Palca (municipality of La Paz city).

High exposure to climatic events and their limited adaptive capacity makes this population highly vulnerable to climate change and glacier retreat in particular. The glaciers Mururata and Illimani are the main source of water for the basin, so was the urgency of adaptation measures related to water use in the watershed to ensure continuity of production, being one of the most important activity due to the agricultural character identified with the communities under study.

Although the population has been developing measures to adapt to climate variability, lack of resources (economic, social and human) and access to them limited the adoption of new measures to adapt. Thus the project consisted of research of impacts of climate change in regions affected by the recession of the named glaciers; assess the vulnerability of the indigenous communities to the effects of climate change and develop a participatory local strategy for adaptation from the experience of communities.

The main objective was to develop strategies and establish mechanisms for dialogue, collaboration and consultation for the use and water management in regions affected by the retreat of glaciers in such a way as to ensure the provision of urban drinking water without adversely compromising surrounding rural production systems, reducing potential conflicts and promoting actions to adapt to climate change impacts.

Through the project, there are both locally and nationally incidence and as a precedent will be research on the impact of climate change in vulnerable regions of Bolivia and action proposals against this global phenomenon.

## **Adaptation of marginal and small farmers to regional climate changes of Chhattisgarh state in Central India**

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In Chhattisgarh state of Central India, the annual rainfall is around 1400 mm and hence, farmers take rice crop during wet season under rainfed conditions. About 70 per cent of the cultivable land is under marginal and small farmers and hence, the agriculture for them is for subsistence. Only 20 per cent of the area is under irrigation. But it is protective in nature, that is, irrigation water is available only during reproductive stage of the crop and after sufficient rains are received in the catchment area of the reservoirs. During drought years, the irrigation also fails. It has been observed that since last 2-3 decades the rainfall in the state is in decreasing trend ranging from 30-35 per cent of normal values in some pockets to 0-5 per cent in some other areas. As a result, the rice crop, especially the long duration varieties, which the farmers usually take, are facing severe water stress conditions with reduced yields. Observing this, the farmers started early or early-medium duration rice varieties for escaping drought conditions. In upland ecosystem, the farmers are changing from rice to other pulses and oil seed crops. Thus, they started adapting the climate change scenario with out understanding the science behind it. Under such decreasing rainfall conditions, it is necessary for mitigating the ill-effects of decreasing rainfall and drought conditions, rain water harvesting and recycling is one of the strategies. In this paper attempts have been made to assess the water harvesting potentials in different district of the state under excess, normal and deficit rainfall conditions.

## Spatio-temporal modelling of climatic effect of malaria incidence in Brong Ahafo Region of Ghana

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Malaria is a major challenge both to the public and the socio-economic development of Ghana. Major factors which account for this situation include poor environmental conditions, climate variability, and prevention services. In spite of the numerous intervention measures that have been embarked on the disease continues to be the most prevalent health problem. The risk measures reported on Ghana were based on household surveys which provided inadequate data for the accurate prediction of new and future incidence cases. This poses a serious threat to the planning and management of the Ghanaian health care delivery system. Environmentally-driven studies using the effects of climatic variables such as rainfall, temperature and humidity for malaria risk, and population maps coupled with adequate data have shown to better define the public burden of the disease. In Ghana, such relationships have not been well studied or documented. The research, using Brong Ahafo region as a case study, explores the potential influence of climate variability in Ghana that can be used to predict malaria risk and hence provide early warning system information for the control of the disease, both from spatial and temporal point of view. This is achieved using autoregressive integrated moving average (ARIMA) and generalized linear regression (GLR) models to available data within the period, 1990–2009. The results indicate relatively low incidence rates of the disease during the heaviest rainy and hottest seasons, also show high correlations of the incidence rates with minimum temperature and relative humidity. Malaria risk in the region looks highest in areas located within the tropical rain forest. It is hoped that this statistical modelling be useful for short-term forecasts and also provide a basis for allocation of resources for the disease's eradication in the country.

## Policy for sustainable forest development for increasing carbon sink and mitigating climate change

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According to an assessment, there was 3.454 billion ha i.e. 26.6% of total landmass area of world in 1995 under forest cover and about 57% of the forests were in developing countries. Though, we have been losing forests over the years across the world, but in nineties developed countries have been able to reverse the trend whereas developing countries continue to lose forests. The annual rate of the loss of forests in the world were estimated to 11.21 million ha in total where as the annual rate of loss in developing countries was 13.03 million ha. To reverse the trend of continuous loss of forests in developing countries Sustainable Forest Development (SFD) has emerged an important tool. In its famous report titled "Our Common Future," World Commission on Environment and Development defined sustainable development as "economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Following this definition SFD may also be defined as the forest management practices that meet the needs of the present population without compromising the future and ecological diversity of these forests. Thus, SFD must ensure well stocked, socially beneficial, environmentally benign and economically viable forests. SFDs have been successful at many places in rejuvenating even degraded forests Global warming leading to climate change is becoming real problem before contemporary society. The latest reports of Inter Governmental Panel on climate change proved its disastrous consequences beyond any reasonable doubt. Climate change is likely to alter the distribution and quality of natural resources and adversely affect livelihood systems. The climate sensitive sector e. g. agriculture, horticulture, forestry may face major threats due to climate change. It may also affect food production and food security, particularly of poor people. There have been efforts for reduction of emission of Green House Gases (GHGs) in accordance with the Kyoto Protocol. It was also found that there was decrease in the emission of GHGs in the last few year of twentieth century in developed countries. But, recent data showed that emission of GHGs in the developed countries actually rose between 2000 to 2005. In this context comprehensive policy analysis has been carried out in conceptual framework, in the paper. Further, on the basis of the analysis, new / modified consistent policy components have been identified and detailed in the paper. It was found that though forestry provides the most important tool for carbon sequestration, it is not at the central stage of climate change mitigation strategy. Due to cumbersome processes, only one Project Design Document (PDD) of Forestry has been approved till date. Moreover, vast area are under shifting cultivation and hot and cold deserts. Even in the existing forest area, total growing stock and biomass and thereby corresponding carbon is less than their carbon absorption potentiality. In some countries even definition of forestry is turning out as deterrent for forestry PDD. Therefore, there is need to act as responsible global citizen and promote SFD with focus on carbon sequestration and adopt simplified forest friendly project designing framework for increasing carbon sink. Supporting meticulous project formulation of forestry PDDs and their implementation and comprehensive monitoring may turn out to be most important tool for retrieving climate change. Hopefully the strategic shift in the policy would go a long way in reducing GHGs from atmosphere and mitigating climate change.

## Multiple Ecosystem stable states and Desertification

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The structure and function of dry land ecosystems changes as a result of aridity or increased intensity of human utilization. The rate at which the land recovers its structure and function following removal of causative factors has important implications. Rapid return to the following state means the structure and functions can be adjusted as desired, but lags and changes that persist even when the perturbations are removed make management more difficult or that persist even when the perturbations are removed make management more difficult or impossible. Multiple ecosystem states that, once triggered, persist under the same conditions have been described but their occurrence in degraded dry lands has received less attention. Studies in northern and Mpumalanga provinces of the Republic of South Africa of the dynamics of international net primary production (NPP) indicate the existence of long-term persistence of degradation. In paired sites that have similar climate, soils, topography and land capability, but one of which has been subject to long-term heavy use and the other not, provide direct evidence of multiple stable states in semi-arid grasslands. The evidence for multiple stable states in degraded dry lands will be reviewed and a research strategy proposed for further study.

## Vulnerability to climate change in Cameroon: Adaptation strategies and layers of resilience

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Cameroon is vulnerable to climate change. As in other countries, its impacts are visible in human health, agriculture, water, ecosystems, wildlife, sea level rise and extreme weather conditions. This paper reviews the current situation on vulnerability to climatic change in relation to the agricultural sector of the country. An agro-ecological map which was developed in 1975 has been revised in 2003. Countries staple crop production has been continuously affected due to drought, floods, temperature rise, and sea water intrusion etc. Other important plantation crops such as tea, rubber and coconut, and other export agricultural crops such as cinnamon, pepper, cloves and cardamom etc. will have positive or negative consequences due to climatic change. Other subsidiary food crops could also be affected. Possible increased frequencies of these climatic changes can decline agricultural productions and lead to decreases in real incomes as current food prices go up. Rural sector paddy farmers have shifted from farming, resulting in about 63% of their mean household income coming from non-agricultural activities. As a consequence of all these impacts the country has faced a severe food scarcity and decrease in real incomes as food prices go up rapidly. For the small marginal farmer, vulnerability to climatic change can mean indebtedness, loss of land, etc. Impacts on women farmers will be adverse because of their traditional role as collectors of water, fodder and fuel. As adaptation strategies, the following steps can be suggested. Efficient water management in farming situations, use of micro irrigation systems, rehabilitation of large, medium and small water tanks, streams and dams, recycling of waste water if usable, follow soil and water conservation techniques, recommendation of crop by agro-climatic zones, breeding of new varieties resistant to drought, pest and diseases, salinity, high temperature, and introduce short-age varieties, launch awareness programmes and reinforce environmental laws and regulations to the maximum level.

## Pacific Island responses to Australian and Japanese governments' assistance in dealing with problems of adaptation to climate change

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It is widely acknowledged that the Pacific Island Countries (PICs) are particularly vulnerable to the effects of climate change and that they have limited resources and capacity to deal with the problems of adaptation without assistance from the international community. While PICs might logically take a regional approach in requesting international assistance to implement adaptation measures, climate change affects a wide range of activities. This study examined Pacific Island responses to donors' assistance, with particular focus on Australian and Japanese assistance and explored cross-sectoral issues associated with planning and implementation of adaptation measures by PICs.

Australia asserts that a scientific knowledge base and capacity to use timely locally tailored scientific data is a fundamental requirement for guide policy makers and planners to provide cost-effective resource management and the implementation of locally suitable adaptation measures. Australia has provided assistance on that basis through its overseas aid program from the early 1990s. However, given the diversity of local concerns, the different stakeholders have different perceptions of the threat and risks of climate change and preferred response measures. Under these conditions, robust scientific knowledge alone does not necessarily translate into sensible decision-making processes, in the absence of further assistance to assist PIC in enhancing their institutional capacity and to implement climate change projects.

Japanese assistance, which specifically targets climate change in PICs, was found to be limited to the promotion of climate change research and human resource development. More broadly, Japanese ODA has prioritized PICs' environmental problems and the improvement of their livelihood over time, because the primary objective of Japanese assistance is to support PICs' taking ownership of their own development through capacity development with its



grant aid and technical cooperation. Interviewees' opinions, particularly those of government officials, regarding Japan's assistance indicated that PICs adaptation needs were generally consistent with their needs for livelihood improvement and economic growth. Responses also revealed that it was of fundamental importance to PICs that donors' recognize and understand the diverse condition in each country and develop individually tailored responses through comprehensive program-based assistance. The delivery of Japanese ODA on a bilateral basis was thus welcomed by many PICs.

It is clear that PICs are unable to implement the necessary adaptation responses without significant donors' financial and technical assistance. Interviewees responses tended to highlight their personal or agencies' preferred process for obtaining and delivering aid. Both Australian and Japanese assistance to date have provided little impetus for institutional change to promote a long-term commitment to the implementation of adaptation measures by PICs. In addition, the different funding mechanisms have caused institutional fragmentation between agencies in PICs, resulting in limited information sharing and lack of policy coordination across agencies. Donor expectations and PICs' adaptation needs are unlikely to be met until PICs' institutional challenges, preventing them from effectively utilizing existing funds, are addressed.

## **Adaptigators: Addressing climate change through building social capital**

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Climate change has often been described as a “diabolical” and “wicked” problem. Latest projections from climate modelers suggest that the time for action to mitigate its harmful effects are seriously diminishing thus, leading to an increased need for society to adapt. There is no doubt that the failure of governments to achieve any real agreement at Copenhagen has sent unsatisfactory signals to many parts of society. However, our research confirms the majority of the lay public believes that climate change is an issue requiring urgent action from all levels of society. And in spite of the failure of Copenhagen to incite governments to act, individuals are proactively making changes to their own behaviours both individually and as communities to address the issue.

This paper explores the role of “adaptigators”, community activists leading others to take action on climate change through behaviour change at home and at work. It reports on a process that has been successfully implemented by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to broker knowledge around the topic of climate change, mitigation and adaptation. Drawing on the theories of social identity, cognitive dissonance, risk communication and the theory of reasoned action the process brings together small groups of individuals (no more than 10) to progress through a series of climate related discussions in the comfort of their own home or workplace. The sheer nature of the process ensures that by enabling the groups to meet regularly over a 12 month period their social capital is increased. This in turn encourages them to openly espouse intentions to change behaviours which will help to mitigate or adapt to climate change. Knowing they will be asked to report on their actions at the next group meeting, encourages them to overcome the value action gap so often prevalent in behaviour change programs.

Although the program ostensibly set out to focus on changing behaviours for mitigation, researchers and participants alike became increasingly aware that it was difficult to separate mitigation and adaptation. This finding has also been reflected in the journey of many international policy makers who are now advocating for ways to bridge the gap between mitigation and adaptation as a way of avoiding creating opportunities for maladaptive behaviours.

The CSIRO process embeds multiple evaluation methods in order to provide empirical evidence of effectiveness. This includes longitudinal measures of beliefs, values, attitudes, behaviour and dissemination of knowledge. Along with quantitative results, this paper will report in more detail on the activities participants are implementing to “adaptigate” to climate change some of which include implementing new technologies, increasing water catchment opportunities through more rain water tanks, use of grey water to care for gardens and much more, identified through qualitative responses. In addition, the paper also highlights the success of the process for building social networks amongst participants and beyond.

Our future research will focus on developing more adaptation specific information to include in the current session materials as well as an adaptation only group session process for a rural context. Details of these developments will be discussed.

## **Climate Change - the Limits of Adaptation**

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Adaptation to climate changes will be an essential feature of this century and probably those following. The degree of adaptation required clearly depends on the global response to reducing greenhouse gas (GHG) emissions (mitigation) and the climate's response to GHG forcing.

There are good reasons why areas subject to increasing hazard arising from climate change should not be hastily abandoned; retreat should not be the principal adaptation response to increased risk.

In many areas, the costs of accommodating changes such as sea level rise is modest, for modest changes in sea level and modest rates of change. Similar comments may apply to bush fire risk or water stress where prudent changes to behaviour and resource use can allow continued occupation and use of areas facing change.

Examples can readily be given for a wide spectrum of expected changes where communities already cope now in one place with conditions that may apply in the future in another, demonstrating some of the character of the accommodation and change that is required.

But not all change can be accommodated so readily:

- We can adapt by designing new assets to the new conditions but that does not help with the existing structures.
- While new assets may be designed for anticipated new conditions, if conditions change differently or more quickly than expected, the new assets will also not be suitable for very long.
- At the extremes, very much longer periods of heat or drought, or whole islands submerged from rising sea levels will be beyond accommodation. While examples exist of the more extreme conditions, few people can - or choose - to live there (eg. deserts).

In some conditions, particularly for sea level rise but also for other risks, the costs of accommodating, or the sheer practicalities mean that retreat from the stressed area becomes the only alternative.

There are two critical factors:

- Rates of change that overwhelm accommodating responses
- Changes beyond normal habitability/economic productivity

Examples are provided of how these two limits to adaptation apply in different situations such as:

- Changes that occur at rates that overwhelm the normal renewal rate of assets
- Impacts on assets of modest value over extensive areas
- Different assets that have different adaptation rate limits
- Boundaries on habitability and economic viability

Where adaptation proves to exceed local responses at a significant extent, it may encourage geo-engineering responses to adapt on a wider scale. The limits of these approaches are also discussed briefly.

## Climate Change Adaptation: Sharing Experience of Coastal Bangladesh

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The country of Bangladesh is highly vulnerable to the impacts of climate change due to its geographical location, extreme poverty and high economic dependence on climate sensitive sectors like agriculture, food and fisheries. To make things worse, irregular weather patterns in recent years have also exacerbated the impacts of climate change, particularly in Bangladesh's vulnerable south-western coastal region. These weather patterns include frequent cyclones (which often result in a tidal surge and subsequent flooding), extreme temperatures and lower precipitation. Further, this coastal zone is, on average, less than 10 metres above mean sea level, which places it at a higher risk of sea level rise (15% of land area is less than 1 metre above sea level, and 60% of the land area is less than 10 metres above sea level). These areas also suffer from river erosion. Finally, salinity is a major problem in the region, particularly impacting access to fresh drinking water and diminishing agricultural production. Between 1973 and 2000, there was a 22.5% increase in salinity ingress. Taken as a whole, all these factors have dramatically reduced the stability of the coastal environment in Bangladesh. This study investigates the impacts of climate change on the two most vulnerable coastal districts of Khulna and Bagerhat in Bangladesh between 2008 and 2009 by analysing both recent and predicted changes to the coastal environment and livelihood patterns. In particular, it examines the climate change adaptation strategies undertaken at the grass-roots level, in order to propose improved strategies for mainstreaming climate change adaptation and mitigation. Although some strategies to mitigate the impacts of climate change have already been implemented, there seems to be a lack of adoption of these initiatives at the local level. Accordingly, this paper examines ways to more effectively implement strategies that will mitigate the impacts of climate change in the affected communities of the coastal areas of Bangladesh.

Our first principal finding is that the coastal region of Bangladesh currently experiences livelihood and food insecurity as a result of the impacts of climate change. In particular, large numbers of people are being displaced, either through a temporary move to find work during the lean seasons, or a permanent move to another place to avoid the unstable living conditions experienced in these vulnerable coastal districts. Our second finding is that the climate change adaptation initiatives currently implemented in the vulnerable coastal districts of Bangladesh are inadequate to support the huge number of people affected by the impacts of climate change in a way that will ensure the security of their livelihood. Accordingly, we conclude that less overlapping and more effective integrated actions between communities, civil society organisations, NGOs and various local government departments are needed in order to build a climate change resilient community at the grass-roots level.

## Mainstreaming Climate Change Adaptation Strategies for Safe Water Supply in the Low Lying Coastal Region of Bangladesh

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Supply of safe drinking water in the salinity affected coastal areas of Bangladesh is becoming an increasingly challenging task due to the growing demand for water and the widespread damage to the region's water supply caused by water related hazards such as pollution and salinity intrusion. To make matters worse, the low lying coastal regions of Bangladesh are particularly vulnerable to the impacts of climate change due to their geographic location, extreme poverty, irregular weather patterns, and shifting rainfall levels. This means one of the most important considerations for water management in Bangladesh is climate change, particularly for the coastal regions where the low-lying land suffers acutely from salinity. The primary aim of this study is to find appropriate climate change adaptation strategies for the supply of safe drinking water in the low lying coastal regions of Bangladesh. The study relies on local people's perceptions through community consultations, as well as baseline surveys, in order to identify the most important factors contributing to the scarcity of safe drinking water. The study also aims to find strategies for a more effective and sustainable long-term water supply that will be suitable for the low lying coastal areas of Bangladesh.

The study finds that there are a number of interrelated factors that contribute to the shortage of safe water supply in the coastal regions of Bangladesh. These include salinity intrusion (from both human and natural causes), changing weather patterns, poor implementation of water supply management and storage, reduction of upstream flow of fresh water, the local hydro-geological condition, and lack of strong policy, governance and research initiatives for technological innovation. The study also finds that current initiatives which have tried to resolve the problem through introducing alternative options for safe water supply have largely failed due to lack of co-ordination and strong implementation strategies at the local level, weak governance and management systems, and lack of adequate policy. Accordingly, this study suggests three options that should be considered to mainstream climate change adaptation for safe water supply in the low lying coastal region of Bangladesh: community based management, community water enterprise, and household demand based management.

## What is next for Australian local government? Moving from Local Adaptation Pathways to integrated adaptation planning and decision making

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National and sub national governments, including in Australia, are increasingly developing a range of plans, policies, strategies, assessments and programs to direct, advise and support adaptation responses to climate change. These governments are also increasingly recognising the important role local government will play in achieving effective adaptation to climate change.

As key decision makers and service providers in areas such as land use planning, infrastructure delivery and maintenance, public health and safety and disaster management, local governments have a vital role to play in identifying, planning and implementing appropriate, cost effective and timely adaptation actions 'on the ground'.

In 2008, the Australian Government implemented the Local Adaptation Pathways Program to support local governments to prepare their communities for climate change. The program provided assistance – in the form of grants – to help local governments undertake climate change risk assessments and develop adaptation action plans.

Under Round 1 of the Local Adaptation Pathways Program, more than sixty local governments received \$1.5 million funding for a total of thirty three projects. The majority of these local governments were located in coastal and urban areas. Under Round 2 of the Program, thirty local governments in regional and remote areas of Australia received a total of \$874,000.

A key goal of the program was to help local governments integrate climate change risk assessment and adaptation planning into their broader decision making processes. However, a comparison of the outcomes generated by those local governments who have participated in the Program with the original Program goals reveals a disparity.

This presentation will explore in detail the nature of this disparity using five case studies of Local Adaptation Pathway Program projects from Queensland, Victoria and South Australia that were delivered by AECOM's climate change practitioners.

The key outcomes delivered through these projects will be presented, and the challenges associated with developing appropriate, cost effective and timely adaptation actions within an environment of competing priorities and institutional and financial constraints will be explored. This exploration will provide a 'reality check' of current adaptation practice at the local scale in Australia.

Finally, the presentation will explore the reasons behind the apparent program-practice disconnect and suggest ways in which it may be addressed. In doing so, it will argue that for similar future programs to be more effective, they will need to take better account of some of the basic economic and political realities within which local governments operate.

Indeed there may be a need for a reorientation of national government program objectives in order to support local governments in overcoming the institutional and financial constraints they often face in addressing their climate change risks and in delivering adaptation actions.

## Looking ahead and adapting? Comparative analysis of future scenarios for the fisheries sectors in Peru, Senegal, Ghana, Mauritania and Vietnam

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Localized changes in the productivity of marine and inland waters induced by climate change and increased climate variability will pose new challenges to the fishery and the aquaculture sectors globally. However, climate change does not occur in isolation of other drivers of change: processes of environmental, economic, social and political change can affect the fishery sector, potentially creating additional vulnerability to climate change. Scenarios are a useful tool to explore uncertainties and understand non-climatic drivers of change. Despite their prevalence in global environmental change research, few studies have conducted a cross-country analysis of sectoral scenarios in order to understand their methodological challenges and policy relevance when applied in different contexts. Additionally, while links between food systems and the environment are well documented, fishery production systems have seldom been the subject of scenario analysis. This paper presents an integrated approach to the construction of fisheries sector scenarios at the national scale in Peru, Ghana, Mauritania, Senegal and Vietnam. Through an expert elicitation survey, we identify and analyse the multiple drivers of change faced by the fisheries sector in the past as well as exploring future ones, including drivers that reach well beyond the sphere of fisheries. During workshops and validation surveys, experts construct future scenarios for the sector in the four countries for 2050. Through a comparative analysis we address three fundamental questions: 1) what are the methodological hurdles when developing expert-based scenarios in different contexts 2) how thinking about the future informs adaptation planning to climate change and policy making, and 3) which lessons can be drawn for future implementation of scenario approaches and upscaling as well as downscaling of results. The comparative results show avenues for increasing the capacity of the fisheries sector to face the challenges posed by climate change under diverse conditions and highlight the contribution of scenario approaches to adaptation planning.

## Vulnerability of the aquaculture sector to climate change in Vietnam

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Aquaculture production along Vietnam's coastline and in deltas is an important food-producing and livelihoods-generating sector, contributing to both export earnings and domestic protein consumption.

Aquaculture systems are particularly sensitive to changes in sea surface temperature, sea level rise, floods and increase of extreme events and water stress. Given Vietnam's projected increases in overall temperatures, changes in rainfall patterns and rising sea levels, understanding the vulnerability of the aquaculture sector to climate change is essential to inform sectoral adaptation planning. This paper presents a national vulnerability assessment of the aquaculture sector as well as a more detailed analysis in the Mekong River delta, the largest aquaculture production region of the country. At the national scale we develop a composite vulnerability index and maps identifying provinces most vulnerable to potential climate change impacts on their aquaculture sector. In the Mekong River delta, the vulnerability assessment focuses on two production systems: shrimp and catfish farming. This regional assessment links expected changes in climate to changes in aquaculture production, in particular the predicted changes in hydrological regimes, and the ability of these production systems to adapt. The preliminary results presented provide the opportunity to explore the methodological implications of conducting vulnerability assessments across multiple scales and with different units of analysis (who is vulnerable? a province, a production system?) using Geographic Information System, and how these choices respond to different policy needs. Finally, we discuss the limitation of vulnerability indices, the need to combine different approaches and scales when assessing vulnerability, and the policy implications in terms of coastal adaptation planning in Vietnam.

## Near Real-Time Agrometeorological Information for Mexican Agriculture: Dissemination and Application

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A national network of over 800 automated meteorological stations strategically located in agricultural areas in 29 Mexican states has been established by INIFAP (Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias) in collaboration with the Mexican Department of Agriculture, state governments, farmer groups, and other agencies in order to service Mexican agriculture. The objective is to provide near real-time meteorological data for application in agricultural processes and in the planning of mitigation and adaptation strategies in the face of severe weather. Data collected automatically every 15 minutes from the stations are processed and stored in the central database at the Laboratorio Nacional de Modelaje y Sensores Remotos of INIFAP and transmitted nation-wide to farmers and other users in near real-time, free of charge, on the internet through the website [http:// clima.inifap.gob. mx](http://clima.inifap.gob.mx). The data have been used to develop pest and disease models for sugarcane, orange, apple, pecan, avocado, strawberry, lemon and other plants. The weather data have also been used for frost alerts, calculation of water needs of irrigated crops, regional climatic characterization, and assessment of damage to crops due to severe weather. Other high-impact uses include

climate prediction and national yield prediction of basic food crops such as maize, dry bean, sorghum, wheat, barley and sugarcane. Additional farmer training programs, website improvements, and research on applications are needed to ensure that the information generated by the national network of agrometeorological stations will truly help farmers and decision-makers in government and agri-business cope with the challenges presented by climate change.

## Adapting Cities to Climate Change: Lessons from Local Practices in Australia

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Adapting to climate change is a crucial challenge faced by many Australian local governments. Climate adaptation at the local level is usually implemented through bottom-up approaches coordinated by councils as part of broader sustainability initiatives. Although there are various climate change actions, either planned or implemented, the overall picture on the triggers, barriers, and the capacity to adopt good practice is not clearly understood. The range of available solutions will vary from place to place depending on specific social, financial, and physical constraints and, from a practical point of view, it is not clear which actions have the greatest potential impact for addressing climate change.

Recent research emphasizes the importance of cross-city learning, and the absence of a 'knowledge pool' that goes beyond context-specific individual case studies is an important barrier to such learning. To fill this knowledge gap, many important research questions need to be addressed, including: are there commonalities and emerging patterns across individual cases?; what are the determining factors and mechanisms shaping these patterns?; what defines and contributes to the success of a good practice? and; how can cross-city learning be facilitated?

This presentation reviews ongoing research by CSIRO's Climate Adaptation National Research Flagship that aims to understand the range of adaptation strategies being undertaken by local governments in urban Australia. The objective of this research is to develop a broad understanding and information base of state-of-the-art practices in climate change adaptation across Australian local governments. Some of the theoretical underpinning of this research includes ideas such as system innovation, an evolutionary perspective on urban environment and governance, and sustainability transitions.

The project has four components aimed at understanding climate adaptation practices: 1) identification of local government perceptions, triggers for action, plans and approaches, and key actors; 2) development of a typology of policies and practices and identification of best practices; 3) evaluation of the barriers and opportunities for effective climate adaptation; and, 4) development of a referencing tool for local government to facilitate dissemination of study results, guide implementation process, and cross city-learning.

An internet-based questionnaire collects information from officials in local government (LGAs) in urban Australia. The questionnaire captures data on: 1) the respondent and their local government area; 2) their perceptions of risks and responses to climate change; 3) the responsiveness, including barriers and capacity issues, of their local government to climate change; 4) the specific policy measures undertaken and how they have been managed; and 5) the key processes and actors involved in decision making. We have involved local governments in the development and testing of the survey before implementation nationwide.

In this presentation, the motivation, conceptual framework, research design, and initial results of the survey will be discussed along with the linkages to policy development and practice.

## Eyre Peninsula Climate Change Vulnerability Assessment

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Community adaptation to climate change requires an understanding of the vulnerability of various sectors to the likely impacts imposed by a range of climate stressors. An assessment of climate change vulnerability for three study areas on the Eyre Peninsula of South Australia was undertaken to identify likely risks and recommend actions to increase adaptive capacity for each of the five capitals: human, social, financial, physical and natural. Climate change impacts for the years 2030, 2050 and 2070 under the IPCC A1B SRES scenario of temperature, rainfall, available moisture, extreme events (flooding, bushfire, heatwave), sea level rise, increased CO<sub>2</sub> concentrations and the introduction of a carbon pollution reduction trading scheme, were assessed according to the ANZ ISO 4360 methodology and included a measure of the climate stressor and likely exposure.

The adaptive capacity of each of the five capitals was then evaluated in the face of likely exposure to each climate stressor for the year 2050 and was based on scientific evidence, surveys of residents in the region and ABS and other data. Vulnerability was determined as a product of impact and adaptive capacity. GIS mapping was used to illustrate the vulnerability of various natural capital variables including soil type, vegetation connectivity, threatened species, and marine environments.

Results identified a backdrop of pre-existing non-climate related stressors within the Eyre Peninsula community and biophysical systems that already reduce the region's adaptive capacity and constrain resilience without the additional stressors of climate change.

The key findings included:

- Communities in the study region have a moderate to high range of potential climate change induced stress in the areas of health and the provision of adequate facilities;
- Some communities have a very high exposure to the effects of climate change, but this is offset by the relatively high resilience within the community;
- The high potential impact on the financial capital of the area was offset by the range of possible adaptation strategies in the agricultural, fisheries and other industry sectors;
- The vulnerability of existing infrastructure was relatively low as there is good capacity to include new technologies and improved engineering design. However, if communities are unable to implement adaptation options, then vulnerability is relatively high.
- Natural capital included terrestrial (soils, landscape modification, connectivity) and marine indicators into the vulnerability assessment. There was spatial variability in the vulnerability of soils as a result of projected changes in rainfall and the water holding capacity of soils. Landscape connectivity was determined to have a high exposure to future climate changes and have a low adaptive capacity. Marine vulnerability is moderate to high.

Recommendations for priority actions to improve adaptive capacity, reduce impact and improve knowledge gaps were identified and communicated to the target audience.

## Identifying key health adaptation opportunities in greater western Sydney

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Western Sydney is the fastest growing region of the fastest growing city in Australia. Its population is culturally and socioeconomically diverse and includes significant disadvantaged sub-groups, such as migrant and Indigenous groups. The availability of health services, education, employment and recreational opportunities and access to public transport is limited when compared with other more advantaged areas of Sydney. The region also has a relatively heavy burden of underlying chronic disease including diabetes, heart disease and their precursors – conditions which will increase the impacts of climate change on mortality and morbidity, especially through excessive heat.

The climate change impacts likely to be of greatest concern to this region include:

- direct health effects of excessive heat and other extreme weather events;
- urban air pollution and aeroallergens;
- increased foodborne disease related to ambient temperature;
- reduced physical activity and increased discomfort of exercising in poorly serviced area and in warmer temperatures;
- poorly designed infrastructure, rising costs of energy, reduced capacity to adequately heat and cool homes, failure of both mass transit and personal transit systems;
- poorer nutrition from the rising costs and decreased availability of fresh food; and
- reduced ability to connect with the natural environment.

Given its size (geographic and population), relative disadvantage, capacity for continued expansion (and thus the opportunities for better planning that this affords), greater western Sydney provides an ideal location to study and plan for climate change adaptation and mitigation; it provides opportunities to model a range of climate change impacts on urban Australia and to develop key adaptive strategies for minimising impacts, especially among the most vulnerable.

Our project aims to identify key adaptation opportunities in this region, especially as they relate to human health and wellbeing. Focus areas include urban planning and transport, health service infrastructure and access, and community services and support. We will be presenting our work in progress.

## Resilience and vulnerability among older Australians: Adaptive responses to heat

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Australia's cultural acceptance of heat is sedimented within the national psyche: the sun, sea and outdoors barbecue reappear over and over again as iconic Australian scenes. In short, there are good reasons for Australians to have developed a culture which has an ambivalent relationship to heat.

Heat has profoundly influenced many aspects of Australian life. We argue that Australians have not found living with the extremes of heat provided by the Australian climate as difficult as one might imagine. This may be due to the fact that heat waves are not considered unusual in Australia. Nevertheless, during the 2009 heatwave in Adelaide (South Australia) there was 10-fold increase in sudden deaths mainly among the elderly on one day. Older people are particularly vulnerable to excessive heat due to an increased burden of underlying chronic disease, poorer housing quality, reduced ability to access places of relief (e.g. air-conditioned shopping centres) and fragile social networks.

We aimed to reflect on the manifestations of this ambivalence by considering a vulnerable sub-population's experiences of heat and what we consider as the potential problems that result from the attitudes and predispositions that Australians employ to think about, respond and adapt to heat. We interviewed older people living in western Sydney about their experiences of extreme heat and its influence on their daily activities (eating, sleeping, social activities, domestic tasks and transport).

We found near universal reliance on air-conditioning in the home and car for improving comfort and normalising activity and function on hot days. This has major implications for power use – and the expected rising personal costs of electricity as part of government climate change mitigation strategies – as well as for overburdening power supply infrastructure with increasingly warmer weather. Other measures used for personal cooling included ceiling fans, blinds, insulation, use of cool breezes, frequent showers, sitting in water, use of a swimming pool, and sucking ice. Participants also reported making significant changes to their daily routines by reducing physical activity and time outdoors and re-scheduling activities, and changing their diet and cooking activities. Effective behavioural adaptation to warmer weather will become increasingly important as large parts of Australia will be experiencing warmer average temperatures and a greater numbers of hot days.

Australia's culture of heat 'resilience' belies a number of vulnerable sub-populations, such as the elderly, that will require particular attention when developing adaptation policies and strategies to deal with climate change.

## Impact of climate change and socio-environmental factors on dengue transmission in the Asia-pacific region

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The notion that global climate change contributes to the increasing transmission of dengue has received widespread attention. The increasing trend in urbanization, population growth, weakened vector control programs and global interchange of dengue serotypes through international travel might also contribute to the substantial increase of dengue transmission in the world over the last few decades. We reviewed the published literature on associations between climate factors and dengue transmission, as well as other non-climatic factors that influence the distribution of dengue viruses and its vectors. Our aim was to provide an overview of the current situation of dengue transmission related to climate change and socio-environmental conditions, particularly in the Asia-pacific region, as limited research has been done in this area.

A search of the published literature on PubMed, ISI web of Knowledge, Blackwell Synergy and Google Scholar was conducted using broad search terms. The authors reviewed abstracts and selected all relevant articles on the impact of climate change and socio-environmental factors on dengue fever.

The body of evidence revealed that the transmission of dengue fever appears to be sensitive to climate variability. Temperature, rainfall and relative humidity were found to be major determinants of dengue transmission. However, the magnitude of the association between climate variability and dengue fever varied with geographical location and socio-environmental conditions. A positive association between increased temperature and dengue incidence was found in most countries in the Asia - Pacific region. Rainfall was reported as negatively associated with dengue incidence in Thailand, Indonesia and Taiwan; however, dengue outbreaks usually occur in rainy season. A strong relationship was evident between dengue epidemics and El Niño event in Thailand and Australia; although, there was spatial heterogeneity in this relation. Urbanization and international travel were reported to be associated with increased risk of dengue transmission, even though no statistical modelling has been applied in this area.

The review indicates that global climate change is likely to affect the seasonal and geographic distribution of dengue fever in the Asia-Pacific region. However, current empirical evidence linking dengue fever to climate change is inconsistent across geographic locations and absent in some countries where dengue is endemic. More research is needed in such locations such as Bangladesh, China, Vietnam, India, Myanmar and Sri-Lanka to better understand the relationship between climate change and dengue transmission. Future studies should also consider important socio-demographic factors such as urbanization and international travel.

## Using science to articulate an uncertain future for strategic climate change decision-making

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Much decision-making that is undertaken for natural resource management (NRM) assumes a stable although variable climatic situation. Projections of future climate change, particularly in the regions experiencing a Mediterranean climate in Australia, suggest that the assumption of stability can no longer hold. The challenge is to inform governance and management of natural resources so that effective adaptation is possible, even in the case of changing climatic conditions. The paper describes a regional approach to adapt to climate change that focused on engaging the NRM community. Recognising that new levels of risk are apparent, which cannot be properly assessed by current management and planning tools, the South Australian Government and the Adelaide and Mount Lofty Ranges Natural Resources Management (AMLR NRM) Board worked in partnership to implement a broad framework to assist decision-making within and across NRM sectors.

A decision-making framework provides a clear, logical progression for NRM managers to develop climate change adaptation strategies in their regions.

1. Awareness raising and ownership of climate change.
2. Vulnerability assessment of the region.
3. Development of adaptation responses.
4. Appropriate integration of adaptation responses into management and planning activities across different timeframes
  - a. Incorporation of climate change into risk management approaches in the short-term.
  - b. Application of adaptive management techniques that can be adjusted over time.
  - c. Application of decisions based on the precautionary principle that allow for increased long-term risk.
  - d. Rigorous analysis of alternative adaptation actions.
5. Ongoing revision, reassessment and alteration of those approaches.

An integrated vulnerability assessment for the region, showed that there is significant capacity for adaptation to potential climate change by 2030. In broad terms, the most vulnerable systems were initially assessed to be those that are under less human management and control such as biodiversity conservation, or those that have long management response timeframes, namely coastal and bushfire management, biodiversity conservation and perennial horticultural systems

A series of case studies of some of the more vulnerable systems such as soils, groundwater, biodiversity, perennial horticulture and coasts, and their interaction with climate change were developed. The case studies were designed to trial different approaches to developing adaptation responses and to avoid replicating other work underway in the region. These studies critically applied different approaches that could be used to support strategic planning for NRM systems in light of future climate change projections. The different case study approaches were: Scenario modelling; Applied participatory Geographic Information Systems (GIS) modelling; formal Environmental risk analysis; and Participatory action learning. They represented a spectrum of approaches, from those that rely strongly on empirical science-led analyses and scenario modelling through to stakeholder-led participatory research.

Scenario modelling successfully reinforced or improved the knowledge of climate change impacts and potential adaptation responses, particularly where resource use is currently close to the upper limit and is likely to become more so with projected climate change. However, scenario modelling outputs are limited by the range of factors included in the model, incomplete knowledge of current systems and their lack of immediate application.

The Applied and participatory GIS modelling confirmed that better integration between scientific researchers, planners and managers of natural resources expands knowledge of current and historic resource condition and enhances the legitimacy of planning conclusions. The lack of detailed base-line information in many NRM systems still limited this approach.

The environmental risk assessment process raised immediate and valid concerns, but the risk assessment framework struggled to guide a broader examination of industry needs and associated NRM issues over the longer term as many likelihoods and consequences of climate change on NRM systems are poorly understood.

The Participatory action learning approach supported stakeholders to analyse and use information, in combination with their own knowledge, to better understand the implications of climate change on their systems. The approach focused on the need to have multiple independent local adaptation responses to climate change running in parallel to planned regional activities. Although this approach lacked some credibility with the NRM board due to the lack of scientific input, by working closely with individuals who are involved in NRM activities, local responses can evolve to manage future risk.

The key initial step to undertaking planning for an uncertain future is the ownership by decision-makers of the emerging risk. By working closely with stakeholders through a process of knowledge development, decision-makers are empowered to build strategic responses to climate risk into their planning and policy. Peri-urban regions such as the AMLR are going to become increasingly contested as a result of climate change in association with the impacts of ongoing urbanisation upon vital natural resource regions. Governance of climate change within vulnerable peri-urban spaces will need to allow for the physical, systemic and conceptual “space” for social learning and the evolution of approaches for effective adaptation management and policy.

## Regional Adaptation to Climate Change in Germany

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While climate change is global in its origin, climate impacts will lead to problems that have to be solved in specified regions. Damage of global warming, changing precipitation patterns and weather extremes will always occur in a well defined region and cannot be discussed ignoring the spatial dimension. Rising sea levels will endanger specific coastlines, extreme weather events will occur locally and heat waves will affect certain regions. Therefore, adaptation can be organised by individuals or regional and national governments. Each company, each local municipality and each country is interested in reducing potential damage costs of climate change as it is supposed to take place.



Adaptation can be organised by private business or all levels of government agencies. Because of existing governance structures, some regional or national adaptation measures must be organised as collective goods. Building or strengthening protection against rising sea levels is the most prominent example. Other public goods like sewage infrastructure must be adapted to future climate conditions as well. However, financial funds and sufficient knowledge is needed to build adaptation capacities. Furthermore coordination between public administrations might be necessary as climate impacts on the regional level and administrative borders do not always fit.

Within the research framework of „KLIMZUG – Managing Climate Change in the Regions of the Future“, relevant players in seven selected regions in Germany just started to build adaptation capacities. These regions face very different challenges: While summer drought and its impact on agriculture are critical in some regions, flooding and transportation issues are more important in other regions. The objective of the KLIMZUG-projects is to develop innovative regional strategies for adaptation to climate change and related weather extremes. Therefore, potential changes in climate have to be integrated in processes of regional planning and development.

Water balance and water supply is one of the KLIMZUG-projects' main topic. Additionally, houses, facilities and plants – including power plants and supply lines – have to be protected against floods and storms which in future will become more severe and will occur more often. Farming as well is highly affected by climate change with a strong relationship towards water supply. Actions have to be taken early to prevent damages and crop failures. Appropriate measures are expected to vary between regions due to climate as well as social varieties. The joint projects in the KLIMZUG-regions will help to gain the needed experiences.

All regions will establish networks with local authorities, business, non-governmental organisations and research institutions. Within these networks, research needs for specific problems have to be identified, solutions must be presented and strategies for the implementation of the findings have to be discussed. As adaptation will be a process for decades, the networks are supposed to work and to evolve on a long term basis. They should continue to strengthen the competitive advantages of the region under future climate conditions. Furthermore, best-practice-solutions should be identified and transferred to similar regions.

## **Engaging agricultural stakeholders to discuss climate variability and change: Lessons on participatory process design from the southeastern USA**

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Within the Southeast Climate Consortium (SECC) scientists are integrating regionally downscaled climate scenarios with crop models to generate a range of potential impacts in future agricultural production. It is assumed that the results of these models will support stakeholders as they make decisions within the context of a variable and changing climate. However, the way in which climate information is delivered and dialog facilitated among stakeholders affects how people process, understand, and incorporate new knowledge to manage risk. This poster demonstrates how participatory tools and processes can support social learning among farmers, extension professionals and scientists. Specifically, we review the establishment of a new climate working group for row crop agriculture that includes stakeholders from Florida, Alabama and Georgia. In April 2010, participants met to discuss the production of peanuts, cotton and corn within the context of a changing and variable climate in the southeastern USA. Rather than presenting the simulated model results of potential regional future climate scenarios, we initially emphasized a reflection on past climatic variability. Participatory tools such as fishbowls, timelines, and farmer-led storytelling were used to initiate discussions about past extreme events and risk management. This narrative format was complimented with scientific displays of historical data on climate cycles and references to web-based decision support tools. During breakout groups, stakeholders examined hypothetical climate situations (warmer, colder, drier, and wetter) over differing timescales to explore potential opportunities and constraints to adaptation. This poster presents perceived socio-economic factors at various scales that shape decisions in row crop production. These findings have implications for the degree to which climate-related information can support farmer-led adaptation. More broadly, this case study suggests how process facilitation and information delivery might condition interactions among stakeholders, thereby informing our understanding of how to design effective spaces for social learning.

## **Climate and child health in rural areas of low and middle income countries: a review of the epidemiological evidence**

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Children are amongst the most vulnerable to climate change because they currently experience a very high health burden from climate-sensitive diseases. Rural populations in low and middle income countries are also vulnerable to climate change impacts because of a high dependency on local environmental resources. We investigated the evidence base for the direct impacts of current climate factors on child health using a systematic review of studies have quantified an association between temperature and/or rainfall and child health outcomes. We found 35 papers that met our criteria, which were classified as spatial or temporal analyses. There is good evidence that climate factors (temperature and rainfall) affect the spatial and temporal distribution of malaria, however there was limited evidence for other diseases. There is also good evidence

that temperature and rainfall factors are an important determinant of diarrhoeal disease morbidity, reflecting both acute mechanisms (water contamination) and long term effects (chronic water scarcity). The review highlighted that less is known about the specific mechanism that link climate patterns with disease or mortality. Only few analyses were of high quality, which would include adjustment for spatial or temporal confounders. Many studies did not distinguish between seasonal and other climate effects making interpretation difficult. There is a need for more research to describe the mechanisms by which climate variability affects child health and to identify those communities most at risk we need both improve the understanding of the epidemiology of disease and identify intervention to lower the impact of the changing climate

## Managing Water Resources under Climate Uncertainty: Challenges and Opportunities

B Bates<sup>1</sup>

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Managing Water Resources under Climate Uncertainty: Challenges and Opportunities Bryson C. Bates CSIRO Climate Adaptation Flagship (Email: bryson.bates@csiro.au) Water supplies in southern and eastern Australia have been identified as one of our most vulnerable sectors to climate change. This vulnerability is due to projected decreases in precipitation and increases in temperature, evaporation and human and environmental water demand. Thus concern about future climate change and persistent drought across southern Australia and their impacts on our society, economy and environment, have led to their emergence as key problems for policy- and decision-making. Although the number of climate change impact assessments continues to grow in Australia and elsewhere, there has been little consideration given to how the results can be best used by water planners and stakeholders to make informed, robust decisions on adaptation strategies under considerable uncertainty. While there is little but slowly growing evidence of the incorporation of climate uncertainty in Australian decision and policy making, this is largely due to ongoing hydrological droughts in southwest and southeast Australia rather than projected changes in drought intensity, frequency and duration. The need to characterise the impacts of climate uncertainty has led to the development of so-called probabilistic climate change projections in recent years. Conventional methods for characterising uncertainty at each step in the impact assessment process and the propagation of uncertainty from one step to the next are simplistic and incomplete. Considerable work would be involved in developing a defensible 'end-to-end' probabilistic assessment, which would be substantially affected by any probabilities assigned to emissions scenarios and global climate models. Moreover different approaches to probabilistic analyses can lead to different risk-based decisions and there is a need to focus on state-of-the-art rather than ad hoc methods for the characterisation of uncertainty. Therefore it is premature to make definitive statements about the levels of uncertainty (or our levels of confidence) in climate change impact assessments, unless appropriate caveats are listed explicitly. There is an increasing demand for policy-relevant information that incorporates consideration of multiple stressors and drivers in climate vulnerability and adaptation assessments. To meet this demand consideration needs to be given to the adoption and proper execution of a participatory scenario (or storyline) approach to planning rather than the currently-favoured prediction paradigm. This will require the identification of stressors and drivers, the formulation of a small number of narrative storylines using expert knowledge and modelling that capture socio-economic and institutional as well as hydroclimatic aspects, and subsequent assessment of the need for contingency plans and the number and timing of key decision points for different water futures. The presentation will provide a brief overview of the sources of uncertainty in hydrological impact assessments, the current methods used to characterise this uncertainty, the advantages and limitations of probabilistic scenarios, and the role of scenario planning. It will outline a number of prudent actions that water planners can take to enhance preparedness through the development and application of robust adaptation strategies that work well under present conditions and plausible future climates, and that are insensitive to the resolution of uncertainties and violated assumptions. A key ingredient is the recognition of uncertainty as a source of opportunity, discovery and creativity rather than the source of a debilitating problem.

## Adaptation to Drought – Learning from Africa

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In the 1970s and 1980s, a fierce debate took place concerning the vulnerability and adaptive practices of farmers and herders in the West African Sahel, and the utility of concepts including 'adaptation' to drought. The region has had the most primary research conducted on drought vulnerability and response, and it is referred to as an archetype, notably in work on human security and famine. It also has great significance for understanding Australian drought management. Stressing human vulnerability and the historical political economy of British and French colonialism, some writers (eg Michael Watt's 'Silent Violence' 1983) painted a gloomy picture of rural life, with farmers beset by brutal commodity markets and extractive governance stretching back over 100 years. Food shortage and famine was, for Watts, created by colonial policies and unequal access to resources. However others, for example Michael Mortimore (author of 'Adapting to Drought' 1989) found something very different in the same region of Nigeria – regardless of threats to their survival households responded (adapted) to drought in innovative and largely successful ways: diversifying into livestock from farming, moving into labouring and small business activity, and finally considering some temporary outmigration to less affected or more affluent regions to provide remittances. Reversible adaptations occurred before less reversible ones. Incommensurability of these and other, francophone accounts drove Batterbury's long term work in Burkina Faso and Niger. Adaptation is socially mediated, not always successful, and is linked into broader political and economic forces. Its utility as a concept is constrained if wedded to Darwinian uses.

'Productive Bricolage' characterizes livelihoods, with different responses pursued at the same time, and for different lengths of time. Development projects can assist community resilience and individual response to food crises, but in unexpected ways. Our findings, which married data on land quality and erosion to livelihood decisions in SW Niger, and in Burkina were conducted with the country's most successful soil and water conservation program over 3.5 years, are discussed and linked to the new preoccupation of the millennium; 'climate adaptation'. New research on adaptation in semi arid regions urgently needs to learn from this vast reservoir of contextual knowledge in the African drylands, some of it dating back over 40 years.

## Using vulnerability as a key concept to the study of adaptation to climate change (CC)

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Today, adaptation to CC is the main concern of a great number of speeches and reports. Support to adaptation has been claimed by the international community as a necessity for developing countries. This issue is linked to development aid since the third IPCC report (2001). Since then, many international organisations and NGO's claimed to be in favour of integrating adaptation as part of the development projects. However, despite the numerous propositions to support adaptation through development policies, few activities are already in place. In order to realize adaptation to CC, in concrete terms, it will first be necessary to define a framework of study. Regarding this issue, several authors propose the use of the concept of vulnerability as a starting point to their analyses of adaptation to CC.

In this paper, we propose to study the use of the concept of vulnerability as a tool to study the way society and people could adapt to CC. This concept was first used in the studies of risk. Vulnerability to natural disasters has then been frequently studied during the 90's. Today, many authors and scientific institutes have made a clear link between vulnerability and CC issues. IPCC, NGO's, or development actors such as the E.U. use this term when they claim the necessity to support adaptation for developing countries. The relevance of this notion of vulnerability in the context of CC and the opportunity it could bring as a way to implement adaptation will be studied in this paper.

The paper will address the question of the relevance of this link through scientific literature and field study. The surveys were made in several departments of southern Benin, in the context of our PhD on adaptation to CC. In this paper, we will first explain the role of the concept of vulnerability in the context of risk studies. We will then analyse why it became central in the field of natural disaster. A second point will underline the use of vulnerability in regards with CC. This use became important during the 21st century. This will be detailed through study of literature. A definition of the concept in context of CC research will be proposed. How and why the concept is used by several authors in their case studies of adaptation to CC will be the subject of a next point in our paper. Finally we will discuss the advantages and the limits of the concept of vulnerability as a key notion to the study of adaptation to CC. Data collected in Benin will be used to support our analyses of the literature and our conclusions.

## Challenges to adaptation in the WA farming community

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Farmers' ability to manage climatic risk is critical to their profitability and sustainability and should be integral to all aspects of on-farm management. This paper describes our research which had the objective of scoping and documenting factors influencing farmers' decisions relating to the management of seasonal variability and climate change risk. Its focus was on exploring the perceptions of farmers as well as those people in the supply and advisory network who could be expected to have some degree of influence over farmers' decision making.

We have found that farmers' responses to seasonal variability in WA are highly variable and depend on a range of factors such as level of exposure to and the consequences of seasonal risk, the risk profile of the farmer, age, use of appropriate technology and practices and levels of management experience and expertise.

Many farmers are uncertain about whether climate change is occurring, some denying that it is. There is a low level of acceptance that it is the result of human activity, reflecting a high level of uncertainty rather than widespread open scepticism. Advisors mirror these attitudes to a degree but are more likely to agree that climate change is manmade. Where climate change is accepted, many believe that current risk management is appropriate and adequate to managing climate change.

An examination of perceived constraints to improved adaptation to seasonal variability and climate change provides evidence that there are three key factors which are fundamental to understanding the reasons for the variation in knowledge, attitudes, skills, aspirations and the uptake of practices – the extent to which those practices are perceived to be adoptable, the effectiveness of systems, networks and intermediaries linking researchers with farmers, and extension and communication activities delivered as part of these systems appropriate to farmers' needs.

These factors also provide pointers to ways to better assist the farming community to adapt, to build resilience and to respond effectively to climatic risk. Of a prospective portfolio of approaches, three examples can be cited. First, the private and public advisory sectors would collaborate to deliver a common approach, seeking to communicate information about climate change to the farming community and to identify strategies to encourage resilience within that community. Second,

they would design a tailored program of activities, targeted at the agribusiness finance sector. This would enhance their confidence to engage with clients about longer-term planning for the impacts of climate change. Third, they would develop case studies showing how farmers have managed climatic risk, and deliver them using a highly participatory approach.

Several of these initiatives are currently being trialled as part of the DAFWA adaptation project, a WA State Government project established as part of its Priority Plan for Agriculture which has the aim of improving the adaptability and resilience of WA producers through the delivery of information, training and tools.

## Adaptation to extreme heat in Australian cities

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The majority of the world population now lives in urban areas, yet we have a relatively poor understanding of the impacts of climate change on human health in cities. The issue of understanding vulnerabilities to urban heat exposure associated with the potential impacts of climate change, such as more frequent and severe extreme weather events, is now central to the policy and research agenda for our urban planning, housing and health agencies. With growing recognition that considerable climate change is 'locked-in' and cannot be mitigated, there is increasing government emphasis on finding ways of reducing vulnerability and helping communities adapt to current and anticipated climate change impacts.

In this presentation, we describe research into adaptation options for extreme heat in Australian capital cities. At the broadest level, this research contributes to the conceptual and scientific basis for identifying climate adaptation options related to human health and well-being in cities. Our overarching goal is to develop a multi-scale social-ecological systems and spatial analytical framework to: 1) Quantify relationships amongst the geographies of climate impacts, including the links between residential buildings and urban context, and resilient and vulnerable populations, and 2) Develop spatially explicit methodologies and approaches for rapid identification of how urban form influences urban thermal performance and, within this context, characterizing the thermal performance of residential buildings and neighborhoods.

The project and this presentation are structured into four components:

1. Urban form and thermal performance. To understand spatial variability in the vulnerability of the built environment to extreme heat, we used high resolution satellite remote sensing to quantify the influence of urban form (e.g., 'urban form hot spots' related to the spatial configuration of different land cover / building types) on urban thermal performance. Land surface temperatures during and outside of heat waves were estimated from Landsat TM/ETM+, and compared with land cover classifications derived from high resolution remote sensing imagery (i.e. Quickbird, Ikonos).
2. Urban thermal performance and the thermal performance of buildings. Given that most people spend a substantial amount of their time in buildings, a key focus of this study is the development of methods for linking this indoor and outdoor environment perspective. We focus on residential areas and are developing an automated method for rapidly characterizing the thermal performance of residential buildings in collaboration with built environment experts.
3. The social geography of heat stress. We draw from social-ecological perspectives on vulnerability and resilience to identify vulnerable populations and the social-ecological context of the urban environment within which they interact (e.g., neighborhood / building characteristics that increase or mediate exposure to extreme heat). This work relies on the integration and interrogation of a range of spatial datasets (e.g., population census, greenspace, land surface temperatures, location-based services).
4. Framework for decision making about climate adaptation options. To assist with interpretation and decision-making, we have developed a systems-based framework for exploring the multiple intervention points for climate adaptation. In this context, we have conceptualized climate adaptation as comprising a 'palette of options' ranging from planning, design and physical interventions (i.e., retrofitting; cool roofs; urban greening) to the promotion of behavioral change and coping strategies to help people to adapt to extreme heat (e.g., warning systems; social networks). We argue that our framework allows the development of more informed/targeted intervention and adaptation strategies and an understanding of the necessary drivers and barriers of change at various scales – individual to population, local to federal government, and neighborhood to city. There are trade-offs in terms of where and what kinds of interventions to utilize, but we suggest an 'adaptive management' approach to promote transitions to healthier urban environments.

## Probability ensembles of 21st century range changes among micro-hyloid frogs of Australia's Wet Tropics

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Shifts in the range margins of diverse taxa have provided one of the strongest biological indicators of current climate change. There is, however, considerable uncertainty as to the extent to which species potential ranges may shift in response to 21st century warming and precipitation changes. While modeling of current and future species distributions has been a common technique used to elucidate potential range shifts, limitations occur due to factors that include species data and

ecological niche models (ENMs), and uncertainty and errors associated with climate scenarios. There has recently been a trend towards the use of 'ensemble forecasts' to combine the results of numerous species distribution models and calibration datasets to account for a greater range of uncertainty in the output. However, ENMs are usually projected onto a limited number of climate scenarios, and do not allow an assessment of the biases associated with small sample sizes, or provide guidance as to the likelihood of species range shifts occurring across the variability of climate model projections.

Here, we describe how we advanced ENM ensembles to a) incorporate multiple climate scenarios derived from alternate emissions scenarios, climate models and model runs (realizations), and b) develop probabilistic distributions functions (PDF) showing the likelihood of range shifts across 11 frog species from the family Microhylidae. These leaf-litter frogs are of significant conservation and ecological interest; they are endemic to Australia's Wet Tropics, and are recognized as being among the most geographically restricted vertebrates of the region. Small and cryptic, the frogs lay eggs in terrestrial environments before direct development into fully formed froglets.

Using the R-package BIOMOD, we created models of each species current distribution. Scenarios of future climate were created with an R-based package we are developing, that enables the downscaling, projection and conversion of climate model netCDF files into the 19 commonly used BIOCLIM variables of direct relevance to impacts modelers. PDFs consisting of more than 250 projected distributions (based on eight ENMs, 30 climate scenarios derived from six climate models, two emissions scenarios, and up to nine realizations) were calculated for each of three time periods (2030, 2050 and 2070). While the PDFs will remain dependent on the conditions sampled, our ensembles currently provide the most thorough exploration and incorporation of uncertainty in estimates of species' future range shifts.

## Climate and weather impacts on tourism in New Zealand

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Climate and its manifestation as weather are important facilitators for tourism, and changes in climatic conditions are therefore important for its ongoing viability. Projected changes of climate relevant for New Zealand tourism include a drier east and wetter west, increased westerly winds, increases in number and frequency of extreme events (especially tropical cyclones in the North), and sea level rise. Little is known about how these changes will affect tourism. This research reports on how weather - in the first instance - interacts with the tourist experience. Three data sources have been used for the analysis: i) the International Visitor Survey (IVS, N= 5,292), ii) an archive analysis, and iii) a climate/weather tourist survey. In the IVS, questions around tourists' highlights, disappointments and recommendations were analysed for weather specific components. The results show that weather does not have a major influence on tourists' overall satisfaction, but it does interfere with route planning and activity participation. Tourist characteristic variables, such as country of origin or travel style, have a moderating influence on how tourists perceive the weather and how well they are able to cope with changing conditions. The analysis also reveals a range of place-activity combinations that are particularly vulnerable to adverse weather conditions. This research on the tourist-weather interaction will be enhanced by detailed analyses of business vulnerabilities.

## Mosquitoes and Climate Change in Australasia

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There is much speculation on what the effects of climate change may play on mosquito distributions and in turn on mosquito-borne disease. This reflex is often based on the unfounded premise that warmer temperatures will lead to expanding mosquito distributions resulting in increase mosquito-borne disease. The use of models in trying to understand these relationships is one approach, but without sound knowledge of the history, biology and ecology of mosquitoes and their pathogens, the outputs from modelling can be deceptive. In this presentation I will discuss these issues in terms of our region of Australasia and highlight the gaps in our current knowledge with respect to our mosquitoes and the human pathogens they can transmit.

## Coastal retreat contribution to carbon cycle of Arctic Ocean on example of Yamal coast, Kara Sea

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Arctic carbon cycle makes a substantial contribution to total carbon cycle of the Earth. During the last 15 years a lot of papers arisen dedicated to calculation of stocks and fluxes of C-containing materials in Arctic. However almost no direct researches were conducted to distinguish the exact amount of carbon coming to ocean with coastal retreat. Meanwhile this input can increase with warming due to accelerated erosion. Less extensive sea ice creates more open water, allowing stronger wave generation by winds, thus increasing wave-induced erosion along arctic shores. Rising temperatures also contribute to the thawing of permafrost and correspondingly increase coastal erosion and carbon input to the sea. The aim of our investigation was to estimate fluxes of particulate organic carbon (POC) and particulate inorganic carbon (PIC) from terrestrial to marine area through coastal erosion on the exact place - near Kharasavey settlement on the western coast of Yamal Peninsula, Kara Sea, Russia.

Coastal dynamics were observed near the Kharasavey settlement during the summer of 2008, adding an additional year of data to an existing long-term record. Here stationary observations are conducted along a 21 km section of the coastline from Cape Kharasavey to Cape Burunniy. The northern half of this section is relatively stable, while the southern half was observed to be retreating. Observations were carried out using repeated geodetic surveying from 33 benchmarks which were set up in 1981. The rate of bluff erosion was measured in both natural and human influenced environments. In total, data on coastal erosion have been collected for an extensive coastal section of the Yamal Peninsula over a long time period (1981-2008 yrs). Using these data, we estimate the scale of morpholithodynamic processes. The average long-term rate of coastal erosion ranges from 0.2 to 2.8 m per year along the coast. As a result of coastal erosion, 47500 cu.m. of unconsolidated matter moves into the water from the Kharasavey coastal section per year. Up to 80% of the eroded material is composed of fine-grained fractions.

Simultaneous with direct observations of coastal dynamics in 2008, sediments from the coastal bluff were sampled along the same coastal section. At each point, samples were taken from the main lithological units and from the organic-rich upper part of the coastal bluff. Total carbon (TC) and total organic carbon (TOC) content in these samples leads to calculations of the carbon flux into the sea along a 10 km of the shore.

## **The best heat wave index for local climate adaptation: associations between measures of temperature and mortality in Victoria, Australia, 1990-2000**

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<sup>1</sup>The Australian National University

Positive associations between temperature and mortality have already been well established in overseas and Australian settings, with mortality increasing by approximately 1-3% for every 1degC rise in temperature (1). Increased mortality is most obvious during periods of extreme high temperatures (or "heat waves"), but heat-related mortality also occurs outside of these defined periods. Climate change scenarios predict rising urban temperatures, which are likely to result in increased mortality rates. The result of inaction concerning heat events is, literally, life or death for many people.

A key adaptive process in response to an environmental threat is the development of public health advice and warning systems. The first requirement for establishing an effective warning system is a clear definition of what constitutes 'high' or 'dangerous' heat, specifically with respect to health outcomes.

At present, a variety of temperature metrics are being used in research and weather forecasts. Some metrics are based on air temperature alone, such as daily maximum or average temperatures, or the number of consecutive days over a temperature threshold. Other heat indices also consider additional meteorological factors such as humidity, radiation and wind speed. There is currently no consensus on which metric is 'best' and most closely associated with changes in mortality.

Our research identifies the temperature metric that best represents the empirical relationship between temperature and mortality in Australia. The results of a pilot study using data from Victoria will be presented.

Trends in daily all-cause mortality were analysed for Victoria, for 1990 to 2000. Daily weather data from the Bureau of Meteorology routine monitoring sites was used to estimate local exposures. We first examined the relationship between mortality and traditional measures of temperature (daily maximum, daily minimum and daily average air temperature, and diurnal temperature range). Further analyses examined mortality associated with some of the most widely used heat indices (wet bulb globe temperature (Australian approximation), apparent temperature, relative strain index, heat index and humidex) to examine whether these would more accurately represent the association. Associations between temperature metrics and daily mortality were examined using Poisson regression with distributed lag and spline models. Analyses were adjusted for age, sex, place, season and day of the week / holidays.

This research will identify the temperature metric that has the optimal relationship with mortality, and may indicate a need to review and adjust existing heat warning systems in Australia.

## **Institutional Challenges to Climate Change Adaptation in NSW, Australia**

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Adaptation to sea-level rise and climate change is a complex and dynamic process that requires institutions and governance to respond effectively to changing environmental conditions and growing socio-economic needs. This foster presents the role of institutions in shaping adaptive capacity of New South Wales (NSW) coastal communities. It argues that conflicts about sea level rise responses are outcomes of institutions in place (or lack of them) which fail to respond to the problems within the context of coastal environmental limits, increasing risks and social-cultural and economic development needs.

The inherent complexity of the coastal environment combined with a potentially changing storm regime and sea-level rise can be extremely difficult to cope with. Climate change is likely to increase the frequency and intensity of storms. In NSW, the incidence of '100 year storm surges' is expected to increase on average to once every 40 years. Elevated sea-level provides a higher base for storm surge to build upon, aggravating coastal erosion and flooding in the process. By and large, the currently retreating beaches will retreat further and faster. Relatively stable beaches will begin to retreat and the

proportion of accreting sand will decrease. By 2100, coastal inundation in NSW would invade about 45 to 90 metres inland primarily affecting more than 1000 kms (69 percent) of NSW sandy coastline. While more than 400 kms (30 percent) are rocky and erosion is less likely, coastal settlements in rocky areas or cliffs can be at risk from increasing wind hazards.

The effectiveness of adaptation to sea-level rise and climate change in NSW is largely constrained by institutions which define current economic and development priorities and coastal planning and management direction. Problems of coastal erosion and flooding epitomize the incompatibility between society's persistence to settle and develop the hazard prone coastal areas. Current state and local government policies and institutional arrangements still fail to discourage development and settlement on environmentally fragile coastal areas. As current institutions define sea-level rise and climate change merely as environmental problems, the classic response is heavily dependent on technological fixes with narrow consideration of the wide gamut of economic, social-cultural and coastal environmental dynamics.

The failure of three levels of governments in NSW to deal with adaptation challenges is deeply rooted in systemic breakdown of institutions and decision-making systems, and conflicts between sustainability and economic development priorities. Current institutions fail to consider sea-level rise and climate change as cross-cutting issues, requiring a comprehensive and integrated management approach. Instead, these problems are interpreted merely as environmental problems and become the basis for politically acceptable adaptation strategies that lack effectiveness. For sea level rise and climate change responses to be effective, there is a need to create a proactive institutional system which facilitates appropriate responses to increasing risks and accommodates dynamic socio-cultural and economic development needs while sustaining ecological processes.

## Information overload and risks in climate adaptation for local government authorities

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Local governments face many and varied risks related to extreme weather events and climate change. At present over 40 councils have received funding from the Australian Government Local Adaptation Pathway Program, with a myriad of others having undertaken self-funded climate change risk assessments and adaptation plans. Many of these councils are experiencing dramatic shifts in population and responsibilities; many have only basic historical observations collected over a period much shorter than the important low-frequency climate drivers and limited access to the climate research community.

Framing a strategy for climate-related resilience for Council operations requires:

- an appreciation of the varying exposures and vulnerabilities to extreme weather events for important communities across the relevant region,
- estimating the likelihood of events of various severities (based on historical observations of often limited extent) and
- appraisals of how exposures and vulnerabilities are likely to change in a warming climate and expanding infrastructure.

However, there is a vast array of climate change models, IPCC emissions scenarios and academic literature that present an assortment of guidance. As results from the risk assessments are heavily based on the future scenarios chosen, it is essential to appreciate the complexities of General Circulation Models (GCMs) and the role of climate variability and what the results means for local government planning. The authors argue that the vast array of climate data that exists often leads to confusion for the risk assessors and end users of risk assessment results. Poorly chosen (or explained) climate change scenario inputs and poorly-understood return probabilities for extreme events (especially related to the intensity-duration-frequency relationships needed for engineering and planning strategies in coastal environments) may lead to mal-adaptation and potential litigation for local governments.

To highlight the complexity, the results from climate change projections of five GCMs (CSIRO Mk 3.5; ECHO - 3G; IPSL CM4; MICROC 3.2; MRI CGCM), a single GCM (CSIRO Mk 3.5) and results from the new 20th Century Re-analysis Project looking at long-term climate drivers of extreme events are used to show the variety of outputs for informing council decision-making processes.

The authors show that the differing results can have considerable implications for local government strategic planning, development assessments and understanding of general local government and community risks. The authors introduce examples from Eastern Australia and provide a comparative analysis of the quantification of risk results.

## Climate change and adaptation in coastal zone: case study of south western region of Bangladesh

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Climate change and its impacts are now one of the most important issues now-a-days. Some impacts such as sea level rise, precipitation change, floods and drought are certain. It is getting more focus on extreme events and salt water intrusion in the coastal zones. Assessing the previous trend and recent observation has shown the risk of continuing rapid climate change in the coastal zone and the significance of long-term adaptation to avoid these impacts. The existing coastal flood control structures are not adequate to adapt these changes. The study aims to develop a comprehensive understanding of the possible effects of climate change in the coastal

zone and mainstreaming climate adaptation into coastal zone management to facilitate policy development. Here adaptation has been limited to structural adjustment for the existing flood protection structures.

South west region of Bangladesh has been selected as the case study area for the implication of adaptation measures. The topography of the area is flat and gently sloping towards Bay of Bengal. The river system is very complex and is influenced by the downstream tidal water level fluctuation. The flat topography gives rise to a strong backwater effect, and there is considerable seasonal variation between the saline water and freshwater – with freshwater dominating during the monsoon and the saline front penetrating further inland during the dry season. The time series of average annual rainfall at different stations in the area shows small increasing trend. Moreover, the severity of the storm surge has increased because of climate change causing failure of existing flood control structures. Salinity intrusion is a major issue in this area and may increase due to sea level rise. Major part of the area is covered with dykes against river flood. The first most important adaptation to climate change would therefore be to build or maintain appropriate drainage infrastructure along coastal embankments. In fact flow regulators had already been incorporated in the design of existing embankments. However, in many cases the required number of regulators was not built as per design. In other cases, even if the regulators were built, they lacked proper maintenance and consequently failed to serve their intended purpose. Therefore building of new drainage regulators along coastal embankments needs to be complemented by an assessment of the need for renovating existing regulators, followed by periodic monitoring and maintenance. The second adaptation strategy will be to reduce the threats of increasing salinity, particularly during the low flow period. This may involve a range of physical adaptations to offset salinity entrance, including: (a) increasing freshwater flows from upstream catchment; (b) recovery of existing river networks towards improving flow regime; and (c) development of existing river networks to facilitate freshwater flow regime along the rivers supplying freshwater to the coastal zone.

An integrated hydrodynamic model, which is a combination of surface and river parts, was utilized for flood simulation. A newly developed salinity flux model was integrated with the existing hydrodynamic model to simulate floods and salinity in the complex waterways. The hydrodynamic model uses the one dimensional unsteady dynamic wave form of St Venant's equation for river flow simulation and two dimensional unsteady equations for floodplain flow. The river salinity model uses Advection Dispersion equation in the longitudinal case using explicit solution scheme. The tool was applied under a range of future scenarios. The results show the sensitivity to flood from the changes in various climate parameters. The results also give a basis for the consideration of adaptation by showing the degree and distribution of the possible impacts. These types of impact estimation would be of value to flood plain management authorities to minimize the socio-economic impact.

## Effect of different plant functional groups on methane emissions from wetland ecosystems

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Methane is a potent greenhouse gas (GHG) and wetlands are its single largest natural source. Plants are one of the major factors influencing methane fluxes from wetlands along with temperature and water table. Various plant species have been shown to have a positive or negative impact on methane fluxes, by affecting different mechanisms involved viz. production, consumption and transport. Therefore, a shift in species composition may have drastic effect on carbon balance of wetland ecosystems. For anthropogenic reasons such as eutrophication, many wetland ecosystems show species shifts from slow growing low productive species towards high productive fast growing species. In general it is believed that methane emissions are directly proportional to plant biomass. It implies that with increased productivity of wetland ecosystems, methane emissions may drastically increase. However, it has also been demonstrated that higher belowground biomass reduces methane fluxes. Current knowledge about relative behaviour of species in relation to methane emissions is rather poor. A relationship between methane emissions from wetlands and plant functional groups, if any, may help in estimating current scenarios and also in making model-based predictions, which in turn could assist in designing appropriate mitigation strategies. Here we present a large scale screening experiment to investigate the comparative effect of 20 different forb and graminoid species from European wetlands (both low and high productive) for their ability to influence methane fluxes from peat cores. A novel sealing technique was used to study the gas transport through plants i.e. the chimney effect. Differences in chimney capabilities of different plant species ranged from 30 to almost 100 percent of the total flux. Graminoids exhibited a higher gas transport capacity than forbs. On the whole, most of the species (12 out of 20) significantly reduced methane emissions, whereas only one species *Succisa pratensis* caused significantly higher emissions as compared to bare pot control. On the whole, species adapted to low productive habitats resulted in higher emissions than those belonging high productive habitats. On the basis of our experiments, we conclude that a shift in species composition towards high productive species may indeed reduce methane emissions from wetlands.

## Could non-cash rewards change behaviour and motivate homeowners to respond to the risk of flooding caused by dangerous climate change?

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It is estimated that 5.2 million properties in England, or one in six homes, are threatened by floods. Within this number, nearly half a million properties are located in areas subject to a significant (greater than 1 in 75 years) risk of flooding. While many of these properties are protected through existing or planned structural defences, it is estimated that about half of the households currently in areas identified as at significant risk of flooding might remain unprotected. Furthermore, the number of people at risk of flooding



is significant and is likely to grow with the progressing climate change as the projections identify increase in winter precipitation. Therefore, for many houses, property-level measures could be the only flood protection available to owners in the future. To date the uptake of property-level flood protection improvements in England and Wales has been minimal and less than 5,000 homes have adopted these measures. This is associated with the cost of these measures, which range between £4,000 and £30,000 per house and, therefore, is unaffordable to many. While the State's expenditure on subsidies would not be feasible, incentivising the house owners to purchase and install flood protection measures could result in their better implementation. It has been found that non-financial incentives (e.g. vouchers for fruit and vegetables or free bus travel) can be more effective in influencing sustainable behaviour than financial incentives. They also can bring additional sustainability benefits. This paper addresses the maintenance and improvement of liveability of cities under the climate change. It reports on research carried out within the 'Resilient Homes' initiative which has been promoted and funded by the Environment Agency for England and Wales. The overall goal of the Resilient Homes project was to examine the potential of a Non-cash reward scheme to increase the adoption of energy-saving and flood protection measures by the house owners. Attitudinal telephone survey has been carried out with 1,043 home owners living in flood risk areas in England and Wales. The survey investigated respondents' awareness of floods and perceived risk, their willingness to install and pay for flood resilience measures and their willingness to accept non-cash rewards for doing so. The results suggest that while cash incentives are the preferred motivation option for respondents, nearly 60% would be motivated to install flood-protection measures if they were offered non-cash rewards. The most popular rewards were vouchers for fruit and vegetables, followed by free meals at restaurants, while free bus travel was the least popular. There were positive associations between factors such as the level of concern about climate change, awareness of living in flood risk area, perceived future risk of flooding and feeling of responsibility for protection of one's property, and the willingness to accept non-cash rewards. Interestingly, over 80% of those who would accept non-cash rewards would be happy with their value not exceeding the value of their investment into flood protection measures. In addition, those willing to pay more for flood protection measures were interested in lower value of rewards. These results suggest that non-cash incentives could be used to promote the property-level flood protection measures. Furthermore, considering the fact that respondents were content with their value lower than the value of their investment, non-cash incentives could be more financially feasible than cash subsidies. However, the level of people's awareness of climate change risks needs to be raised first to increase their interest in the flood protection measures. The paper will conclude with the results of a trial conducted in a flood-threatened area of Greater Manchester where householders were offered a range of incentives. The paper will describe the engagement process, and the way in which the householders responded to the reward scheme."

## **Lifestyle identity driver reef tourism enterprise resilience and propensity to conserve the Great Barrier Reef**

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The Great Barrier Reef (GBR) is one of the world's premier Marine Protected Areas. Tourism in the GBR contributes AUD\$ 5.8 Billion to the Australian economy per annum and sustains 55000 jobs. Tourism to the GBR is stagnating, whilst the reef itself is under threat from the combined effects of climate change and sediment and pollutant runoff from adjacent catchments. Maintaining a sustainable tourism industry and a healthy reef is central to the future social and ecological integrity of the GBR. The resilience of reef tourism enterprises to climate change-induced and other disturbances, as well as enterprise propensity toward reef conservation in their operations are thus integral to the future of the social-ecological system centred on the GBR. The resilience of reef-tourism enterprises to climate change-related and other systemic shocks as well as their propensity for reef conservation was measured through a survey of 48 reef tourism enterprises. Enterprise resilience to systemic shocks was measured through a composite scale. Propensity for conservation was measured through a Likert scale questioning enterprise attitude towards minimising the environmental impacts from tourism, even if it increased operating costs. Lifestyle identity, business characteristics and the extent to which enterprises can draw on human, social, physical, financial and natural capital in the face of disturbances were hypothesised and measured as the explanatory variables in this study. Lifestyle identity, measured as the extent to which owners and managers of reef tourism companies are in the industry for lifestyle reasons was the strongest determinant of enterprise's propensity for conservation ( $r_s = 0.405$ ,  $p = 0.004$ ,  $N = 48$ ). The results of a binary logistic regression analysis showed that human capital ( $p = 0.01$ ) and lifestyle identity ( $p = 0.02$ ) were positive determinants of enterprise resilience. Reef tour operators with a high lifestyle identity score were thus more confident in their business's ability to cope with climate change or other disturbances to the reef tourism market and showed a stronger propensity for reef conservation. These results suggest a need for the consideration and promotion of lifestyle values among reef tourism enterprises to strengthen the resilience of the vulnerable reef tourism industry and support reef conservation.

## **Small in a small island state: implications of climate change adaptation on human security in the Solomon Islands**

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In least developed countries (LDCs), one of the risks in mainstreaming adaptation to climate change into national policies is to perpetuate or exacerbate existing inequalities and vulnerabilities of marginal groups and communities. Human adaptation to climate variability and change is specific to people and places; therefore policies and the implementation of national adaptation activities require informed consent of people or communities concerned in order to be considered fair and successful. Recognizing this dilemma, participatory vulnerability assessments in local communities have been

one of the keystones in the preparation of the LDCs National Adaptation Programs of Action (NAPA), and a criterion for access to adaptation aid from the least developed countries fund (LDCF). As a result, the shortlist of priority activities in the NAPAs ideally addresses the immediate needs and concerns of the most affected and vulnerable communities.

This paper explores the outcome of the NAPA process in the Solomon Islands and its implications for marginalized communities in remote low-lying islands. It considers how factors such as culture, language, living conditions and geographical setting influence climate risk and vulnerability. Based on these findings, it is proposed that the implementation of the NAPA priority for low-lying islands in the Solomon Islands – i.e. applying relocation as an adaptation measure - risk creating new vulnerabilities and threats to these communities, rather than promoting human security and sustainable development. The paper argues that any future adaptation planning should make special efforts to recognize and involve the voices and priorities of local communities and particularly vulnerable groups.

I will present the findings from research in the Solomon Islands in 2006 and 2009/10, which involved field work in two different groups of remote low-lying islands; the Reef Islands in Temotu province and Ontong Java atoll in Malaita province. Results are based on quantitative and qualitative methods, mainly framed by DFIDs 'sustainable livelihoods' approach. The research forms part of my PhD at the Department of Geography and Geology, University of Copenhagen

## Future makers or future takers? A scenario analysis of climate change and the Great Barrier Reef

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The extent to which nations and regions can actively shape the future or must passively respond to global forces is a topic of relevance to current discourses on climate change. In Australia, climate change has been identified as the greatest threat to the ecological resilience of the Great Barrier Reef (GBR), but is exacerbated by regional and local pressures. Although there is great concern among GBR institutions about uncertainty surrounding climate change and other threats, and a recognition of the need for longer-term planning, ongoing and integrated strategic planning by these institutions has been limited.

Scenarios—alternative future visions—provide a mechanism for individual and collective consideration and articulation of perceptions and aspirations for the future, and the opportunities and risks that may be associated with particular decisions. Scenarios can help to illuminate the enabling conditions for and constraints on current and future management approaches and strategies, identify possible adaptations and ultimately assist agencies such as those in the GBR to move from a position of 'taking' to 'making' desirable future change.

Using existing data, models and regional scientific knowledge, we undertook a scenario analysis to explore how two key uncertainties may influence climate change impacts in the GBR region in 2100: whether (1) global development and (2) Australian development is defined and pursued primarily in terms of economic growth or broader concepts of human well-being and environmental sustainability, and in turn, how climate change is managed or mitigated. Scenarios depicted four futures: one in which global and Australian development are both based on an economic growth paradigm, resulting in a lack of global action on climate change and no regional mitigation (Trashing the Commons); one in which global development is based on an economic growth paradigm but Australia adopts a sustainability paradigm focused on increasing broader societal well-being, resulting in a lack of global action on climate change but mitigation at the regional scale (Treading Water); one in which global development is based on a sustainability paradigm but Australia pursues an economic growth paradigm, leading to a progressive global agreement on climate change but no regional mitigation (Free Riders); and one in which both the world and Australia adopt a sustainability paradigm and climate change is addressed proactively at both scales (Best of Both Worlds).

We compared the implications of these four scenarios for marine and terrestrial ecosystem services and human well-being. The results suggest that while regional actions can partially offset global inaction on climate change until about mid-century, there are probable threshold levels for marine ecosystems, beyond which the GBR will become a fundamentally different system by 2100 if climate change is not curtailed. Management that can respond to pressures at both global and regional scales will be needed to maintain the full range of ecosystem services. Modest improvements in human well-being appear possible even while ecosystem services decline, but only where regional management is strong.

Our analysis points to a need to design management responses for the GBR region that account for cross-scale processes even if appropriate global responses and institutions do not exist or if there is limited apparent scope to influence these from below. Furthermore, the future of the region depends largely on whether individuals, as well as national and regional decision-makers, choose to be active future 'makers' or passive future 'takers' in responding to global drivers of change. Despite uncertainty and knowledge gaps, there is much scope for proactive future making in the GBR, and we conclude by discussing potential avenues for using these scenarios further with GBR stakeholders.

## Changing weather scenario and Western Rajasthan – a case Study

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Drought and famines are natural calamities against mankind in the western part of Rajasthan. It has potential impact on agriculture as well as on surface and ground water resources. In western Rajasthan rainfall plays a major role as most of the agricultural production is dependent on rainfed dry farming. Arid zone of this part is characterized by extreme temperature, sandy storms coupled with meagerness of precipitation. The uncertainty and very little amount of rainfall also have adverse effect on crops. The rainy season commences between June last week to September..However when monsoon fails then not only crop failure but also there is a scarcity of water and in turn these all together affect the socio-economic conditions of the people of this region. The flood in 2006 in Jaisalmer and Barmer districts and deviation in rainy season from the normal time period increases problem for not only farmer but also on implementation of forestry Programmes.

In Arid Zone of Rajasthan specially in western Rajasthan management of trees with agroforestry system is a better option for mitigating Green House Gases, but the changing climate affects both agriculture and forestry sector in this region. Adaptation of the agriculture sector to climate change will be a costly but vital factor for food security, poverty reduction and also for maintaining ecosystem but the key issue is how much it costs and who will pay this. The effect of climate change definitely differ in different parts of the world and looking towards the conditions prevailing in western Rajasthan and changing behavior of weather condition in recent past may leads to deteriorate the situation more worsen in future. It is need of present era to develop technology and agricultural policies and also to work not only with respect to government perspective or business perspective but with respect to society and human kind. The past years data of this region already warn about the future and any further delay may leads to threat of human kind in the arid zone of Rajasthan.

## Prominence given to Climate Change Phenomenon by the Media in sub-Sahara Africa in the Millennium Decade

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Access to Information and is critical adaptation strategy for sustainable development. The study analyzed manifest-content of Newspapers publications on climate change phenomenon in sub-Sahara Africa. Four newspapers were selected for the study namely The Daily Times, the New Nigerian (both government-owned), The Punch and Nigerian Tribune (both privately-owned) newspaper. A total of 4909 editions were reviewed for a decade. Manifest-content on climate change phenomenon that affect small farm holders were considered and expressed in terms of the followings: agro-forestry; irrigation; range management; aquaculture; desertification; and other agricultural related effects. Instrument for the research was an exhaustive code guide with appropriate categorization of construct (variable). Data were analyzed with the usage of Percentage, Means, ANOVA, and Duncan Multiple Range Test. The study showed that climate change phenomenon received very low level (42.3%) of reportage among the Newspapers despite the devastating effects of climate change on man and his domesticated animals. In addition the study revealed a very low level of prominence given to climate change information as reflected in page positioning (about 82% of the published articles were not found on the front and back pages). Furthermore, only 18% of the aggregate information was presented with streamer headline which is indicative of less prominence. Statistical evidence showed that there is significant difference in the level of prominence given to climate change phenomena reported among the four newspapers. The mean numbers of words used in reporting climate change information in the selected newspapers were 282(words) for New Nigeria, 202(words) for The Daily Times, 264(words) for Nigerian Tribune and 271(words) for The Punch Newspaper. Spaces allotted to climate change news were 0.03m<sup>2</sup> for New Nigeria, 0.04m<sup>2</sup> for The Daily Times, 0.039m<sup>2</sup> for Nigerian Tribune and 0.04m<sup>2</sup> for The Punch, comparatively to 0.12m<sup>2</sup> available per page There is a significant difference (P

## A Synthesis of Practice and Theory: Enhancing Agriculture's Capacity to Adapt to Climate Change

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This paper contributes to research on the theme of Institutional Adaptation, a part of the Victorian Climate Change Adaptation Program (VCCAP). The research progresses a participatory approach to the development of an Adaptive Capacity Index (ACI). An ACI is a composition of indicators that characterises a region's capacity to adapt by highlighting societal and geographical variation across space. Research into institutional components of adaptation is an emergent and significant topic due to an increased recognition of the importance of an individual's perceptions and values as well as societal determinants that influence adaptive capacity.

Victoria's south-west dairy industry was the focus of this research due to; (1) the south-west region being the focus of VCCAP research, (2) the dairy industry being of significant economic importance to the region, and, (3) the potential vulnerability of the dairy industry to the effects of climate change; namely from projected reductions in rainfall and increased maximum temperatures. Through deliberative workshops with participants both directly and indirectly related to the dairy industry, an industry specific ACI was developed. Two key insights emerged as a consequence of participant observations, surveys and documentary analysis. The first relates to the key outcomes of the workshops and participants perceptions of what contributes to adaptive capacity. The highest ranked and weighted indicators were consistently around themes of education,

socioeconomic status, demographic change, community involvement and human well-being. These indicators were capable of being spatially mapped for the whole of Victoria and could be used to target policy intervention.

The second insight derived from reflection on the process, analysis of the data gathered and then a synthesis with current theory on adaptive capacity, to provide an approach government's could undertake to better engage and facilitate regionally-specific climate change adaptation. Key needs would be to develop a learning-focused, long-term engagement process, where government acts as a facilitator and works alongside regional institutions. The necessity of a long-term-regional engagement process is underpinned by the nature of climate change impacts, which will be locally-specific and will occur over long temporal scales. Furthermore, time will be required to develop trust, ownership and build the capacity to learn through experimentation. This research suggests that a methodology, modelled on an adaptive co-management approach, which combines and builds on the strength of systemic thinking, adaptive management and social learning, could be a possible way forward.

The value of this paper is that it demonstrates an attempt in-practice to measure adaptive capacity and build the capacity of those directly impacted by climate change whilst reflecting on the process to determine a way forward. Such a reflective practice contributes to the body of knowledge on adaptive capacity whilst building the capacity of institutions to learn. This approach is applicable to other natural resource based sectors and/or vulnerable communities as any future application could test the strength of this approach.

## Water Pipe Failure Predictions under Different Climate Change Scenarios

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Water authorities use simulation tools to help manage their networks. These tools are based on different types of failure prediction models (e.g. statistical, physical) and allow various management scenarios to be investigated so that the 'best' asset management strategy can be selected. A statistical failure model has been developed in previous research, which predicts the yearly number of pipe failures in a network located in the Melbourne area. Pipes react differently depending on their characteristics (e.g. diameter, material) and their environmental conditions (soil movement potential, weather conditions); consequently such parameters are input to the model.

Because weather impacts the condition of infrastructure and with the threat of climate change, especially through an increase in the number of severe climate events, we are expecting to see intensification in the deterioration of our city infrastructure. A report from the Victorian government has highlighted that buried water pipes would be impacted due to increased ground movement resulting from such events. The need for models including weather parameters is thus becoming critical, as projections of network performance and costs need to take into account climate change.

Using climate change scenarios to produce the weather parameters required by our model, we are able to quantify the impact climate change will have on buried water pipe networks. This paper presents pipe failure predictions using two climate change scenarios and compares them with a baseline scenario which assumes there will be no change in climate over the next 100 years. The expected number of failures for each year in the future and cost estimations are presented, assuming no asset management strategy. This can be used to assess the long term performance of the networks and also to determine the direct economic cost of each climate change scenario on the network maintenance. This model has the potential to be integrated into software to allow more accurate simulations using diverse management strategies and climate change scenarios.

## Response to elevation CO<sub>2</sub> of various genotypes differing in tillering, WSC accumulation, transpiration efficiency and early vigour

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Atmospheric CO<sub>2</sub> levels have been increasing from about 280 ppm in the pre-industrial era to 379 ppm in 2005 (Tans, 2009); and the majority of the greenhouse gas emission scenarios considered by the Intergovernmental Panel on Climate Change (IPCC) estimate that the atmospheric CO<sub>2</sub> concentration will not stabilize before at least another hundred years (Bernstein et al., 2007), and the level at which it will stabilize depend heavily on the actions that we undertake in the next 10 to 20 years. Higher CO<sub>2</sub> concentrations might stimulate photosynthesis in C3 plants such as wheat, but large variations have been reported in the literature in the response to elevated CO<sub>2</sub>, and increases in yields in field trials tend to be more modest (around 8% in free-air CO<sub>2</sub> enrichment as opposed to 22 to 33% in chambers, Long et al., 2005). Those studies that have looked more closely at the physiological basis for this increase in yield have observed higher tillering (Gifford, 1977; Sionit et al., 1980; Sionit et al., 1981a; Sionit et al., 1981b; Ziska, 2008), higher water use efficiency (Gifford, 1979; Samarakoon et al., 1995), and higher nutrient efficiency (Sionit et al., 1981a; Drake et al., 1997). The objective of my current study is to determine the response to elevated CO<sub>2</sub> of 20 genotypes which differ in tillering, WSC accumulation, transpiration efficiency and early vigour.

Our hypothesis is that genetic variability in the response to elevated CO<sub>2</sub> does exist in wheat, and that the traits mentioned above are partially responsible for this variability. In addition, as these traits are of considerable interest to current breeding programs, it is important to determine if these traits are still useful in a high CO<sub>2</sub> environment.

For example, would low tillering / low WSC lines still show low tillering / low WSC accumulation under high CO<sub>2</sub>? If low tillering lines do maintain low tillering, would they accumulate high levels of WSC, beyond what they currently exhibit, and would this be useful? Would high transpiration efficiency cultivars, such as Drysdale, still have superior performance in dry conditions if elevated CO<sub>2</sub> concentration increases transpiration efficiency in all lines?

Two experiments were performed since June 2009. Plants were grown in growth chambers in the CEF with CO<sub>2</sub> levels controlled at 420 ppm (ambient) and 700 ppm (elevated), and 24/18°C day/night temperatures. Plants were also grown in the glasshouse compartments with, again, CO<sub>2</sub> levels controlled at 420 and 700 ppm and 24/15°C day/night temperatures. A third chamber was included with elevated CO<sub>2</sub>, and 28/22°C day/night temperatures to evaluate the effects of higher temperatures combined with the elevated CO<sub>2</sub>. Seeds were selected for homogeneity and seeded four per container in tall columns (10-cm diameter and 100-cm height) filled with the University of California mix C (Chandler et al., 1979), and watered daily with pressure compensated drippers. After establishment, plants were thinned to two per columns: one marked for physiological measurements, the other was used for gene expression analysis. An effort was made to select lines with similar height and time to flowering, as well as lines with similar genetic backgrounds for contrasting trait expression.

The two experiments included detailed characterization of the leaf appearance, tiller development and developmental stage of wheat genotypes. The Haun's score (Haun, 1973) was evaluated twice a week until flowering, and the number of tillers was recorded at the same time. The Zadok score (Zadok et al., 1974) was also recorded from stem elongation to full flowering. A destructive harvest was also performed in the two controlled environment experiments at flowering, where leaf area and biomass were determined as indicators of wheat growth. Non-destructive measurements of the maximum width and length of the first four leaves were also recorded as an indication of early growth. Water soluble carbohydrate accumulation in stems was also evaluated. During the second experiment, in the glasshouse, photosynthesis and transpiration rates were collected once a week on half of the plants in each of the three chambers with a LICOR 6400 (LICOR Biosciences).

## From climate change science to adaptation planning and decision making: The Ouranos experience

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This presentation will discuss how Ouranos, a consortium on regional climatology and adaptation to climate change initiated in 2001 in Canada and supported by an increasing number of members, has created an applied research environment that supports the development of useful and relevant adaptation strategies to climate change.

Recognizing that adaptation is a process as much as an end, and that the way adaptation is achieved is at least as important as the measures themselves, Ouranos has brought together science and decision-making in an original structure that promotes high quality scientific research to respond to the needs of decision-makers at various levels, from national government-level through to local communities or targeted groups. Members of the Ouranos consortium include government departments and agencies, research institutions and utilities, but the collaborations triggered by the consortium goes over and above those 18 members as well over 100 organizations are involved in the scientific and technical program which has a global budget of approximately 10 millions CAN\$/year on average. Now seen as a key institutional tool to facilitate adaptation in the province of Quebec, the organization follows many of the characteristics of a boundary organization, acting as an interface between researchers and its members within a very flexible framework. Offering facilities to house 100 specialists, Ouranos activities are usually achieved by project teams consisting of Ouranos employees, contributed personnel provided by members and collaborators coming from an extended network of experts and adaptation stakeholders maintained by Ouranos. This "action-research" approach allows for more relevant projects to be developed, includes multidisciplinary perspectives from the beginning, facilitate mainstreaming by involving adaptation actors and constitute an interesting mechanism to transfer knowledge and information to specialists and decision makers at key decision points.

The two fold scientific and technical program is dedicated to "regional climate science", including the development and use of the Canadian Regional Climate Model (CRCM), and "impacts and adaptation", including 10 thematic or regionally based programs. Both are bridged through a special group dedicated to produce "climate scenarios" required by the impacts and adaptation community. After years of interactions, we come to conclude that there are approximately 4 main types of users, from those using extensively the "top-down" or "IPCC scenario" approach to those using limited climate information through, for example, a "bottom-up" approach trying to assess vulnerability by using existing expertise and knowledge of current situation. We also note that the structure of each project varies between top-down and bottom-up approaches according to the level of understanding of the issue, the availability of expertise and data, the level of awareness of the issue of potential end-users for the study results and type of adaptation decisions targeted.

One of the projects that best illustrates the relevance of Ouranos and its way of functioning is the work done on coastal erosion and flooding in the context of climate variability and change. The project, subdivided into different studies, brought together hydro-climatic experts with specialists in the field of biophysical coastal dynamics as well as three user groups made up of representatives from various level of governments, community groups, sectorial stakeholders that examined possible adaptation options for three communities developing in different socio-economic context. Each group advanced in parallel, exchanging information as the project

developed to base the analyses on the most up-to-date data available, including uncertainties.

The project had many significant spin-offs including:

- Increased awareness and finer understanding of the issues around coastal erosion
- More accurate data and analyses of the biophysical impacts and risks in a climate change context
- Support tools to help decision-makers (cost-benefit analyses of various adaptation options, etc.)
- Implementation of study results for the most optimal adaptation options
- Increased collaborations for an issue that was initially creating extensive confrontation

Other conclusive and multidisciplinary examples include urban infrastructures and land-use planning, permafrost degradation and arctic community development and, most recently, the support for an integrated provincial-wide adaptation strategy in development and lead by the Quebec provincial government.

This presentation objective is to share our experiences on various components that appears important to allow an efficient bidirectional transfer of information between experts and decision makers in order to mainstream adaptation optimally into existing environments, policies, practices and other initiatives.

## **Determinants of adaptive capacity relating to the health effects of climate change: Where does governance fit in the equation?**

**K Bowen<sup>1</sup>**

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Research on the determinants of adaptive capacity relating to the health effects of climate change is in its infancy. Understanding the determinants is the basis on which to strengthen adaptive responses to the health effects of climate change. The role of governance and its relationship with other determinants of adaptive capacity requires further review. Importantly, the provision of adaptation policies in sectors that have a focus on health is vital to complement the public health sector, including for example, urban planning, agriculture and transport. Inter-sectoral and cross-sectoral adaptation strategies are needed in order to reduce the health effects of climate change, as the health sector lies outside the direct arena of adaptation measures – sectors such as water and sanitation, education, trade, agriculture, tourism, transport, development and housing. The aim of this research is to develop an integrated conceptual framework, and associated indicators, of the determinants of adaptive capacity related to the health effects of climate change for developing countries, with particular attention given to the role of governance. Preliminary reviews of existing approaches of defining and measuring the determinants of adaptive capacity related to the health effects of climate change are presented. It is hypothesised that the current conceptual understanding of the determinants of adaptive capacity in relation to the health effects of climate change does not include indirect factors related to health outcomes, including governance frameworks. Field work is currently being conducted in the Asia Pacific region to further understand the governance and decision-making processes within relevant sectors surrounding the processes of developing adaptation strategies in response to the health effects of climate change; preliminary results will be presented.

## **Flood Risk in Australia: A Review**

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The economic and social risks of flood present a growing concern in Australia due to increasing population and prosperity in areas at risk and concerns about the impact of climate change. This study will review the current state of knowledge in Australia vis-a-vis flood risk and identify gaps in the knowledge base and other challenges to better policy and landuse planning needed to reduce the nation's vulnerability to this peril. It will also examine the changing role of insurance in transferring this risk from the individual homeowner. Until recently, most homeowner insurance policies in Australia did not cover damage by caused riverine flood. This is now beginning to change as the Insurance Council of Australia is funding the development of a National Flood Information Database that will allow companies to properly rate this risk. However there is still much to be done in terms of policy development. This project will aim to identify the steps needed to move forward to a more certain future.

## **Climate adaptation strategies and cultural engagements in Mumbai, India: exploring paths to more effective climate governance via mass media communications**

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This paper seeks to address the conference themes of:

- a. adapting to climate change in cities,
- b. risk communication and behavioral change, and
- c. communication of information for adaptation. This paper approaches these intertwined and challenging subjects by exploring four critical, dynamic and intersecting features as they manifest in Mumbai, India.

These are:

1. the continually fraught nature of global North-South relations on climate change,
2. the rise in attention paid to climate adaptation,
3. the increased presence and importance of city-level actors in climate adaptation governance, and
4. the intersections between formal climate science-policy negotiations and everyday culture, political economy, and society.

Mumbai, India is an illuminating case study for four reasons related to those above:

1. India is a fast-growing global economy, yet it remains a developing country (non Annex I). Thus, India has become a key player in ongoing climate negotiations and a key voice in the ongoing North-South dialogues regarding climate governance and action
2. In a changing global climate, coastal India is a region particularly at risk from climate change. Through intertwined issues of human vulnerability, urban inequalities and geographic hazards, Mumbai is a place facing particularly amplified climate-related impacts.
3. Mumbai city proper is considered the most populous city in the world with about 13.6 million people, and is the fifth most populous by metropolitan area (19.2 million). Mumbai is also one of the more densely populated large cities in the world. These factors make it a fascinating space for analyses of urban adaptation to climate change
4. Mumbai is considered the financial centre for India. A natural deep water port contributes to considerable economic activity and makes the city one of the world's top centers of commerce, measured by global financial flow. Similarly, Mumbai is a central hub for Eastern popular culture, home to the Bollywood film industry and associated celebrities. These historically-developed, yet currently salient and intersecting factors in Mumbai make it a case-study that will provide insights for urban climate adaptation challenges and cultural engagement in other spaces and contexts in the years to come. The larger project "contextualizing this paper" pursues how city-level groups, organizations and actors are emerging as key figures shaping formal post-Kyoto climate treaty negotiations "particularly Adaptation Fund discussions" and as important links to informal cultural and societal engagements among urban populations. The paper that Boykoff would like to present at this 2010 International Climate Change Adaptation Conference endeavors to provide a more textured understanding of the interactions between climate adaptation decision-making and stakeholder understanding via media representations of climate change. This project will help ongoing investigations to make sense of emergent architectures of climate adaptation initiatives and programs in Mumbai. The research seeks to help researchers, and practitioners understand how public perceptions, attitudes, and behaviors influence multi-level climate adaptation governance.

To do this, we employ a mixed-method approach:

1. semi-structured interviews with Indian journalists, and
2. critical discourse analyses and content analysis of media representations of climate change. Piloting work has involved interviews with Mumbai-based environmental journalists, and examinations of coverage in the Hindustan Times, the Hindu, Times of India, and the Indian Express. These multi-scale data points seek to better understand climate adaptation strategies in Mumbai, in the context of Indian climate governance. To date, Boykoff has co-authored many articles, book chapters, opinion pieces and reports, and has convened workshops on media representations climate change. However, these analyses have been limited to examinations of Western media representational practices. This paper uniquely then extends into the combination of examinations of media portrayals of climate adaptation, and links between city-level governance, risk communication and behavioral change. How communications on climate adaptation between Mumbai leaders and citizens "in this paper via media representations" confront the formidable challenges and robust possibilities associated with these issues will illuminate the spectrum of possibility for coordinated and substantive action to address threats associated with anthropogenic climate change.

## Adapting economics to climate change adaptation

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The economics of adaptation policies relies on cost-benefit analysis techniques, that are used to identify the relative merits of alternative options. The approach is essentially drawn from the project appraisal literature, and applied to specific adaptation problems (for example, the net benefits of levee construction versus retrofitting buildings in response to sea level or flooding risk). The approach assumes a centralized decision maker – which could be the state or someone else – deciding between plausible alternatives.

In reality, adaptation efforts will reflect, as they have in the past, the efforts of myriad agents, private and public. The key questions thus are: to what extent should these efforts be coordinated to produce a socially optimal adaptation outcome, how might such coordination be achieved, and what is the role of different tiers of government policy in achieving this. These questions go well beyond the standard cost benefit analysis paradigm. The latter supposes a choice between alternatives made by a decision maker. In reality, what we need to do is ask who the relevant decision maker is in the first place, how do we know what the relevant alternatives are, and what can we say about the wider impact of these alternatives?

A starting point is to consider that private agents have incentives to adapt. "Autonomous adaptation" is a possibility where there is pre-existing adaptive capacity, where there is scope for market driven substitution, and where adaptation tends to be a smooth process. Where these conditions do not hold, there may be scope for government intervention.

Moreover, there will be scope for government intervention when the privately beneficial adaptive actions of agents are not socially beneficial. These may be due to standard market failures such as externalities in adaptation. But there may also be inefficiencies in existing product or factor markets. The mis-pricing of water is one such example. If uncorrected, the misallocation of resources resulting from these distortions is likely to lead to actions that exacerbate the impact of climate change, and lead to deficient adaptation policies.

The concept of market failure and the coordination problems that arise as a consequence provide a motivation for government action, and also suggest the types of adaptive action that are appropriate. These are likely to extend well beyond the project type interventions that are considered in the standard adaptation literature, to include such actions as defining property rights, reforming pricing mechanisms, or developing markets for risk.

Quantifying the costs and benefits of these instruments is not straightforward. For a start, there are inherent problems associated with uncertainty, which in the context of adaptation may be particularly acute given the wide range of predicted outcomes for a range of climatic variables. This uncertainty will tend to favour policy approaches that have built in “optionality”. For example planning restrictions may be a less capital intensive way of preventing flood damage than acquiring land for the purposes of levee construction. However, the former carries a high cost potential if the risk of flood damages turns out to be overstated; whereas the latter represents an option that can be exercised as the state of the world becomes clearer.

A second issue is that many interventions will have behavioural consequences that need to be taken into account. Continuing with the example just discussed, it may be that the decision to purchase land to provide the option for constructing levees leads agents to believe that they will be largely insulated from flood risks. All else being equal, this will lead to a more intensive use of the flood prone land than would have otherwise been the case, in turn increasing the projected level of damages associated with a catastrophic flooding event in which the levees fail. This problem may be further exacerbated if, as is usually the case, governments cannot pre-commit against providing ex-post disaster compensation.

These examples are illustrative of the complexity inter-relationships between approaches to adaptation – a level of complexity that increases if one considers economy wide effects rather than sector specific results. Moreover, resolving the trade-offs that inevitably arise across alternative approaches will raise issues of an intrinsically ethical nature (on account, for instance of differences in distributional outcomes).

## Shaping Climate Resilient Development – a framework for decision making

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Climate adaptation is an urgent priority for custodians of national and local economies, such as finance ministers and mayors. Such decision makers may ask: What is the potential climate-related loss to our economies and societies over the coming decades? How much of that loss can we avert, with what measures? What investment will be required to fund those measures – and will the benefits of that investment outweigh the costs?

The aim of the report is to provide decision makers with a systematic way of answering these questions. Focusing specifically on the economic aspects of adaptation, it outlines a fact-based risk management approach that national and local leaders can use to understand the impact of climate on their economies – and identify actions to minimize that impact at the lowest cost to society.

The report is based on the initial findings of a study by the Economics of Climate Adaptation Working Group, a partnerships between the Global Environment Facility, McKinsey & Company, Swiss Re, the Rockefeller Foundation, Climate Works Foundation, the European Commission and Standard Chartered Bank.

Some of the key outcomes of the report are summarised below:

- 1. Designing a Systematic Approach to Climate Adaptation:** Over the past 50 years severe weather disasters have caused some 800,000 deaths and over a trillion dollars in economic loss. Climate change could cause significant incremental loss, even within the next 20 years. The Working Group has developed a quantitative decision making framework built around two sets of tools:
  - (i) First, the framework provides tools to quantify a locations “total climate risk” i.e. the expected annual loss to the location’s economy from existing climate patterns, a projection of the extent to which future economic growth will put greater value at risk and finally an assessment of the incremental loss that could occur over a twenty year period under a range of climate change scenarios based on the latest scientific knowledge;
  - (ii) Second, the framework uses cost-benefit discipline to evaluate a selection of feasible and applicable measures to adapt to the expected risk. The Working Group developed detailed methodology to underpin this framework, and applied it in eight on-the-ground test cases in China, Guyana, India, Mali, Samoa, Tanzania, the UK and US.



**2. Taking Climate Resilient Development Forward:** The framework presented in this report can help societies better understand the climate risk to their economies – and provide vital input into impactful, cost-effective adaptation strategies that boost overall economic development.

**3. Conclusion:** In summary, the report found that:

- Sufficient data exists to make economic related adaptation decisions;
- There is significant economic value at risk:
- under today's climate 1-12% of GDP is at risk by 2030,
- under a high climate change scenario 1-19% of GDP is at risk by 2030;
- A large proportion of the risks identified can be averted:
- for 40-65% of the losses identified the economic benefits of adaptation outweigh their costs;
- Adaptation is no substitute for mitigation;
- Insurance measures help address low frequency, high severity events.

## Assessing the adaptive capacity of Tasmanian producers to climate change

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A DAFF funded three year research project is investigating climate adaptation strategies for Tasmanian mixed farming systems. A total of 25 case study farmers across five regions will be interviewed to assess current and future risks and opportunities for crop and pasture production using the Climate Futures Tasmania (CFT) climate predictions for Tasmania. The response of producers to projected changes to enterprise mix will be assessed during workshops and in one-on-one interviews. This poster presents findings from introductory workshops focusing on the following questions: How do you [farmers] currently manage seasonal climatic variability?; How might they respond differently in the future?; What might prevent you from adopting future strategies?

## Using Scenarios to Explore the Complexities and Adaptation Strategies of Future Arctic Marine Navigation

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The Arctic Marine Shipping Assessment (AMSA) of the Arctic Council was approved by the Arctic Ministers in Tromsø, Norway on 29 April 2009. AMSA focused on Arctic marine safety and marine environmental protection, consistent with the mandates of the Arctic Council, an intergovernmental forum. AMSA can be considered three things: a baseline assessment of Arctic ship data and impacts early in the 21st century; a strategic guide providing adaptation strategies for a host of Arctic and non-Arctic stakeholders; and, a policy document of the Arctic Council, since the 'AMSA 2009 Report' was negotiated and approved by the eight Arctic states. Scenarios and scenarios thinking were used in AMSA to sort out and assist in the identification of the key drivers and uncertainties among the many significant changes ongoing in the maritime Arctic. The scenarios creation effort allowed the AMSA Team to better understand the interplay in the Arctic region among globalization, climate change, governance, natural resource development, indigenous use, Arctic geopolitics, and more. AMSA identified two primary drivers and uncertainties: (A) Resource development and trade; and (B) Governance; four scenario narratives (Arctic Race, Arctic Saga, Polar Lows and Polar Preserve) were developed with these two, key uncertainties as the framework elements. Underlying these elements is that marine access in the Arctic Ocean is changing in unprecedented ways due to the extraordinary transformation of Arctic sea ice in response to global climate change. The changes in Arctic sea ice - thinning, extent reduction, and a reduction in the area of multiyear ice in the central ocean - have significant implications for longer seasons of navigation and for the growth of Arctic marine use. The presentation will focus on the process of identifying the key uncertainties and significant wild card factors that might heavily influence and add considerable uncertainty to the adaptation strategies in response to future Arctic marine operations. Using scenarios within AMSA was one of the keys to developing future adaptation strategies the Arctic states could pursue to build effective and appropriate governance of the global industries operating in the Arctic Ocean. The use of scenarios thinking applied to this complex topic - a complex mix of globalization, climate change and geopolitics - also provided significant insight into how the maritime Arctic is linked to the entire planet in unforeseen ways. Understanding these global linkages, partly through the creation of the AMSA scenarios, was critical in shaping the AMSA recommendations and adaptation responses to climate change and globalization at the top of the world.

## Limits and opportunities for adaptation of forest and livestock-based livelihoods in Northern Mali: Perceptions, levels, and strategies

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Adaptation to climate change is a need and a challenge for ecosystems, for human beings and for governance systems. In West Africa, livelihoods depend heavily on forest ecosystem goods and services, often in interplay with agricultural and livestock production systems.

The area in of former Lake Faguibine in Northern Mali has experienced drastic changes in the ecological, social and economic context, ranging from a drying out of a Niger-fed lake system in the 1970s to ongoing political and societal events including rebellion,

tenure reform and decentralisation. Forests have emerged in the area and have gained importance as part of local livelihoods.

In 2008, field research in Mali took place at different scales: national (Bamako), meso (Timbuktu and Goundam), and local (Tin Aicha and Ras El Ma). Specific objectives of this case study were to assess vulnerability of forest and livestock-based livelihoods, and to identify needs and priorities for adaptive strategies, under climate and societal change. The assessment used participatory methods and tested and adapted different tools in 8 workshops across levels and genders in the specific context of forest and livestock-based livelihoods and climate change adaptation.

Our results highlighted different perceptions on vulnerability and adaptive strategies. Local representatives and community members perceived mobility as a well-established traditional adaptation strategy to climate variability. In contrast, governmental representatives with more technical background perceived mobility more as a risk than as an adaptive strategy. In this context, power and perceptions in reference to specific paradigms (sedentarisation versus mobility), as well as scale, determine the choice and prioritisation of adaptive strategies. In addition, strong divergences emerged between local representatives and representatives of governmental structures across levels regarding the prioritisation of institutional versus technical adaptation. Local representatives argued that technical improvement without institutional change would increase the already existing power struggles and therefore was likely to lead to maladapted use of forest resources. Governmental actors gave highest priority to technical measures and strategies and did not include the institutional dimension in their scoring of adaptive strategies to reduce vulnerability. This focus on technical aspects became obvious also in the results from semi-structured interviews at the national level.

The research results showed that socio-ecological systems were adapting to climate change in an autonomous way, but long-term resource management planning under climate change was lacking. We can conclude that three preconditions can enhance adaptive capacity and avoided maladaptation:

1. awareness of and agreement on adaptation objectives due to the different perceptions across scales and groups, by exchanging knowledge about adaptation needs and techniques;
2. transparency in institutional arrangements regarding rights over forest ecosystem services, by ensuring equity in their access, use and management;
3. flexibility in the broader legal framework provided at the national level to enable planned adaptation at the local level, by transferring planning authority, and accompanied by measures to empower the local level.

Adaptation, even though inherently local, is determined by broader institutional frameworks and will need shared perceptions of the objectives of climate change adaptation among different levels and diverse stakeholders.

## Conservation and Sustainable Adaptation - the Experience of WWF

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Adaptation to climate change is a complex process that involves many sectors of society. The public sector role in adaptation includes providing information on climate risks and vulnerability to support public and private investment and decision making, and protecting public goods such as species, ecosystems, and sites of cultural significance. Private sector involvement is needed to mobilize the vast financial resources needed for adaptation and deliver many of the solutions. What, then, is the role of civil society?

In the area of climate change, the role of Non-Governmental Organisations (NGOs) has progressively changed from that of critical agents lobbying for issue recognition and action, to that of full partners in the epistemic community of climate change. As such, NGOs are active in developing methodologies, frameworks and partnerships for implementation. In the policy sphere, NGOs participate in academic or policy discussions; facilitate and participate in climate change networks, and work with the media to communicate a clear message to the wider public and politicians. NGOs also utilize their extensive networks to engage in action research. In this role they can act as intermediaries or boundary organisations, forming coalitions, and communicating the science that is needed for policy decisions, or the societal changes needed for sustainable adaptation to occur. Ideally, large transboundary NGOs can communicate this policy and practical experience within and between different countries.

WWF is one of the world's largest and most experienced transboundary NGOs. It has close to five million supporters and a global network active in more than 100 countries. In fulfilling its mission, to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, WWF engages with climate adaptation science and policy at national and international levels. Over the past decade, WWF has conducted climate vulnerability and adaptation projects in a diverse array of countries and ecological and social settings. Many of these projects are what is currently referred to as 'ecosystem-based adaptation'. Ecosystem based adaptation uses biodiversity and ecosystem services in an overall adaptation strategy. It includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to the adverse effects of climate change.

This paper will discuss two key questions with reference to case studies from around the globe.

- Firstly, what have we learned from attempts to reconcile developmental and environmental objectives in adaptation practice on the ground?
- Secondly, what roles has WWF played vis-a-vis science, government and the private sector in its adaptation work? Does this experience suggest areas where civil society can facilitate more rapid and effective climate change adaptation?

## Climate Change and Coastal Adaptation Challenges in Albania

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In this paper we review the increasing demand for trans-national GEC research to contribute towards adaptive solutions as the stresses imposed by human activities on the life-support systems of planet Earth become more pressing. Today, the climate and indeed the GEC research community generally faces an increasing challenge to present research results in more accessible and informative ways to stakeholders, especially to policy makers. This demands that inter- and trans-national research builds into political and economic decisions (i.e. that research improves societal outcomes) with an understanding of the kind of information that decision-makers need.

## Understanding Design for planning alternative landscape futures to adapt to Climate Change: Learning from Temporal inconsistencies in vulnerability and adaptation studies

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Current climate change vulnerability studies tend to examine the impact of future climate change scenarios on current social-ecological conditions and patterns of regional landscapes. Future landscapes however, will be quite different from the present. A three-pronged approach to synthesising some characteristics of ecological, social and economic of vulnerability was applied in a case-study of climate change vulnerability and adaptive capacity of the Hunter Coast region of eastern Australia. Sea level rise and other climate change weather predictions were drawn from the maximum scenarios for 2030 and 2070, produced by the Intergovernmental Panel on Climate Change. The brief, 5 month, study undertook biophysical and social-ecological modelling of both the present landscape and three projected future landscapes for the study area; investigated a wide range of social characteristics drawn from the 2006 Census; surveyed the attitudes of the local population to assist in the social analysis; and analysed some key underlying concepts, such as the costs and benefits of adaptation to climate change. Vulnerability was considered in through 3 types of landscape elements: ecological, through predicting landscape change and its resulting biophysical consequences; economic, through examining impacts on built capital and its need for adaptation; and social, as measured in characteristics of the local community that indicate community sensitivity to change and adaptive capacity. A focus of the study was to trial an approach for spatial representation of 3-D vulnerability surfaces as a means for policy makers to rapidly appraise places where multiple vulnerabilities (social, economic, environmental) might stack up and thereby require closer examination and adaptive strategies towards increased resilience. Some key lessons for theory and practice are drawn from the case-study.

## Assessing the Destination Hubs: the Relocation Suitability Index

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This study introduces a new tool developed to address the issue of assisted human migrations from the areas vulnerable to the climate change impacts to the new safer locations. The proposed Relocation Suitability Index (RSI) is designed to evaluate alternative destination hubs based on their ability to absorb the migrants with the least possible impact on the existing physical and socioeconomic infrastructure. It represents an aggregate single value derived from a conceptual framework that integrates diverse factors from various categories such as natural hazards, land use, environment and sustainability, infrastructure, socio-economic status, and geopolitical circumstances. Moreover, the RSI incorporates a novel category unique to this concept named relocation potential, which comprises variables like willingness to move, ability to move, remoteness, size of relocating cohort, urgency to move, and anticipated migration rate, to account for influences associated with the pre-migration parameters. The tabular Index framework contains categorized variables, suggested and validated weights based on their assumed importance, and normalized scores which are further summed up to generate a single value of relocation suitability or RSI for each alternative location. This easily upgradable, expendable, and adaptable tool is designed to respond to different needs of stakeholders and decision makers in exploration of alternatives and responses to anticipated human migrations induced by the climate change. The RSI is compatible with the GIS and other visualization applications that can better demonstrate the most favorable relocation destination hub(s) among the alternatives. It can be used to assess relocation scenarios of different scales and levels of complexity, such as migrations to alternative urban centers, rural locations, or even different counties or neighborhoods by selecting/deselecting the variables that are relevant for the preferred analytical scale. This modeling tool and consequent implementation could help lessen the adverse impacts of emergency relocations and alleviate undesirable pressures on some already strained urban communities, which suffer from various socio-economic downfalls and would not have the capacity to absorb and integrate incoming refugees in any meaningful fashion. As such, RSI could facilitate smoother transition of environmental migrants, as well as methodically foster improved psychological, socio-economic, and cultural adaptation and integration in the new socio-economic structure with the least possible adverse impacts on the indigenous population.

## Zambia Climate Change Risk Case Study

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Climate Risk Case Studies are elaborated as a part of IFC's Adaptation Program, whose overall goal is to develop general tools and methodologies to assess risks and opportunities resulting from the impact of climate change that could affect the private sector, and to evaluate appropriate responses. Given IFC's role as a public institution, an equally important emphasis is placed on engaging private and public stakeholders in the elaboration of the studies, and on later dissemination of results among these groups. The Program will also address the larger role of private sector adaptation opportunities and its relation to public sector initiatives.

Tetra Tech is currently supporting the IFC with a project in Zambia where the impacts of climate change on a hydropower operation are being analyzed. The project involves downscaling GCMs, using a weather generator to simulate precipitation and temperatures for three different time scenarios, running hydrologic and hydraulic models, and identifying and quantifying

## Predicting climate change impacts on the toxicity and yield of a tropical root crop: cassava

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Cassava (manioc, *Manihot esculenta*) is the third most important food source in the tropics (after rice and maize), consumed by approximately one billion people, with the greatest per capita daily consumption in African countries. Despite this, little is known about the impacts of elevated carbon dioxide concentrations and associated climatic changes on the nutritional quality and yield of cassava. The tuberous roots of cassava are high in starch but low in protein; and the leaves which are a good source of protein and vitamins are also eaten. The roots and leaves of this perennial shrub are also fed to animal stock. Cassava contains cyanogenic glucosides, in all parts of the plant, which break down to release toxic hydrogen cyanide gas. Cases of cyanide poisoning from consumption of high cyanide varieties of cassava have been associated with epidemics of the permanent paralysing disease konzo (which particularly affects children and women of child-bearing-age), and endemic tropical ataxic neuropathy and goitre. Outbreaks of konzo are more common during agricultural crises caused by drought and war. In drought, the cyanogen concentration in cassava increases; while in war, people turn to high cyanide cassava, and often inadequately process it. Any change in the nutritional quality of cassava has implications for human health and necessitates improvements in post-harvest processing of the cyanogenic roots. Building on existing cassava research and breeding programs in Mozambique, we are studying the interactive effects of drought, temperature and soil nutrient availability on the total cyanide content and yield of cassava.

Using climate models of southern Africa, we are creating a framework to facilitate predictions for the future nutritional value and productivity of cassava as a staple crop. Mozambique is expected to become drier and warmer in the future, leading to more incidences of drought. By correlating the concentrations of cyanogens and yield of cassava with environmental conditions such as water and nutrient availability and temperature, across a latitudinal gradient in Mozambique, we will be able to make future projections of the impacts of these aspects of climate change on the nutritional value and productivity of cassava. Adaptation strategies to avoid cyanide poisoning from cassava in the future could include: development and implementation of low-cyanide, high-yielding and pest-resistant varieties of cassava; improved processing of cassava and its products; and diversification of the diet of cassava-dependent communities.

## Biomimicry and Urban Resilience

D Burton<sup>1</sup>

<sup>1</sup>NCCARF, Australia

Cities are complex systems and identifying a city's climate risk portfolio is a challenging task. Current risk assessment strategies follow simplistic methods (e.g. using the AS 4360 standard) which fail to identify the confluence of climate change impacts. As such the author uses a discussion on biomimicry to identify the "keystone species" and "food webs" to locate critical components for local resilience. To first ascertain risks it is imperative to identify the critical components and interactions that allow the local area to function. Components which are critical to the resilience of a local system include:

the council, and services it provides; the natural environment and the services it provides; the local economy; the local community.

These components are also influenced by external factors including: the Australian and State Government; neighbouring council activities and resilience; financial institutions; insurers; the wider environment (regional and global); and, international and national markets.

All of the above are linked and supported by movement of the following:

- people
- services (e.g. water, energy, ICT, ecosystem services)
- money
- risk
- goods
- reciprocity

Identifying how climate change will impact on a local area involves an assessment of how it will impact on each of the components and the interactions between them. The author uses his experience of providing 23 local government risk assessments to discuss the challenging nature of risk assessment.

## **Adapting to the Confluence of Impacts in Australian Cities: One Shock Away from Disaster and the Benefit of Resilience Planning**

**D Burton<sup>1</sup>**

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Although climate change by itself presents significant risks for cities, the risks do not exist in a vacuum. In fact climate change exacerbates many of the current and soon to be realised risks (e.g. global financial crises, pandemic, peak oil, cluster of extreme weather events). In this paper the author presents findings from a study on the mid north coast of NSW to argue that the by 2030 the region (like many throughout the country) will be perhaps only one shock away from systemic collapse.

The author describes a likely scenario of 2030 using recent downscaled climate change projections, climate variability patterns, projected changes in population demographics, anticipated council operational costs, international energy association oil forecasts, NSW policies and changes to economic outlook. The author shows that a confluence of these issues is likely to lead to a perfect storm, and potential system failure.

To overcome these challenges the author argues that climate change adaptation planning must involve resilience planning for other stressors. Examples of win-win adaptation processes are introduced to facilitate a discussion on challenges for local government adaptation.

## **How to enable the public to participate more effectively in adaptation policy and practice**

**P Burton<sup>1</sup>**

<sup>1</sup>Urban Research Program, Griffith University, Australia

Public participation remains an important principle in the development of all public policy and is widely held to offer a number of benefits. These include better policies, greater political legitimacy for policy making institutions and systems and a more engaged and active citizenry. These benefits have typically been taken for granted but there is a growing body of work that seeks to measure rather than simply accept the empirical extent and achievement of these benefits. There is also a small but growing body of work that seeks to compare these putative benefits with the possible costs associated with greater participation. These bodies of work are leading to productive reconceptualisations of the principles of participation and to more effective practice.

The broad field of public policy responses to climate change is similarly affected by this long-standing commitment to the principles of greater public participation along with a dearth of detailed and rigorous studies of the impact of participation on the practices of climate adaptation. But the principles and practice of effective participation in climate adaptation policy face a number of additional challenges arising from the global nature of the phenomenon and its local scale manifestations, from popular perceptions of the degree of uncertainty around the science of climate change and from the need to balance short and long term perspectives and priorities.

This paper explores the general case made for greater public participation in policy making and the case made in relation to climate adaptation policy in particular. It describes a number of pitfalls that stem from conceptual confusions and shows how these can present substantial difficulties when they underpin the development of local level policy and, even more significantly, its implementation and translation into local practice.

The paper draws also on early empirical work investigating the development of local scale adaptation plans in South East Queensland, Australia. It concludes by offering more general lessons for the development of more effective approaches to public participation in the development and implementation of local climate adaptation policy.

## **Risk Perception and Adaptation to Climate Change: Comparative Case Studies**

**C D Button<sup>1</sup>**

<sup>1</sup>Department of Geographical and Environmental Studies, The University of Adelaide, Australia

Public risk perception is playing an increasingly important role in shaping environmental policy and management response systems, in part through the realisation that adaptation must seek to incorporate important social and cultural values. Increasingly, in this respect, the management of climate change risks are being subjected to public debate and input, consequently, perceptions of these risks are of considerable interest to local planners and decision makers. Recent media coverage of the potential risks that climate change imposes on Australia's populations, such as that detailed in the recent senate inquiry, 'Managing our coastal zone in a changing climate', and Department of Climate Change report, 'Climate change risk to Australia's coast', have contributed to an increased public awareness of such risks. Several research priorities emanating from the National Climate Change Adaptation Research Plans detail the need to evaluate the perceptions of risk at the local level, as well as to assess the expectations, behaviour and adaptive capacity of communities so as to develop appropriate and socially acceptable adaptation strategies.

This research is attempting to examine the role that perceptions of climate change risk have in creating a willingness to support policy initiatives and adapt to climate change. Utilising representative samples of two Australian non-metropolitan coastal local governments, analysis of data obtained from a mail-out survey indicates an optimism bias amongst property owners in the two regions. Specifically that their personal risk is perceived to be less than the risk faced by others in the same situation, and less than that faced by the community as a whole. Interestingly, respondents showed strong concern about climate change, perceived climatic changes to be highly likely to occur in the very near future, and agreed that disruption to homes, the community, as well as beach and foreshore areas was likely as a result of such climatic changes. This has implications for behavioural change, and hence, proactive adaptation and vulnerability reduction since adaptive capacity will not necessarily translate into adaptive action to begin with. Also, due to the apparent presence of underestimations of personal risk and high levels of self-efficacy in regards to autonomous adaptation, this suggests that it will lead to a significant number of the population believing themselves to be exempt from future risks. This is despite their belief that risks are, and will be, present and that future change is highly likely. It is clear from these results that certain heuristics, which serve to simplify one's decision making during times of uncertainty, are present in responses and have contributed to respondents' perceptions of climate change risks.

This paper will present preliminary research findings and discuss the relationship between the demographic, attitudinal and social contextual variables associated with respondents' perceptions of climate change risk. In particular, this paper will detail gaps and trends apparent from the survey's analysis of respondents' perceptions. Further, this paper will discuss how this might help us to better inform the public of risk, and policy-makers of the way the public perceive risk, such that adaptation responses are framed more appropriately.

## **Evolving sustainability supportive ecosystem approach to climate policy in Guyana: Rising above the gathering storm of the political ecology of climate change adaptation**

J C Caesar<sup>1</sup>

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Humanity's global interdependence provides a unique opportunity for efforts to mitigate and adapt to the looming catastrophic climate change and its consequence. Having firsthand experience of the devastating impact of flash floods potentially induced by the changing global climate, Guyana's policymakers, evidently studious in the climate change policy debates, have been crafting a climate policy framework which recognizes the nation's major natural resource asset – neotropical Amazonian rain forest. The prime importance of avoided deforestation in a national menu of measures for mitigating and adapting to climate change has since been evolving. The policy capitalizes on the opportunities to advance an ecosystem approach acknowledging the provision of a plethora of forest ecosystem services that support and sustain the well-being of its citizens and more so its indigenous peoples who are more culturally-dependent on forest biodiversity and related services. The basis for this policy framework for adapting to and mitigating climate change is rooted in a Constitutional environmental ethos enjoining citizens to care for the environment. With a government white paper entitled “Creating incentives for avoided deforestation” subsequently articulated, a draft national Low Carbon Development Strategy has been launched with extensive public consultations as the nation's blueprint for climate-friendly sustainability supportive development. Guyana's avoided deforestation blueprint seeks to provide a model economic valuation construct for rewarding developing countries endowed with large pristine rain forests with the requisite economic returns on ecological services provided for climate change mitigation. In facilitating this global ecological ethic for climate change adaptation and mitigation, Norway has partnered with Guyana by committing to provide monetary rewards for the latter's avoided deforestation programme for sustaining neotropical forest ecosystem services for global common good. In tandem, this climate-friendly sustainability supportive policy partnership will provide additional resources alongside others to be leveraged for implementing a number of adaptation measures including sea defences against sea-level rise and imminent threat to very vulnerable and predominantly coastal population, infrastructure and economic activities. The concept engenders other types of sustainable economic development, minimizing deforestation and devolving to the well-being of local communities and indigenous peoples of both countries. Blinkered by business interest, an apparent lack of better understanding of humanity's global interdependence and a national constitutional obligation to the maintenance of the nation's ecological integrity is presently emerging among segments of the mining and forestry sectors with their apparent insistence on maintaining the pre-low carbon development strategy status quo. Despite earlier national consultations, the emerging political ecology landscape appears to be an unfolding resistance to stringent enforcement of environmental and forestry regulations, while policymakers are adamant there is no intention to curtail mining activities except greater enforcement of existing and evolving regulations to ensure the ecological integrity of the forest ecosystem and the phasing out of mercury use in gold mining. Against this background we propose the leveraging of best-practices in natural resource management conflict resolution, aggressive and sustained public education and awareness on the detrimental effects of some development paths such as mining on the environment and human and ecosystem health and well-being, greater involvement of environmental groups within civil society, institutional re-engineering for environmental monitoring and enforcement in the climate change era, advancement of a national programme for climate change and conservation psychology and the sociology of behavioural change within the context of socio-ecological governance as a national framework to weather the rising storm.

## Moving beyond impacts: Placing adaptation and resilience at the forefront of tourism development strategies

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Lifestyle choices, resource consumption patterns and livelihood portfolios and strategies are being increasingly questioned and re-evaluated due to global warming and the quickening of global environmental change, the increased frequency and intensity of extreme natural hazards and the uncertainty these events bring. The heightened risk that these events and processes pose to tourism host communities is considerable, particularly for coastal, mountainous and nature-based destinations.

Yet risk and adversity at the hands of change are nothing new for the tourism industry. Coping with political unrest, economic downturns, health epidemics, and environmental degradation caused by overdevelopment have long been an ever present concern for tourist destinations that are heavily dependant on demand for a non-essential product – an experience – that is sold and consumed by the travelling public when funds and time are available. A rising concern about the severity and impact of natural hazards and global environmental change on tourism destinations only add another layer to the growing debate in tourism circles over suitable solutions in dealing with multiple shocks and stressors that affect tourist flows to tourism destinations.

Climate change concerns have increased interest in finding robust yet flexible solutions to help destination communities and supporting agencies effectively respond to change. Current action points include:

- a. raising awareness of both the potential impacts of climate change on tourism operations in various locations and the impacts tourism has on climate change;
- b. improving our understanding of the possible economic impacts of climate change on the industry;
- c. modelling future climate conditions;
- d. exploring the influences of climate change on consumer's choice of destination and subsequent demand; and
- e. offering management and adaptive strategies for furthering the viability of destinations and host communities affected by climate change. Strategies include: snowmaking, marketing campaigns, product development and diversification, adaptive capacity building strategies, and the relocation of operations.

Identifying and addressing the causal factors of vulnerability is recognised as a key component of the adaptation process prompting the undertaking of numerous vulnerability assessments of climate-sensitive destinations to fulfil this need. Yet still missing are (i) holistic assessments that identify the highly contextualised causal factors and processes that heighten vulnerability and stifle resilience in destination communities, and (ii) robust theoretical frameworks or tools to guide the analysis of destination vulnerability and resilience. A community or sector may have the adaptive capacity to respond effectively to climate change or shocks but there is no guarantee that they will choose to make the necessary changes when required. Therefore, there is a need to move beyond the identification of the possible shocks and adaptation indicators to analysing the myriad of interlinked factors and contextual influences that determine unequal resource distribution, choice patterns, action and non-action in a given place over time and space.

We intend to address this outstanding need by:

- a. Designing a conceptual framework for assessing tourism vulnerability and resilience in tourism destinations to climate change and multiple shocks/stressors;
- b. Developing a practical toolkit to facilitate the assessment of risk, vulnerability and resilience levels in tourism destinations and further the tourism industry's adaptation to climate change and multiple shocks/stressors; and

The development of the theoretical framework and practical toolkit will be used to help build resilience and promote adaptation in three destination regions: (i) the Great Ocean Road tourism destination region in Victoria and the sector that supports it, (ii) the South Pacific, and (iii) Bali.

The information gained from destination vulnerability and resilience assessments provide the foundational knowledge needed to address existing weaknesses, capitalise on new opportunities and stimulate long-term positive action, change and transformation. Pinpointing current weaknesses and the scale at which they occur enables destination communities, governance bodies and, policy makers to adjust current practices and formulate and apply new strategies where they are most effective, based on trade-offs among different interests in society.

## Adaptation to sea level rise in Wellington, New Zealand

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Examination of the impacts of sea level rise will inform an adaptation approach across the entire city. The study area contains a range of key infrastructure including a significant highway, an international airport, utilities, businesses, housing, and community facilities.

Given that it is only 1-3m in elevation, sea level rise is seen as one of the key climate change impacts in the study area. Current guidance on coastal climate change hazards recommends that the impacts of a 0.8m rise in sea level by 2090 be considered. However, given high uncertainty and the possibility of catastrophic events, an approach was taken based on testing infrastructure resilience and response using scenarios. Chosen

scenarios reflect the most recent scientific probabilities in the next 50-100 years, while allowing for possible higher levels in the longer term. Three core scenarios (0.5m, 1m and 2m) were used, each having an additional 0.5m storm surge component within the harbour and a 1m component for the exposed coastal areas.

Scenarios were evaluated in an interdisciplinary workshop including expertise in the areas of water, drainage, roading, hazards, transport, coastal, recreational, and urban planning. For each asset key information was gathered, including: description, ownership, criticality, condition, relocatability, economic value, and proposed upgrades. Each asset category was tested against each sea level rise scenario to determine potential risks and impacts. Feasible response options were then proposed.

Key findings included:

- Degrading performance of storm-water systems
- Rising ground-water levels
- Planning for early decision-making and responses
- Considering interactions and interdependency between assets
- Widening the analysis to include the entire city allowing for a full assessment and prioritisation process

Parts of the study area may be susceptible to increased flooding due to a rise in the water-table. A rising water-table is likely to be a more critical factor in the medium term than “over-topping”. However, more detailed work is needed to assess ground-water levels and likely costs and benefits of response options.

The highly modified northern coast-line may require increased water pumping capacity or major engineering works to prevent water infiltration. For the more natural beach environment of the southern coast, maintaining dunes would help the area retain its high aesthetic and amenity values, and could be a more successful adaptation response.

These findings will inform the proposed intensification, development, maintenance and asset management plans for the area. Findings will also be used for further city-wide work, and for discussions within council and the community around prioritising, funding and residual risks.

This study evaluated key information needed to make an initial assessment of climate change impacts in a localised urban area. It has indicated where further work could lead to a more accurate assessment of costs and benefits. A modified approach based on this pilot study will be used to assess climate change impacts across Wellington city.

## **The role of disaster relief in Pacific Island countries: a cause of increasing vulnerability?**

**J Campbell<sup>1</sup>,**

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This paper examines the historical development and contemporary patterns of disaster relief as a response to climatic extremes in Pacific Island countries. It also considers the implications of climate change for disaster relief, and the suitability of (increasing) disaster relief as an adaptive response to climate change.

Prior to European influence upon the Pacific Island region, culminating in the colonisation of most of the countries, there was a considerable level of resilience in the face of extreme environmental events. However, it was not long before colonial governments and missionaries began to intervene after events such as tropical cyclones and droughts by providing assistance, usually in the form of food and building materials, to the members of affected communities. This process intensified in the post World War II era and by the time most countries became independent the expectation of relief following disasters had emerged, particularly in rural areas.

With independence a new wave of relief provision emerged. New governments were keen to show their concern for victims of disasters and to build nationhood, and they responded accordingly. At the same time they engaged with their former colonisers to seek support for the assistance they were providing. In the 1990s and the first years of the 21st Century, the number of donors has mushroomed. New bilateral contributors have emerged and the quantum of assistance has increased. UN based humanitarian agencies have both increased their presence in the Pacific region and have increased their ranges of expertise, levels of involvement in post-disaster settings and numbers of staff. As well, non-governmental humanitarian organisations have also increased their presence, their professionalism and their effectiveness. All forms of relief are being delivered much more quickly. Accordingly, large well-publicised disasters are engendering extremely large (by Pacific standards) and rapid donor responses.

At the same time, it would appear that disaster risk management in PICs is struggling to be accepted, and relief seems to be required with increasing urgency. The research examines the role that relief has had, and continues to have, in reducing the resilience of Pacific Island communities. Not only does relief remove the need for disaster risk reduction, including many traditional practices (for example, maintaining food security through surplus production and systems of food preservation and storage, using famine foods, maintaining agricultural diversity) it enables non-sustainable practices (e.g. new cultivars that are not wind or drought resistant) to become entrenched. At the social level it contributes to the disempowerment of communities who lose control over their own disaster situation, from the assessment of disaster losses, through to identifying what relief items should be given priority and often a role in their distribution. This runs counter to a basic tenet of community based adaptation which is building adaptive capacities of communities through empowerment.



With the adaptation of relief as a disaster response there has been a concomitant reduction in the application of other disaster risk reduction measures, many of which were of traditional origin. While other processes associated with colonialism, independence and globalisation have also contributed to this trend; relief removed a signal that these processes were reducing sustainability. As a result, many communities in Pacific Island countries, while still retaining elements of resilience are becoming increasingly more vulnerable than in the past and increasingly dependent upon humanitarian assistance when disasters occur. A challenge exists for Pacific Island communities, their governments and donors to find humanitarian ways of reducing the vulnerability and dependency and building resilience.

With the likelihood that climate related disasters may increase in magnitude and/or frequency, there may be increased demand for relief. This will be a challenge for climate change adaptation, as adaptive capacity is already being, and will be further, eroded by this process. On the other hand, some of the increased losses will be the result of actions taken by greenhouse gas emitters who should bear responsibility for the losses they cause. Rather than responding reactively to disaster events a case is made for significantly increased funding support of other forms of disaster risk reduction including community based initiatives.

## Exploring the adaptation research challenge: a state government perspective

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Since the launch of the 2002 Victorian Greenhouse Strategy, the Victorian Government has actively invested in research programs to assess the impacts of climate change for a number of key sectors and regions. To date, these efforts have primarily related to the biophysical impacts of climate change.

What is clearly recognised from these experiences is that the challenges of responding to climate change both great and complex, particularly with regards to adaptation. Learnings from the Government's mitigation efforts to date – appear to be largely non-transferable to adaptation.

The inherent uncertainty of climate change combined with difficulty in identifying the vast range of external factors that may influence vulnerability and adaptive capacity over an extended period of time present a complex challenge to both researchers and policy-makers alike. However, increasingly, both the public and government are looking to the research community for a way out of this complex challenge.

Perceptions and expectations for adaptation research have in part evolved from the 'historical' presentation of research and information on climate change impacts. This has helped create an expectation that scientific solutions can be identified and that investment in adaptation can or should have the same outcome-based focus as mitigation. The need to consider adaptation as a process has been slow to emerge against this backdrop of increasing expectations of both policy-makers and the public. At the same time, the re-emergence of media-driven climate change science scepticism threatens to slow down and even derail public support for climate change adaptation.

Effective adaptation will require not only understanding the causes but also the processes that are required to support actions needed to cope with the impending challenges of climate change. Addressing these issues requires the integration of disciplinary and multidisciplinary research, natural and social science, and basic research and full stakeholder engagement.

While there is no doubt that continued research on climate change and adaptation responses is a necessary investment, opportunities to explore and improve on how research investment is identified, prioritised, commissioned and utilised are essential, especially between researchers and policy makers.

To facilitate this understanding, the presentation will focus on identifying some of the research challenges from these four stages from a government perspective.

## Climate change impacts on the water resources of the river basins

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Climate changes occurring at the planetary level are characterized by destructive environmental phenomenon such as droughts, floods, and changes in precipitation. However, this global problem has local solutions. Development and implementation of appropriate policies are required to counteract this global phenomenon. Each region of the world must promote measures against climate change in their countries. These, in turn, must promote the development of optimal policies, programs and local actions to reduce the effects of climate changes on their social and economic activities. These policies should also help populations to best adapt themselves to the new global climatic conditions. The purpose of this study was to analyze the effects of global climate changes at the Papagayo river basin area, a region pertaining located close to the coast of the state of Guerrero in the country of Mexico. Therefore, a general diagnosis of the basin was performed, including the assessment of its main physiographic features such as: hydrology, geology, geomorphology, climatology, soil, vegetation and fauna. The prediction of precipitations at 2, 5, 10, 20, 50, 100 and 500 years was performed based on mean annual rainfall records and using a statistical analysis of 8 probability distribution functions. These results were then used to calculate the maximum precipitation in 24 hr weighted mean in respect of each chosen area per climatologic station using an analysis of Thiessen polygons in the Papagayo river basin. These values were used to adjust the average annual precipitation values

using unit triangular hydrogram method, as well as the percentage decrease in precipitation in respect to the percentage of decline in flow via a regression analysis. The analysis of the 4 different proposed scenarios in climate change demonstrate that changes in precipitation expected by the year 2050 and 2080 will significantly affect the hydrologic cycle, and area drained by the Papagayo river. Based on the percentage of variation in precipitation obtained by these simulations, we obtained a series of polynomial models describing the percentage of variation in flow as a function of the precipitation rate in the region. These models predict that the water availability at the Papagayo river basin will be importantly reduced due to the influence of the use by the City. Therefore, there is urgent need to take local measures to reduce the consequences of this prediction. Such policies should include the ecological conservation of the local ecosystem and a more rational use of the vital fluid.

## **Systematic and transparent exploration of scenario spaces: Socio-economic scenarios for local climate change adaptation**

H Carlsen<sup>1</sup>

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Measures of adaptation to a changing climate may have different impacts depending on the future socio-economic context. There are a number of different methodological perspectives on how to best cope with future socio-economic conditions. In order to analyse possible climate change, its impacts and strategies as well as mitigation and adaptation, a special paradigm of future studies has become the dominated paradigm, namely scenario planning. Within this paradigm a number of different approaches have been suggested for utilising scenario planning for impacts and adaptation assessment. In order to structure the various ways scholars have proposed using scenarios for climate change adaptation, this paper starts by classifying the approaches according to i) downscaling, ii) consistency and iii) independency. Downscaling has been put forward as a way to getting a finer resolution of socio-economic parameters compared to what is the case in major global scenario studies, such as SRES, Global Environment Outlook and the Millennium Ecosystem Assessment. Examples in the second class, 'consistency', include the socio-economic scenarios developed within the UK Climate Impacts Programme (UKCIP). The UKCIP work strived for a close connection with the SRES scenarios and it is argued that this is helpful because it facilitates linkages between socio-economic scenarios and climate change scenarios.

The major part of the paper is devoted to describing a methodological approach belonging to the third class above, i.e. 'independency'. Within Climatoools – a Swedish research programme aimed at providing decision-makers with a better basis ('tools') for developing strategies for adapting to climate change – we have developed a new methodology for constructing socio-economic scenarios for impacts and adaptation assessment. Instead of starting with the national (or global) level, this approach takes the local, regional or sectoral level as the starting point when constructing socio-economic scenarios. A specific set of scenarios is tailored for each specific planning situation and the national level is described from the point of view of the actual focal issue. It is also argued that linking the local scenarios to the global level is in most cases not necessary.

A specific problem addressed by our methodology is how to construct a set of scenarios (sometimes called storylines) from a given set of socio-economic factors with associated states. In planning situations with severe uncertainty and possible irreversible changes it is of primary interest to explore the outer limits of the relevant socio-economic uncertainties. We do so by presenting a novel method that will help scenario developers in generating scenario sets where the scenarios are in a quantifiable sense maximally different and therefore arguably best 'span' the whole set of feasible scenarios. We do not suggest that scenario-building should become a mechanised practice, but think that combining our method with the more qualitative approaches of the 'intuitive logic' school would reduce the problem of too little variation in scenario sets because the tool will stimulate scenario developers to consider the plausibility of other combinations of states than those felt most natural to them. We believe this is an important aid for planners because many societal decisions come with long-term commitment and climate change introduces an increase in uncertainty.

Furthermore, our approach addresses the issue of 'transparency' in scenario construction. Although it is extremely difficult to argue that any scenario exercise is value free, the aim is usually to construct purely descriptive scenarios. It has been argued that it is especially in the combination of states of the socio-economic factors that implicitly introduces a normative element to the scenario storylines. The proposed framework makes the process of going from socio-economic factors to scenarios more transparent, although of course not totally value free.

## **Variations in Urban Climate Adaptation Planning: Implications for Action**

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Urban governments and professionals increasingly are recognizing that climate change poses a wide range of threats to the built environment, natural systems, and human populations. In response, leading cities are developing dedicated adaptation plans or addressing adaptation through existing climate action, sector, or comprehensive plans. In general, most of these efforts are initiated with some form of risk assessment and then proceed sequentially through a series of steps leading to the creation of the plan. Although this process appears to be relatively generic and straightforward, not only is there wide variation in the ways that cities at the forefront of adaptation planning are moving from assessment to plan, but there are notable differences in the way each stage of the planning process is enacted. This paper examines the similarities and differences in planning processes and outcomes in four high-risk cities in the global south. Drawing on case study

research and interviews, it compares and contrasts the ways in which vulnerability assessments, initiating department and governmental support for adaptation, and the engagement of international actors affect the types of plans that are developed, the degree to which plans are viewed as legitimate, and the extent to which they are being implemented.

## **Communication strategies to support successful implementation of managed retreat from coastal margins and floodplains- examples from New Zealand**

**A Carter<sup>1</sup>**

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Managed retreat is defined as any strategic decision to withdraw, relocate or abandon private or public assets that are at risk of being impacted by hazards. The alternative would generally be a considerable increase in protection works.

Hard structures such as seawalls or stopbanks have traditionally been the preferred method for protecting existing development from hazards in New Zealand. Experience has shown, however, that in many situations hard structures are not an environmentally sustainable, reliable or cost-effective method for reducing risk from natural hazards, especially when the effects of climate change are taken into account. Furthermore, when people are protected by hard structures they tend to invest in higher value activities in the protected area. This leads to increased damages and costs when an event larger than the protection occurs or if the structure fails, with the costs borne not only by the property owners but also the community at large.

For these reasons managed retreat policies are increasingly being considered as an alternative to the use of hard structures. However, attempts at implementation of managed retreat have often been met with considerable opposition from affected property owners and have created conflict within communities.

This presentation will use case studies from New Zealand to examine how issues associated with managed retreat are being communicated to affected communities.

The presentation will feature a successful case study where risks and other matters were effectively communicated to support a voluntary managed retreat project. The outcome of the project was that the Waitakere City Council was able to purchase over 80 houses from areas facing increasing risk from flooding, rather than continue to invest in flood protection works. Particular attention will be paid to key messages, communication channels and messengers used in this project, and how these influenced the audience's reception and project outcomes.

## **National Wind Risk Assessment – an overview of research activities**

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This presentation will report on an assessment of regional wind hazard and risk in urban areas, based on innovative modelling techniques and application of National Exposure Information System (NEXIS). A combination of tropical cyclone, synoptic and thunderstorm wind hazard estimates is used to provide a revised estimate of the regional severe wind hazard across Australia at high spatial resolution. The hazard modelling techniques developed in this assessment utilise regional climate model data, which simplifies extension of the method to apply to future climate scenarios and also to other regions. The results of this risk assessment will be compared and contrasted with the risk estimated from the current understanding of wind hazard, as specified in the Australian/New Zealand Wind Loading Standard.

We have also undertaken a national assessment of localised wind speed modifiers (topography, terrain and built environment) to account for these effects in assessment of risk (as the local wind speed is what causes damage to structures, not the regional wind speed). For this activity, the effects are incorporated through a statistical modification of the regional wind speed.

The project will incorporate the outcomes of several related activities, including development of a nationally consistent set of wind vulnerability functions covering principal housing types and age categories to relate local wind speed to building damage.

## **Characteristics of Environmental Performance and Carbon Emission of a Korean Traditional Residential Building – focused on the case study by LCA**

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As changing the environmental point of view from 'Eco-Friendly' to 'Sustainability', which considers environmental, economic and social impacts, there have been eagerly developed many technologies for Low Carbon Green Growth in the fields of architecture and civil engineering in Korea. In especial, construction industry heavily causes greenhouse gas (GHG) emissions because of its complicated networks with other related industries. The Korean construction industry covers 35% of the GDP and the 1/3 of overall carbon emissions when including production, construction and operation. For these reasons, the Korean Government recently has rediscovered the potential environmental value of Korean traditional housing and has promoted various plans and policies to establish the traditional building as a popular residential style.

The Korean traditional housing, which is called "Han-Ok", has environmental advantages in aspects of its spatial composition and construction materials. First, Han-Ok has fully adapted to both continental and oceanic climate of the Korean Peninsula

since 10 C. The spaces in the house can be classified into 2 categories depending on functions; heating spaces for winter and cooling spaces for summer. The two oppositional spaces are coexisted by adopting passive solar design. Second, Han-Ok is mainly constructed with natural building materials such as stones, clay, and wooden materials. Because of the characteristics of construction materials, the building naturally controls indoor temperature, humidity, air quality and ventilation. It means that artificial equipment is less necessary and domestic energy consumption can be reduced. Moreover, the raw materials used for construction contain low initial embodied energy, as a result, the total environmental load of building can be reduced. According to the result of weight analysis of major building materials used for the case, sand, stone and bricks accounts for approximately 81% of the total weight. Wooden materials, which are mainly used for the structure, account for nearly 6% and the traditional clay roof tiles account for around 10%. In other words, 97% of building materials for Han-Ok are transported directly from the nature or undergone simple manufacturing processes.

The environmental impacts caused by construction can be evaluated through the sum of GHG emissions based on Life Cycle Assessment. The procedures of LCA comes from the ISO 14040s series of standards and it is a general-applied tool to evaluate climate change impacts of products. The study carried out the calculation for the quantity of GHG emissions during Han-Ok construction and the result was 321.34 kg-CO<sub>2</sub> / m<sub>3</sub> in material production phase and 46 kg-CO<sub>2</sub> / m<sub>3</sub> by transportation and machinery. The environmental impacts caused by using traditional materials are relatively low compared to reinforced concrete building type which GHG emissions by material production is 503.29 kg-CO<sub>2</sub> / m<sub>3</sub>.

## Protection from crop diseases for food security in future climates

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Many assessments of the effects of climate change on food security indicate that climate and allied socio-economic changes may affect the availability, stability, utilization and access to food across vulnerable regions over time. These projections however, fail to include potential crop losses due to pest and diseases even though in the past, plant disease epidemics have resulted in major famines eg. potato late blight in Ireland and they continue to affect the quality and quantity of food and fibre.

The likely impacts of climate change to pests and diseases include changes in geographical distribution, host-pathogen physiology and potentially an accelerated pathogen evolution from increased population size. These changes have implications for the management of endemic diseases and biosecurity risks from exotic pathogens such as the new wheat stem rust strain UG99. However, from the research to date, there has been little consideration given to pre-emptive strategies that may be required to manage plant diseases under a changing climate. For instance, whether the use of disease resistant varieties would offer effective protection against a target pathogen under increased atmospheric CO<sub>2</sub> levels or whether there is a need to develop and deploy new management strategies such as early planting dates with increasing temperature, have never been addressed. For trash-borne pathogens, all management options will have to cope with large increases in inoculum load due to increased size of crop canopy and biomass. Crop varieties and farming systems necessary to disease-proof crops have not been developed with adaptation to future climates in mind.

In 2007, a free air CO<sub>2</sub> enrichment facility [The Australian Grains (AG) FACE] was established at Horsham, Victoria, to generate data on the response of wheat crops to elevated CO<sub>2</sub> under different temperature and water conditions. A small area in the AGFACE was allocated in 2007 and 2008 to study life cycle of *Fusarium pseudograminearum* (FP) causing crown rot and *Puccinia striiformis* (PS) causing stripe rust. Additionally, the epidemiology of Barley yellow dwarf virus and physiology of its main vector was investigated. A summary of findings from this work is presented in this paper. Other research on potato late blight being initiated in three countries under a newly formed network is also presented to highlight the importance of appropriate forums to improve communication.

Inoculum production by FP in wheat stubble, determined from fungal biomass, and crown rot severity generally increased at elevated CO<sub>2</sub> while FP retained the same level of saprophytic fitness. As FP is more severe under drought, wheat varieties suffer more damage by rapidly depleting water under elevated CO<sub>2</sub>, hence the need for further research on varietal performance. The effects of soil moisture and resistant and susceptible wheat varieties were more important than CO<sub>2</sub> concentration in influencing the life cycle and severity of wheat infected with PS. Unlike other CO<sub>2</sub> chamber studies examining rust fungi, the AGFACE data did not show increased fecundity at elevated CO<sub>2</sub>. To improve disease management, field studies simulating future climates are vital to base these adaptive management plans on. New approaches can only be derived from an improved knowledge of pathogen biology and host resistance under changing CO<sub>2</sub>, temperature, water availability and other climatic variables.

In December 2009, an international project was launched through the Asia Pacific Network for Global Change. This network between India, Bangladesh and Australia has been formed to determine how climate change will impact on a single important crop disease impacting on three countries in the Asia Pacific. The project focuses on the potato late blight pathogen, *Phytophthora infestans* and aims to assess its historical distribution and disease severity patterns in each country. Projected increasing temperatures and increased intensities of drought and flood will be considered relative to the potential impact of this disease in future climates. With this knowledge, modifications to existing management practices may be necessary such as planting schedules or changes in the potato varieties deployed. Current biosecurity policies used to restrict the movement of fungicide resistant strains of this pathogen may also need to be revised to maintain a secure food supply, particularly for developing countries.

## Marine Climate Change Impacts & Adaptation Report Card: Seabirds

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Australian seabirds are influenced by climatic and oceanographic variation and change, manifested through changes in distribution, survival, success and timing of breeding and chick growth. Observed changes including: southward range movement, reduced breeding success and altered breeding timing.

The more strongly affected tropical species share many life-history characteristics: generally larger breeding populations and more pelagic foraging, and are synchronous breeders that feed regurgitated food to young at relatively long intervals. Chicks of these species generally have long pre-fledging periods and slow overall growth rates, making them particularly sensitive to ENSO-related fluctuations in food availability.

For many seabirds and regions, there is limited information on prey distributions and biology, foraging and movement patterns, and the ability of species to alter prey species or life-cycle timing; making generalisations about climate change impacts and adaptive capacity difficult. However, southward expansion of breeding colonies will be limited by available habitat and prey species distribution. Sea level rise is likely to reduce existing breeding habitat, particularly for burrow and surface nesting species on low-lying islands. Increased fire risk has the potential to severely impact some colony nesting seabirds and increased land temperatures to increase heat-related mortality.

Although impacts are likely to vary regionally and by species, and localised assessments of resilience or adaptive capacity may be required, some general principals to aid adaptation include:

- In the short-term, and in terrestrial habitats, the negative effects of climate change may be buffered by managing habitat to provide optimal microclimates for breeding success and adult survival.
- Reducing or eliminating existing non-climate related threats, such as pollution, commercial fisheries, tourism and feral/invasive species, can increase resilience and the likelihood of successful (autonomous) adaptation.
- Research and monitoring. Incomplete information and science constrains the development of effective adaptation actions and decision making. Long-term monitoring of impacts and research into adaptation options for species and ecosystems are required. Resulting plans and actions need monitoring, to determine effectiveness, and adjustments made as new information becomes available.
- Ex situ conservation or translocation. Generally not very cost-effective conservation measures, often considered 'last resorts' for species unable to self-adapt. Can be expensive, difficult and potentially hazardous activities – raising ethical issues, such as 'what impact will translocated species have on existing species in recipient areas?'
- General adaptation measures include factoring the impacts of climate change on seabirds into natural resource management and land-use planning. Other examples include: encouraging establishment of breeding colonies to the south of existing ones, or another location, through the use of artificial decoys, translocating young birds or providing artificial islands; encouraging natural expansion and/or movement of breeding colonies through the removal of introduced predators and optimising vegetation type and cover; restricting public access to breeding colonies; shading nests or designing insulated artificial nesting burrows to reduce heat stress in nesting seabirds.
- At least in the short-term, the adaptive capacity of seabirds to respond climate-associated changes in prey availability, will depend on the species' ability to alter foraging behaviour, nesting location, breeding timing and/or chick growth.

Further research and monitoring of key species are required, including determining which species and systems are more vulnerable to climate change, where generalisations about impacts and adaptation can be made and which species are effective indicators of climatic impacts on higher trophic predators.

## Traits and technologies to design crop breeding systems for climate change

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The year 2050 is only two to five full cycles of plant breeding from now. From the time a new challenge has been identified, new cultivars take 3 to 20 years to be developed. Averaged across many crops, environments and traits, plant breeding in the last century has consistently delivered productivity improvements of about 1 to 4% per year. These improvements are largely in the context of a slowly-changing set of target environments. Radical changes in the occurrence of environmental stresses (e.g. droughts), and increases in pest and disease pressure can greatly impact on yields at farm and regional levels. Increased variability in climate will also directly reduce the efficiency with which breeders can identify adapted lines, i.e. the ranking of varieties becomes confounded by effects of management, season and location, known as Genotype x Environment interaction (GEI).

To deal with increased GEI, our research aims to (1) identify traits and potential germplasm that provide broad adaptation to heat, drought and elevated CO<sub>2</sub>; (2) develop high-throughput-methods to screen for these traits and (3) apply this knowledge to design improved breeding systems that will more efficiently select for adapted germplasm.

Plant breeders have access to a range of genetic resources and many tools to combine the 'best' resources together. Breeding programs typically develop pools of parental germplasm that are suited to their geographical target range – from small regions (10s of km<sup>2</sup>) up to entire countries or ecological zones. When new threats to production arise, breeding programs need to identify new sources of genetic variation, e.g. from the germplasm 'banks' of international institutes. For complex traits like drought adaptation, utilising novel sources takes time (usually 10 to 20 years) to be delivered to farmers as new cultivars. The useful new traits are then combined into existing cultivars that have all the either desirable attributes (e.g. market quality), whether the cultivars are to be conventionally-bred or developed through genetic engineering to utilise 'single-gene' traits.

As others have shown, the winter and summer grain crops in Australia will likely experience warmer temperatures, which translate into shorter crop growing seasons. For wheat, in absence of adaptive measures, a temperature increase of up to 2°C during the reproductive period has been calculated to offset the benefit of elevated CO<sub>2</sub> levels. In addition, many crop processes are also directly affected by brief episodes of extreme temperatures and water stress when they coincide with the time of flowering, e.g. heat stress in wheat and sorghum can directly disrupt reproductive processes leading to reduced grain number and poorly-filled shrivelled grains. Such stress episodes are anticipated to increase as a result of climate change. In current research, we are using increased temperature environments in glasshouses and in the field to examine variation among cultivars for adaptive traits. For example, productive crops evaporate water through their leaf stomata (adjustable 'pores' that allow water out and CO<sub>2</sub> in). We use tools such as far infra-red photography to measure the 'temperature' of these crops and to discover which cultivars are best able to stay productive when air temperatures are high. Other experiments are comparing different wheats under various combinations of high temperature, drought and elevated CO<sub>2</sub>.

The complexity of the breeding process makes it challenging to re-design and improve. Simulation provides the tools to examine opportunities to do this. In previous research, we have combined biophysical simulation models of crop growth with simulation models of the breeding process. This allows us to construct sets of crosses, estimate the growth and yield of new genotypes and identify breeding strategies that can most quickly deliver the new cultivar. The specific advantage of biophysical models is that we can simulate how a cultivar would grow in an existing climate, or in some 'future' climate, whatever that may be. Hence, we can determine the impact of future climates on how well breeding programs can deliver new cultivars that are suited for the future production systems.

In this paper, we will demonstrate how traits for adaptation to climate change can be identified and used in selection, and how we can design new breeding programs to efficiently combine these traits into adapted cultivars.

## Climate Proofing Bribie and Coochiemudlo Islands, South East Qld: Moving beyond the 'case study'

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Climate Proofing combines bottom-up and top-down approaches to climate change adaptation seeking to make assets more resistant and communities more resilient to changing climate. Since 2008, this approach facilitated by SEQ Catchments (SEQC) and University of the Sunshine Coast (USC), has been applied to Bribie and Coochiemudlo Islands in Moreton Bay, South East Queensland. These two distinctly different islands reflect a range of biophysical conditions, exposures to climate induced risks, levels of residential and recreational development, and community perceptions and responses to the climate change challenge.

The process builds on the inherent strengths of the community and the policy commitment of government. Three core principles are applied: identify biophysical and social issues that increase vulnerability with climate change; tailor responses to mobilise long term positive support and strengthen relationships; and focus on capacity and knowledge building.

Coochiemudlo Island is a discrete biophysical entity with sandy beaches, weathered basaltic shorelines, mangrove swamps and beaches fringed by coastal vegetation. The orientation of the island and exposure of shoreline segments to different wind and wave conditions makes the location an ideal 'shore-gauge' to measure and monitor effects of changing climatic and hydrodynamic conditions. The small resident community of 500 is dependent on ferry access to the mainland. In contrast, Bribie Island is a low-lying sand island exhibiting the vulnerability of fragile dune systems and eroding shorelines. The residential and recreational haven is accessed by a two-lane bridge with 41% of residents over 66 years.

Key findings to date are threefold:

- Productive relations between the engaged community groups and local councils are of paramount importance in achieving an effective climate adaptation response. The strength of this link differed markedly between the two islands with concomitant effects. Climate change offers a new prism through which to view old issues. A fresh approach has been made possible with Bribie Island as the simple logic of adaptive action is traced and enacted with shared commitment. With Coochiemudlo Island the initially healthy relationship between the island community and Council

has been strengthened by this process to address climate adaptation following initial catalysis by SEQC and USC.

- With a significant proportion of the community continuing to deny human impact on climate change, it is beneficial to promote positive actions that are both adaptational and mitigational. This maximizes community engagement and uptake of initiatives by appealing to self interest, whilst achieving both outcomes and minimized potential community divisiveness. Again, presenting the path to solutions in a simple logical fashion free of leaps in thinking and knowledge maintains objectivity.
- Many actions and networks required to build resilience and minimize vulnerability in communities already exist, often for reasons other than climate change. By identifying and acknowledging these initiatives as wise adaptational strategies and viewing them through the prism of climate change, fresh support and a new sense of collective purpose is afforded whilst validating and reinforcing the efforts of many.

Learnings of this on-going demonstration project are being disseminated through community-based workshops, conference presentations and public project documents.

## Soft Infrastructure for Urban Resilience and Adaptive Capacity in Australia's Coastal Zones – the Role of the Development Control Plans (DCPs)

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This research outlines the conflicts between risk and resilience approaches to climate change adaptation planning in vulnerable coastal areas in Australia. Based on initial findings from literature review conducted as part of PhD research, it questions 'whether current planning processes shaping vulnerable coastal settlements in Australia are building adaptive capacity for communities under climate change impacts'.

In the field of Climate change adaptation, there is NO shortage of research on technical and physical responses. To perceive vulnerabilities, however, the limitation is a lack of implementation. I will argue that it is the what I call "soft infrastructure", e.g. , which requires research efforts. A fundamental challenge in this context is to raise awareness of the long view. We should build knowledge, incentives, and learning capabilities into institutions, and organizations for managing the capacity of local, regional and global ecosystems to sustain human well-being in the face of complexity and change.

Vulnerabilities are determined using risk approach. It's acknowledged in the literature that this approach while convenient for establishing probabilities and worst case scenarios, the approach is limited in understanding complex, uncertain and dynamic systems. The impacts of climate change are complex, highly uncertain and dynamic. Reviews of the discourse relating to risk and resilience in the context of settlement planning, as well as coastal planning processes in Australia suggests that, climate change is unpredictable and likely to be 'more rapid and severe, costly and dangerous than previously thought. According to some measures climate change is now at or above worst case scenarios projected only a couple of years ago' (CSIRO and Australian Government Bureau of Meteorology 2009). Therefore, I will argue that Risk Approach need augmentation with methodologies that deal more effectively with such environments.

Sciences of system ecology have been developing methodologies to understand complex, uncertain and dynamic systems. I will argue that the resilience methodology can be applied to built environment in order to provide a more holistic base for identify not only risks but also opportunities to adapt to climate change in prosperous ways.

Therefore, the research will make a contribution to knowledge by addressing the lack of research in 'soft infrastructure' for climate change adaptation in the planning sector; and, by investigation of applicability of 'resilience approaches' to climate change adaptation strategies for the built environment.

## Survey of Consumers and Industrial Sectors on Food Safety According to Climate Change

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Climate change has become a pressing issue all over the world. Accordingly, it is forecasted that a significant impact will be exerted upon entire industries including social and economic fields in addition to the natural ecosystem. In particular, the impact on the field of food safety by climate change is an important issue that is directly related to the nation's health. Therefore, in order to implement a preventative system in response to climate change, we have surveyed consumers (1030 persons) and industrial sector actors (95 businesses) on issues regarding climate change and food safety. The results of the survey are as follows. In terms of the degree of awareness on climate change, 85.5% of consumers and 92.6% of businesses in Korea responded that 'climate change is serious.' As for the degree of awareness by consumers and businesses on the relevancy between food safety and climate change, 83.6% and 92.6% respectively responded that climate change exerted a negative impact to food safety. As for reasons for this, consumers' responses included 'inflow of new pathogens from abroad (37.7%)', 'increase of food poisoning (34.8%)' and 'increase in the use of agricultural chemicals (27.0%)'. Responses from the industrial sector included 'food poisoning caused by proliferation of germs due to an increase in temperature and humidity (43.4%)', 'negative impact upon food production due to temperature increase and fluctuation in precipitation (9.5%)', and 'increase in the use of pesticides as a response to increased populations of crop devouring insects (6.4%)'. In addition,

the industrial sector responded that the climate condition exerting the most impact upon food safety was 'temperature increase (73.7%).' In order to correctly inform consumers and businesses about the impacts of climate change upon food safety, continuous efforts will be necessary for information exchange and development of publicity methods.

## Grains Industry Climate Initiative

**B Clark<sup>1</sup>**

<sup>1</sup>Grain Growers Association Ltd

Last year the Grain Growers Association Ltd, Australia's largest grower based commodity organisation, was successful in seeking Federal Government support for an initiative now known as the Grains Industry Climate Initiative. The project is now underway and will deliver outcomes through a range of sub initiatives including:

A communications strategy and associated information to assist members and others within the grains industry about the potential for impacts from climate change and the ramifications of these changes should they eventuate. This would also include information about the proposed Carbon Pollution Reduction Scheme (CPRS) and how agriculture will be considered once the scheme is finalised and legislation in place.

The development of a web based training programme portal and associated database of courses available to grain producers and industry participants so that they can self assess their requirements for improved knowledge, skills development or training to increase their capacity to respond to the challenges that will arise from climate change, and then easily identify the course and provide ones best matched to their needs. Such courses / skills may relate to increased knowledge specifically about climate change or also about adaptation to climate change through improved business skills, grain production and marketing skills or other skills that would assist the participant to understand their options within the context of a changing climate. The skills may also be for personal development so that some individuals can participate in industry leadership roles at various levels to ensure that there is an evolution of skilled and aware people in senior industry roles that can assist the rest of the industry with policy and industry strategy development. Progress on this point has been good and the developing portal has been dubbed the Online Agricultural Training Service (OATS).

Development of a web based decision support system to provide increased understanding of the historic and future seasonal and production changes under climate scenarios to assist grain producers to understand the potential changes that may arise under climate change scenarios and how the grains industry is changing over time. Such a system will also assist industry participants to plan for long run infrastructure investments such as rail, silo and port infrastructure so that decision about these investments might better consider the implications of climate change. The working title for this system is FutureWise and will be developed over the course of 2010.

Consideration of the implications for grain marketing and grain quality arising from climate change for inclusion in specific grains industry courses for growers provided by BRI.

The project goals are:

1. To ensure that grains industry participants are informed with up to date information about the potential impacts of climate change and the Carbon Pollution Reduction Scheme (CPRS).
2. To improve the access to information on climate change and skills development opportunities based.
3. To provide a service to industry participants to self assess their training and information needs and determine the most appropriate course to address their needs.
4. To ensure that the industry leadership and future potential leaders are skilled and equipped to lead the industry to face the challenges that will arise under the range of climate change scenarios.
5. To reduce the transaction costs for growers seeking to improve their skills and knowledge through and industry supported and promoted information and self assessment process.
6. To provide an internet based system for growers to determine likely seasonal implications for climate change which may impact on their annual decision making through improved information systems that can provide information based on previous historical performances integrated with future predictions.
7. To provide a web based system that can inform industry investors in long run assets about the potential impacts of climate change on future investment decisions such as grain related infrastructure planning.
8. To ensure that some specific courses develop to service the needs specifically of the grains industry such as marketing and quality aspects taking into account climate change scenarios.

The project will be run until June 2011.

While general debate over policy and scientific certainty continues, industry bodies continue to consider the risk management implications of the range of changes facing the grains industry in the event of adverse climate change. Farmers generally, and the grains industry specifically, will be challenged by potentially adverse outcomes from the range of projected climate change scenarios if they eventuate.



## Grains Best Management Practice for Managing Climate Variability and Climate Change

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The Grains 'Best Management Practice' (BMP) program for Australia's Northern Grains Region is a voluntary, industry led process which enables broad acre grain growers to improve farm production practices. The program has eight modules to cover property design, managing climate risk, making the most of rainfall, crop nutrition, pest management, irrigation and grain storage. Each module identifies about 20 areas of management (e.g. land preparation) and within each of these areas the module identifies which practices meet a minimum standard defined by industry through a series of reference group meetings. Practices that are not aligned with the minimum standard are described as either at a level that is below the standard, or at a level that is potentially desirable but above the minimum industry standard. The modules are self assessed and growers can complete modules on-line or in workshop environments.

The Grains BMP climate risk module described here focuses on best management practices in Australia's northern grains region for managing climate variability and climate change with some attention to on-farm carbon. Adaptation to achieving greater resilience for managing climate risk in relation to business, environment and social objectives is emphasised. The climate risk module will be initially tested with twenty industry groups in the Northern Grains Region via a one-day workshop, and will develop on-going delivery through a "Train the Trainer" program.

Climate risk is set in the wider context of risk management using the methodology defined in the Australian Standard on risk management (AS/NZS ISO 31000: 2009). The four key areas of the module are: (1) survey of enterprise and climate information regards monitoring the current situation, analysing historical data and evaluating short-term, seasonal and climate change forecasts, (2) risk management principles, framework and process including risk assessment (likelihood, consequence and treatment priority), communication, monitoring and review, (3) review of strategies for managing climate risks (threats and opportunities) such as the "perfect" season for grain production, low and variable rainfall, extended and severe drought, excessive rain and high intensity storms, cool weather, frost, and hot-dry weather, and (4) managerial skills for strategic and tactical management of climate risks at paddock, whole-farm and off-farm levels.

While "best management practice" varies with location, enterprise and land capability, the management practices to emerge as high priority concern: (a) structural adjustments to the enterprise such as enterprise mix, machinery selection and adaptation of land use to on-going reviews of land capability particularly for high-risk marginal lands, (b) adjustments in seasonal tactics such as land preparation, crop selection, cropping intensity, planting methods, weed control, livestock management and marketing, and (c) development of managerial skill, adaptive capacity and off-farm investment. In general, those practices which deal effectively with the climate risks evident in historical records would be at the minimum industry standard, while practices that are designed to also deal with future climate risks projected from climate change scenarios would be assessed as desirable but above the minimum industry standard.

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## Shared Learning on Adapting to Climate Change: Experiences from the Columbia Basin Trust Initiative "Communities Adapting to Climate Change"

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How does a conversation on climate change adaptation begin? How does such a conversation advance from exploratory questions to purposeful planning?

This paper outlines a community-based approach undertaken by Columbia Basin Trust (CBT) to enable adaptation to become part of community planning and decisions in southeast British Columbia (BC), Canada. We provide a snapshot of the history of this activity, from its initiation by CBT to its current status as this effort continues to expand throughout the region.

Building on preliminary surveys of local practitioner and stakeholder views on climate change implications for water management, and subsequent outreach activities, the CBT began to organize its own climate change adaptation initiative. First, CBT commissioned a number of studies on climate change in southeast BC, including climate trends and climate change scenarios, concerns of regional and local water users, and a citizen engagement document entitled "Starting the Dialogue." These were prepared during 2005-2007. During that period, CBT also engaged representatives from several research groups that were active in regional impacts/adaptation case studies in BC and the state of Washington in the United States, as well as community development specialists from provincial agencies, the local government association, First Nations and consultancies through an Advisory Committee. Subsequently, in 2007, CBT launched a program called "Communities Adapting to Climate Change" (CACC). The goal was to support local governments in preparing for climate change.

Using its existing network for contacting municipal, regional and First Nations governments within southeast BC, CBT invited representatives to a climate change adaptation workshop and issued a call for proposals for communities interested in taking part in the CACC program. In 2008, the first two communities were selected—Kimberley and Elkford. Like most other communities in this region, these are small towns with populations less than 10,000. CBT provided a) funding support for planning assistance, and b) a Coordinator and advisory committee, drawn from the research community, provincial agencies, community development practitioners and regional interests, including First Nations, regional districts, and environmental non-government organizations.

Kimberley and Elkford developed their own processes for community engagement, and completed their CBT-funded adaptation plans in 2009. Kimberley's project also worked with the Collaborative for Advanced Landscape Planning (CALP) at UBC in order to gather and integrate spatial data, develop scenarios and visualizations of vulnerabilities, impacts, and response options. Both projects resulted in recommendations of adaptation strategies for the specific issues facing each community. For example, Elkford participants identified a number of measures to address potential changes in flood risk, water availability and water quality. Elkford's plan was integrated with their Official Community Plan review. Kimberley's plan identified over 75 actionable items that are now being integrated into existing planning and operations structures. Meanwhile, a second round of community planning projects is being undertaken in 2009-2010 in Rossland, Castlegar and Kaslo.

Although climate change researchers have been communicating their concerns about future climate for a number of years, the CACC project provides an important opportunity to integrate climate change information within the context of local planning. The idea of climate scenario-based planning is meant to enable planning for change, despite inherent uncertainties in any future scenario. Local planning already accounts for population growth scenarios, so there is familiarity with such projections as a source of information. Climate change information differs because of the need to translate this into local impacts which could be different from the historic record of local climate-related events. The use of visualizations, and spatial and temporal data explored using virtual globes, has shown promise as a tool for communicating the complex spatial and temporal implications of climate change. The scenario method in combination with the layer concept of virtual globes facilitated the understanding that decision-makers have alternative adaptation options.

CBT does engage in mitigation activities through other programs, but the approach taken by CBT's CACC initiative has been to focus on adaptation. Adaptation is generally less understood than emission reduction, targets are harder to quantify, and solutions may be more difficult to design and implement. An important aspect of this kind of endeavour is to foster local innovation and promote ongoing learning, monitoring, and improvement. As a local champion, CBT has positioned this initiative to scale down from global climate science to regional and local planning, and also to scale up from individual communities to a regional network within southeast BC. In this context, the role of the researcher changes from being an initiator of a research project to being an advisor and enabler for capacity building within communities and the regional network as a whole.

We recognize that climate change adaptation will require an ongoing process of monitoring, evaluation, and renewal, as communities grow and change, and as new information on climate change becomes available. Our collective abilities to link global climate science to local scale decisions will depend on our willingness to continually engage in these kinds of learning exercises and planning projects, which have important practical outcomes for communities in southeast BC and other regions.

## Informing the climate change adaptation challenge

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Australia's climate is already changing and in coming decades Australian communities, businesses and individuals will increasingly need to take steps to adapt to the impacts of climate change. Adaptation is one of the three pillars of the Australian Government's climate change strategy and is the principal way to deal with the effects of climate change that cannot be avoided by mitigation. A key component of adaptive capacity includes the ability to generate, access and interpret information about climate change and its likely impacts. The Australian Bureau of Statistics (ABS) collects a wide range of data that can be used to help Australian society to assess the possible impacts of climate change, to develop adaptive responses and determine how communities, businesses and individuals are adapting to these changes. The impacts of climate change will affect the environment, society and the economy. The vulnerability of these systems will vary between regions and sectors depending on exposure to changes in the climate, sensitivity to those changes and capacity to adapt. Some of the areas considered most vulnerable to the impacts of climate change include water, agriculture, biodiversity, coastal settlements and human health. The ABS can provide accurate, high quality information related to these key vulnerable areas to help inform climate change adaptation thinking, including: Responses to changing water availability, including changes to water use and management by businesses and households via ABS industry and household surveys; Changing patterns of production and water use by the agricultural industry, perceptions of changes in climate and changing land management practices by farmers via ABS Agriculture surveys. For example two-thirds of agricultural businesses consider that the climate affecting their holding has changed and from 2005–06 to 2008–9 agricultural water use on Australian farms fell 38%; Changes in transport use, energy consumption and conservation activities, and water consumption and conservation behaviours via ABS household surveys; Analyses of interactions between various sectors of the economy and environment, which enhance our understanding of climate change impacts and society's responses to climate change. These analyses allow comparisons of the effects of changes across time, across industries, across sectors and across regions (e.g. ABS water accounts enable the analysis of the interaction between changes in water use and the economy); Changes in population trends, including overseas migration, interstate movements

and regional growth patterns, (particularly regarding 'at risk' coastal areas or regions with projected lower rainfalls in the future), via a wealth of ABS demographic data; Human health measures relating to climate change including mortality, via ABS cause of death statistics. Australian Bureau of Statistics data can also inform policy relating to people and communities considered at risk and vulnerable, such as people living in remote areas, people on lower incomes, the elderly, and those with poor housing.

## **A new climate change monitoring website for the South Pacific**

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The climate of the Pacific is changing. Several scientific papers describing climate trends and variability in Pacific Island countries underpin our current understanding of climate change in the region. Complementary to the formal scientific process is the routine updating of climate change analyses. Currently, there is no operational, online source of climate variability and change information for the South Pacific.

A new climate change monitoring website is being developed for the upload, analysis and visualisation of climate data for observation stations in the southwest Pacific. The website is being developed under the Current Climate (data management and rehabilitation) component of the Pacific Climate Change Science Program (PCCSP). It is intended to be a robust and convenient source of climate change information, and the primary source of observational data for the research components of the PCCSP.

At present, climate variables available in the data portal include temperature and rainfall, at monthly, seasonal and annual timescales. Climate data is presented as timeseries graphs and basic site information (metadata) is provided to assist users choose the location most appropriate to their needs. Data access is enhanced using MapServer and OpenLayers technologies to provide a range of interactive navigation controls such as map overiewing, zooming and panning, and geospatial information layer rendering and switching.

The new climate monitoring website will facilitate an improved understanding of climate change in the Pacific and help reinforce the message that climate change is already occurring. It is hoped that the information made available through the new website is not only suitable for monitoring climate change, but also lead to improved understanding of its causes, better validation of regional climate projections, and the identification of possible adaptation options for people living throughout the Pacific.

## **Adaptation Strategies of Coffee Producers in Coatepec, Veracruz , Mexico to Climate Variability and Change**

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The state of Veracruz borders the coast of the Gulf of Mexico. The climate in the state is mainly warm, humid or subhumid. However, the altitudinal variations (from sea level almost to 3,000 m) produce high climatic variations. Its central region is considered a region with high biodiversity, which is threatened by land use change. Coffee plantations are imbedded in the rainforests, so they can be seen as a source for biodiversity conservation. Coffee production occupies more than 152,000 hectares in Veracruz, and in the central regions concentrates 90.2% of all the coffee producers in the state. This activity was the source of a major income until the 1990s, when agricultural policies changed and subsidies and technical support was extremely reduced and market prices dropped drastically. Organic coffee production was a response to lower prices, and new markets emerged for a small group of coffee producers. Also, coffee producers are currently struggling with pests, which are reaching higher altitudes with increasing temperatures. In the project: "Integrated Assessment of environmental factors that determine the adaptive capacity of coffee producers in the central region of Veracruz, to climate variability and change", the county of Coatepec (where coffee has been produced for the last decades) was chosen as a study site, considering the approval of the Consejo Regulador del Café de Coatepec, A.C. (Coffee Regulating Council) to developed focus groups and other participatory techniques with their members. In previous research, an econometric model showed that in the central region of Veracruz (where Coatepec is situated), that showed that the temperature and precipitation conditions are ideal to produce coffee (mainly *Coffea arabica* L). Nevertheless, drought, frosts, heavy rains and strong winds can affect the quantity and quality of coffee. Considering the climatic trends, farmers perceived that their coping capacity is being reduced, not only because of climate variability and change, but mainly because their socio-economic conditions have reduced their ability to cope with those climatic events. The increase of climatic extreme events have affected the agricultural production, but also, the drop of prices and the lack of adequate agricultural policies have expelled rural population to urban areas or, mainly, to the United States of America (USA). New studies are now centred in understanding the sources of vulnerability, and the practices, barriers and opportunities of adaptation. For that purposes, interdisciplinary research teams are assembled, stakeholders involvement takes place since the beginning of the projects and new tools are being tested to elucidate and communicate current and future climatic threats. From several focus groups, coffee producers described their coping strategies to fight the spread of pests, the decrease of coffee production, and the diversification of their incomes, particularly during strong ENSO events. To cope with climate variability and change, producers agreed that the increase of protected areas and more strict forests management regulations, are the key measures that could preserved the regional climate and preserve coffee production. In that context, the main objective of the stated project is to demonstrate that the payment of the environmental services can reduce the future vulnerability of coffee producers. Measures of the rates and amount of carbon dioxide

sequestration by forests in the region have been made, but the results are still not conclusive. Also, thermometers have been placed inside and outside of a coffee plantation; these data will be introduced in the econometric model, showing that with climate change that difference of temperature can give coffee producers a lag of time before the worst projected impacts occurred. The list of local fauna and flora can support further studies of regional biodiversity, and activities such as ecotourism.

## Carbon accounting and climate change risks for public lands

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The NSW Department of Environment, Climate Change and Water (DECCW) is leading an inter-agency project to develop regional information on the current carbon stocks in public lands and the impacts of climate change on those lands.

New South Wales has a coastline of about 2000 kilometres and covers an area of approximately 800,000 square kilometres. Almost half of this land is publicly owned. NSW Crown lands, national parks, State forests and water supply lands have a potentially significant carbon storage value and could play an important role in helping Australia meet its emissions targets. Public lands and their carbon stocks are also exposed to climate change risks such as increased fire frequency and intensity, sea level rise and coastal inundation, heatwaves and drought. Information is needed at a regional scale for land managers to factor carbon market opportunities and climate change risks into their current and future planning and operations.

The presentation will focus on:

- **the design of the carbon accounting and risk assessment method:** DECCW collated GIS data from project partners and presented it in consolidated regional maps to show the location and size of Government landholdings. Regions are based on the NSW State Plan regions. These maps are being used to support regional risk assessments (using regionally specific climate projections) and carbon data analysis. Carbon data was sourced from the National Carbon Accounting Scheme. DECCW intends to present the project method and findings to regional natural resource managers as a model for similar approaches on private lands.
- **the delivery of regional carbon estimates and impact assessments:** DECCW will present project results in a whole-of-Government statement. Results will be supported by an agreed set of management approaches to protect carbon values and reduce climate risks.
- **the updating of this information:** project results will need to be updated after the release of the IPCC's Fifth Assessment Report and in line with the National Carbon Accounting Scheme.

## Adaptation to climate change in Africa: Challenges and Opportunities identified from Ethiopia

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This paper addresses entry points for measures to integrate short- to medium-term climate risk reduction within development activities in Africa, drawing from experiences in Ethiopia. We examine the changing nature of climate risks using analysis of recent climate variability, future climate scenarios and their secondary impacts. We assess the effects of climate variability on agricultural production and national GDP. Entry points and knowledge gaps in relation to mainstreaming climate risks in Ethiopia are identified using the Government's plan for poverty reduction. We end with a case study incorporating climate risks within the current social protection programme in Ethiopia, which provides support to 8.3 million people.

Rainfall behaviour in Ethiopia shows no emergent changes and future projections show continued warming but very mixed patterns of rainfall change. Economic analysis highlights sensitivities within the economy to large-scale drought, however, whilst the effects are clear in major drought years in other years the relationship is weak. For social protection substantial changes in number of recipients and frequency of cash payments occur under future climate conditions. We argue that exploring the design of climate risk contingency mechanisms to sit within social protection programmes across Africa could provide an effective component of response to an emerging risk such as anthropogenic climate change.

Our analysis highlights challenges and opportunities for mainstreaming climate risks. Challenges primarily relate to the large uncertainties in climate projections for parts of Africa, and a weak evidence base of complex, often non-deterministic, climate-society interactions and institutional issues. Opportunities relate to the potential for low regrets measures to reduce vulnerability to current climate variability: these can be integrated within an ongoing shift in Africa to move from a disaster-focused view of climate to a long-term perspective that emphasises livelihood security and vulnerability reduction.

## Vulnerability and adaptive capacity to climate change of the Guagua community in central Luzon, Philippines

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Guagua is among the 21 towns and two (2) cities that comprise the province of Pampanga which is in the heart of Central Luzon, Philippines. Pampanga is the capital of the region composed of seven (7) provinces. It is considered the regional

seat of government in the northern part of the Philippines. Guagua is a flood-prone community due to its topography. Its area has been aggravated by the Mt. Pinatubo eruption in 1991 which makes it highly vulnerable to climate change.

The general objective of this study was to assess the vulnerability and adaptation capacity of affected communities in Guagua. It specifically aimed to identify the pattern of climate variability that affected the study site and assess its social and economic impacts, determine the adaptation strategies to the observed climate change related events employed by the municipal local government unit (LGU) and its constituents, improve awareness by municipal LGU officials and community residents on the climate change phenomenon and on the urgency to take action and plan accordingly, and, propose measures to enhance the adaptive capacity of the affected sectors and stakeholders. The necessary data were collected through community consultations, key informant interviews and focus group discussion.

The climate change related events observed in the study area are typhoon, delay on the onset of rainy season, drought and continuous or prolonged rain which mostly affect the sectors of agriculture, fishery, business, students, local government unit (LGU), households (HHs) and transport service. Continuous rain is the most harmful or destructive climate change related event in Guagua as its adverse impact on all identified most vulnerable groups or sectors is considerably large. Agriculture is the most vulnerable followed by the group of students, HHs, LGU, transport service and fishery sector.

The generally declining trend in the costs of damages on infrastructures and houses as well as in the expenditures of the municipal government related to typhoons or floods despite their observed increasing frequency and intensity indicates the increasing improvement and effectiveness of adaptation strategies being implemented by the LGU of Guagua. This implies the vital role of the municipal LGU, in terms of early warning system, that reduces risks to the different sectors. It is implementing innovative adaptation strategies at the local level, such as the establishment, effective recording, and appropriate use of the rain gauge information to reduce adverse impacts of typhoons/heavy rains. Human resource capacity (such as the presence of very good Municipal Administrator and Municipal Planning and Development Officer) is, therefore, very important for promoting effective adaptation. The enhancement of adaptive capacity is a necessary condition for reducing vulnerability, particularly for the most vulnerable community and socioeconomic groups.

Among the recommendations of the study are: a) The LGUs should spearhead the formulation of mitigation and adaptation measures that would address vulnerabilities of sectors and areas where climate change will have the greatest impact; b) Capacity, both institutional and individual, at the provincial, municipal and barangay levels will need sustained strengthening; c) Agricultural and fishery technologies along the lines of developing drought- and flood-resistant crop seed varieties and climate change resistant fish species would have to be introduced; d) To encourage local HHs, the LGU should promote and even subsidize the implementation of certain efficient and effective farm level climate change adaptation measures; and, e) LGUs should ensure political and financial support for the implementation of adaptation strategies.

## **Communication for acceptance, information access and vulnerability awareness of climate adaptation**

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While the consequences of human action on climate change has been the subject of much time money and energy, much less has been done to understand how we can stimulate the behaviour change needed to adapt to the outcomes of global environmental change. It is a common belief of people in developed nations that only those in less developed countries are truly vulnerable to the effects of climate impacts while they underestimate the risk to themselves. In a 2004 study, 52% of British respondents said that climate change would have little or no effect on them. There is a tendency for the public to distance themselves from the causes, impacts and responsibility for tackling the problem.

Communication of climate adaptation issues is marked by four significant factors. Firstly, Climate and adaptation are contested spaces with reactivity to disinformation a drain on resources and focus. Secondly, the climate adaptation concept is not strongly framed in the Australian dialogue. This is both opportunity to develop a positive context for discussion and decision making and offers the danger of having misinformation lobbies exploit this gap first and set the agenda. Thirdly, the complexity and breadth of systematic adaptation makes research synthesis difficult to convey without an over-arching narrative. Will a compelling narrative emerge within a short time frame? Finally, the need to accept increased uncertainty in future conditions is a fundamental issue. While reducing scientific uncertainty is a clear research goal, unpredictable and nonlinear responses in many adaptive systems are expected to increase.

Despite these communication barriers some early adaptors are planning for a new tomorrow through changes ranging from incremental shifts in behaviour to transformational relocation. Groups in Agriculture, emergency services, regional planning and natural resource management have begun to adapt.

Common factors in these groups include acceptance of climate disturbance, access to relevant research information and awareness of their vulnerability. Better understanding the communication patterns that foster this acceptance, access and awareness may be useful to foster additional communities who are adapting to inevitable climate change.

## Measuring the Unmeasurable: The development of adaptation indicators in England

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Climate change adaptation activity is moving forward at a rapid pace in the UK. As organisations develop adaptation actions there is a need to monitor and evaluate their effectiveness, as well as pressure on the public sector to demonstrate value for money. Over recent years the development of indicators has become a key part of policy development – ensuring that new policies and programmes are measurable and accountable. Adaptation decision-makers are now under increasing pressure to develop their own set of indicators as programmes and policies become mainstreamed. Yet measuring adaptation poses a number of seemingly insurmountable challenges given the uncertainty of outcome, the imperfect state of knowledge and the long time-scales involved. This paper will look at one project that tries to respond to the political demand for indicators whilst seeking to avoid the intellectual pitfalls.

Indicators can be used for a number of purposes: to measure the contribution towards achieving a desired goal, to communicate the need for action and the subsequent consequences of an action, to provide a means of accountability and/or value for money and to monitor changes in a system either in response to planned or unplanned interventions (e.g. climate change). Indicators can be process focused (measuring whether a process is in place to move towards a desired objective – often with no defined end point) or outcome based (measuring the achievement of an objective). The presumption in UK Government circles is that public sector indicators should be outcome focused.

Yet, adaptation provides a particular challenge to the development of indicators, especially outcome based indicators. Often, we are trying to measure an avoided event (for example avoided deaths in a heatwave or avoided flood damage) at an uncertain point in the future (we do not know when an extreme weather event might hit) or that continues over time (for example changing species range due to gradual temperature rise) against no fixed baseline as there is no 'reference' event. In addition it can often be hard to attribute successful adaptation purely to actions specifically taken in reaction to the impacts of climate change as there may be many drivers of change, and impacts from an event may be influenced by a change in the socio-economic situation.

In this context, Natural England (the UK Government's Nature Conservation Agency) undertook work to define an initial set of adaptation indicators for the natural environment. The project aimed to identify a package of indicators to measure the level of adaptation planning and activity (process indicators) and the resilience of the natural environment (proxy outcome indicators). Whilst recognising that it is not possible to define a desired adaptation outcome, there is a degree of consensus about characteristics that promote the resilience of the natural environment to climate change.

A literature review was then used to identify existing indicators which could be used to measure and monitor these characteristics. Finally a number of evaluation criteria were established to ensure that the indicators are fit for purpose.

The project developed a package of indicators which, when looked at together give an initial picture of the resilience of the natural environment to climate change and help identify the benefits or otherwise of adaptation measures. Some of these indicators have been input into the work being undertaken by the UK Government to develop indicators for its Adapting to Climate Change programme. By looking at resilience as a proxy for adaptation activity we feel we have avoided some of the pitfalls outlined above. However, there are still a number of challenges to the development of robust indicators not least ensuring a common understanding of resilience. We also struggled to determine indicators for non-biodiversity aspects of the natural environment such as landscape quality and access.

## Nature's Technology: An ecosystem-based approach to adaptation

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Ecosystem-based adaptation has rapidly risen up the agenda as a cost-effective and accessible way of delivering societal adaptation benefits by managing, restoring and protecting biodiversity and ecosystem services. It builds on the work done by the Millennium Ecosystem Assessment and The Economics of Ecosystems and Biodiversity on the importance of ecosystem services to human well-being, recognising that as climate change worsens many of these ecosystem services will become more important as well as more threatened. It has gained traction in many developing countries, but is still given little attention in the developed world – being seen as a 'poor country issue' or as a lesser alternative to technological or engineered solutions. In addition, natural resource policy and climate change policy are often undertaken by different organisations and there is little join-up between the two at both national and international levels. And there is little recognition, from the climate change community, of the value of biodiversity conservation for achieving their goals. This suggests that conservation professionals are failing to communicate the value of healthy and resilient ecosystems and the dangers society faces from their current and projected future degraded state.

In 2009 the Network of European Nature Conservation Agencies, along with a number of experts from climate change and biodiversity conservation fields, held a meeting to identify the role, and examples, of ecosystem-based adaptation

in Europe. The meeting identified a number of examples that were already in place and started to outline characteristics of ecosystem-based adaptation approaches. In addition we discussed the challenges and barriers to the uptake of ecosystem-based approaches in Europe. These included communication issues – many decision-makers are unfamiliar with the concept of ecosystem services and believe that biodiversity is an unaffordable luxury in the face of dangerous climate change. The report from the workshop concluded that there are opportunities for both climate policy and biodiversity policy by implementing such approaches, a conclusion that has been supported by more recent literature. This paper will present the findings of the meeting and highlight some of the key issues faced in improving awareness and understanding of the management of ecosystems as a critical tool for dealing with the consequences of climate change.

## Using General System Theory to understand how farmers manage variability

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Climate change is likely to increase the variability in environmental conditions that Australian primary producers will have to contend with, potentially threatening farm viability. Consequently, to remain viable, primary producers will need to increase their adaptive capacity as climate change progresses. The Australian government has recognised that this will require policy support.

We propose that the key to developing policies that support adaptive capacity in farm systems depends on understanding how farm systems manage environmental variability; and understanding how farm systems can be adapted to manage different degrees of variability while remaining profitable.

In this research we used general systems theory to describe how producers use system regulators, which are an integral part of their farm systems, to manage variability in the environment. General systems theory suggests there are three types of system regulators; aggregation, control by error and anticipation.

The choice among these is based on two key conditions:

- if enough is known about the cause, timing and extent of variability in the environment to predict when to regulate, and
- which creates greater costs to the farm system - regulating unnecessarily or failing to regulate when it is necessary.

We present the management of codling moth as an example of system regulation in agriculture.

We found that adaptation to climate change is likely to require that producers modify the structure of their farm systems by changing the combination of system regulators they use over time. Decisions regarding changes in structure may favour certain types of system regulators over others in three ways.

First, the unpredictable and variable effects of climate change may force producers to use relatively less efficient aggregation regulators over error control and anticipation regulators. This means that the capacity of farm systems to adapt to climate change will be improved by investing in research to maintain the reliability of error control and anticipation regulators which are relatively more efficient. This would involve the identification and development of techniques and technologies that allow farm systems to better anticipate changes in the environmental inputs and to react in a timely manner to those changes.

Second, the capacity of farm systems to adapt to climate change would be improved by investing in the identification and development of techniques and technologies that allow farm systems to better assess changes in the relative costs of different types of regulators.

Third, the attractiveness of new system regulators will depend, in part, on their interaction with other system regulators in the farm system. Consequently consideration of the interactions among system regulators in the setting of priorities for investment in research and extension would be desirable.

We also found that policy measures such as regulation of farming practices, the implementation of market based instruments, the levying of charges, the offering of incentives and financial assistance, infrastructure upgrades and the public provision of extension and emergency services all influence the composition and operation of regulators in farm systems. It follows then that the capacity of farm systems to adapt to climate change will be influenced by such policy measures.

## Australian Agriculture: adaptations to climate change

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Greenhouse gas emissions from Australian Agriculture are approximately 16% of the total, but with simple changes in agricultural practices, this figure could probably be substantially reduced. Although there are no immediate plans to include agriculture in current Emission Trading Schemes, adaptations which Australian Agriculture should consider and prepare to undertake for the future include:

1. solar thermal power - this is now only about twice as expensive as coal or diesel. The most economic method (ie. requiring low capital investment) appears to be the linear arrays of parabolic mirrors which heat tubes of oil. This heated oil can then be stored underground in large vats which can retain the heat for months. When heat or energy is needed on farm

- it can be simply drawn off using steam turbines to generate electricity. Australia receives approximately 1000Wm-2 over most of its land surface on average eight hours per day most days throughout the year this energy is entirely renewable with zero impact to the environment, and Australia should be leading the world in its implementation.
2. zero till in addition to saving on diesel consumption, zero or minimal till practices retain more organic matter in the soil and reduce the need for synthetic fertilizers. This in turn reduces loss of nitrogen to the atmosphere, including the potent GHG gas, nitrous oxide. The ploughing of soil is a convention that follows from the requirement for loosening and oxygenation of the damp and fertile geologically young glacial clays of Europe. In the cold temperatures of winter, not much organic matter is lost via oxidation, but this is a major problem with tropical and subtropical soils if they are overworked. Organic matter is required for satisfactory water retention in Australian soils which tend to be geologically old with low calcium/magnesium and high sodic contents.
  3. methane from intensive livestock waste lagoons - methane release from intensive livestock lagoons is a significant contributor to the total greenhouse gas emission from Australian agriculture. Primary anaerobic lagoons should be covered and the methane collected as a useful source of power. In southern and inland parts of Australia it does get cold enough for livestock sheds to require some heating during winter. Collection of methane from waste lagoons has recently proved useful for the winter heating of farrowing sheds in Queensland
  4. collection of green waste material for conversion to biochar: recent studies by the CSIRO have shown that addition of ground charcoal (or biochar) to soil improves soil fertility, and over the long term would form a useful way of sequestering carbon. As the nearly pure carbon product is dry, lightweight and free flowing, transport and application costs are reduced compared to those of conventional compost. More research needs to be done into the suitability/fertility of various source materials, and the economics of production and application.
  5. use of intensive livestock solids waste for conversion to biochar - sludge when pumped from the base of intensive livestock lagoons and applied directly to land is responsible for significant release of methane to the atmosphere. This sludge should be compressed, dried and the remaining separated solids converted to biochar. Engineering design work needs to be carried out to optimise biochar production and application processes.
  6. use of intensive livestock effluent for algal based biodiesel production - this nitrogen and phosphorus rich stream is abundantly available from the various intensive livestock industries across Australia. Rather than being used to irrigate poor quality soils which may suffer rapid loss of nutrients via deep drainage or overland flow or, effluent water could be used to grow algae for fuel in a controlled environment. Research is now well underway at USQ, UM and the Korean government into how to convert microalgae into fuel oil or biodiesel using photobioreactors. With fuel costs projected to significantly increase into the future, this technology could represent a very promising method for economic and carbon neutral on-farm fuel production.

## Processes of adaptation – lessons learned from three case studies of community-based adaptation in Limpopo province, South Africa

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The IPCC Fourth Assessment Report published in 2007 outlines evidence that climate change is already happening and that further climate change will occur irrespective of cuts in greenhouse gas emissions. With many developing countries already struggling to cope with climate variability, they are particularly vulnerable to climate change. Despite considerable work on livelihood strategies and coping with climate variability and change in Africa over the past 30 years, there has yet been little examination of the actual processes through which adaptations occur, especially what leads to successful pathways of adaptation. This is important as the magnitude of climate change projected over the next century will exceed that of the past century, thus necessitating adaptation to ensure that development trajectories are not undermined.

This paper outlines the adaptation responses developed in communities that are faced with different climate risks, the barriers/constraints they face and the processes through which some households are able to ‘successfully’ adapt (that is, introduce responses which reduce their vulnerability to future climate risks). Community-based adaptation studies are often criticised as being too context-specific, and often extrapolating lessons learned to transfer to other situations is difficult. This paper synthesises the findings of household adaptation responses and processes in three rural communities in Limpopo province, South Africa, that were studied separately for the authors’ doctoral research.

The research explored the different coping and adaptation strategies developed by rural households in response to weather extremes, from drought to flood. In particular we investigated the factors that govern the processes of adaptation, including the role that social capital plays, the features of social capital that may facilitate adaptation, the importance of key agents or leaders, and also the role of non-local and non-climatic factors. The paper finds both similarities and key differences in the way these communities adapt, especially with regards to the role of social capital in the process. The findings suggest that, at least within the same political economy country context, common lessons can be learned from individual community-based adaptation, and that these should be considered in the formulation of national level adaptation policies and strategies to ensure that autonomous and planned adaptation is complementary, rather than potentially in conflict.



## The challenges of agricultural production in a future variable and changing climate

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Global and regional records provide overwhelming evidence of systematic change in the earth's climate over the past century. There is growing evidence that these changes are linked to both human activities and natural variability, with more recent changes increasingly in response to growth in global greenhouse gas emissions. In Australia (as with other countries around the world), current patterns of climate change (particularly temperature but also rainfall) share consistent trajectories with patterns of climate change projected by Global Climate Models (GCMs). In some cases the rate of change in temperature and rainfall already exceeds worst-cast scenarios for the near future.

History has demonstrated that natural resource-based industries, such as agriculture, are particularly sensitive to climate with yields highly responsive to climate variations. For this reason a strong incentive exists to enhance the adaptive capacity of agricultural systems in order to deal with further changes expected as a result of climate change.

The current farming environment is complex, characterised by market risk, increasing input costs, legislative change, significant variation in resource condition and availability of new technologies. Climate change, particularly changes in variability and extremes, will add further complexity, making agricultural production an even more challenging endeavour. Whilst the difficulties associated with agricultural production increase, there are many opportunities to modify and change current management practises to reduce these impacts. Implementation of these modified management options are likely to have substantial benefits under moderate climate change.

Losses of up to 5% of GDP by 2050 have been estimated in response to climate change. Some analyses suggest that adaptation may reduce these losses by half. In a study of the benefits of adaption on Australia's wheat industry, Howden and Crimp (2005) assessed that value of simple agronomic adaptation options (optimal cultivar and sowing window selection) could result in increased national farm-gate income by an average of between \$150M and \$500M per annum by 2070. However, there are limits to the effectiveness of incremental adaptation under more severe climate change. Under these conditions greater diversification of production systems and livelihoods will be required.

Understanding which adaptation options to pursue in response to climate change remains a challenging exercise. This is largely due to the uncertainty associated with regional projections of climate change as well as the limited scope (i.e. largely simulation studies) for validating the effectiveness of adaptation.

Recent research on adaptation has followed a variety of paths; with the main focus on the evaluation of the benefits from general adaptation options defined by the researchers. This past research has identified in broad terms the following adaptation options for cropping systems:

- Altering inputs such as varieties/species to suit prevailing climate conditions;
- Wider use of technologies to 'harvest' water, conserve soil moisture (e.g., crop residue retention), and use and transport water more effectively where rainfall decreases;
- Altering the timing or location of cropping activities;
- Diversifying income through altering integration with other farming activities such as livestock raising;
- Improving the effectiveness of pest, disease, and weed management practices; and
- Using climate forecasting to reduce production risk.

In this paper we will demonstrate how a participatory approach (i.e. working with farmers, integrating their knowledge and including their assessments of costs, benefits, practicalities and constraints) to assessing and evaluating effective adaption options provides a more effective framework of analysis compared with the more traditional generalised approaches. We will show how this approach allows the synthesis of a typology of responses which includes the effectiveness of adaptation options in terms of production and economic returns and the synergies and constraints to implementation.

## Adapting pasture-based dairy systems to future climates

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Australian pasture-based dairy systems rely on efficient conversion of pasture to milk, with stocking rate and calving time being key management decisions used to align animal requirements with the seasonal pattern of pasture supply. Pasture production is heavily reliant on the climate, and projected climatic changes will alter the pattern of pasture growth requiring farm managers to adapt their grazing systems. In south eastern Australia, climate changes for this century indicate warming with a drying trend. The capacity to adapt stocking rate and calving time to future climates was explored, by examining the impact of climate changes on pasture production and farm gross margin at three sites; Terang (south-west Victoria, Mediterranean climate); Ellinbank (Gippsland, Victoria, temperate climate); and Elliott (north-west Tasmania, cool-temperate climate).

A baseline (1971-2000) and 20 future climate scenarios covering the range of climate projections were examined at each site. Future climates were created by scaling the baseline climate by warming of 1, 2, 3 and 4oC (with atmospheric CO<sub>2</sub> concentrations of 435, 535, 640 and 750 ppm respectively) and scaling rainfall events by -30,-20,-10, 0 or +10%. For

each scenario, production of perennial ryegrass/white clover pasture was simulated using DairyMod. Optimal stocking rate and calving time for each scenario was determined by the highest average gross margin using DairyPredict.

In the baseline climate, the mean annual pasture production was 10.7, 11.4 and 12.5 t DM/ha for the Terang, Ellinbank and Elliott sites respectively, with corresponding farm gross margins of \$1336, \$1538 and \$2185/ha. The optimal management was 2.25 cows/ha calving in June at Terang and Ellinbank, and 2.25 cows/ha calving in July at Elliott. Annual pasture production declined with warming at Ellinbank and Terang, while at Elliott there was no difference in pasture production between 2, 3 and 4°C warming which were greater than at 1°C warming. At Elliott there was an increase in pasture production with +10% rainfall, but significantly lower production with each 10% rainfall decline. At Ellinbank and Terang there was no difference in pasture production between the 0 and ±10% rainfall change scenarios, while production declined with -20 and -30% rainfall.

Compared with using the baseline management, farm gross margins in the future climate scenarios were improved when stocking rate and calving time were adapted to match the changes in pasture supply. Where lower pasture production was modelled, reducing stocking rate alleviated some of the reduced gross margin compared to maintaining the baseline management. Where higher pasture production was simulated the implementation of higher stocking rates and earlier calving increased gross margins.

The mean benefit of adapting calving pattern and stocking rate, compared to maintaining the baseline management, across all future climate scenarios was \$76, \$58 and \$471/ha at Terang, Ellinbank and Elliott respectively, indicating larger benefits in the cool temperate region where pasture production was expected to increase in a warmer climate. Consistently lower gross margins and smaller benefits of adaptation were simulated in the Mediterranean and temperate regions suggesting that further changes to the farm system are required to maintain profitability.

## Current concepts of adaptive capacity and its utility for decision making

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Adaptive capacity has become widely acknowledged as a fundamental component of vulnerability to climate change as indicated by the rapid growth of academic publications on the topic. Interpretations of the concept of adaptive capacity vary in the published literature. Its utility for decision making and ultimately for effective adaptation to climate change, have not to this point been the focus of investigation. In order to improve the synergies between climate change adaptation researchers and decision makers, we undertook an assessment of the interpretation of and approach to adaptive capacity research and application among a range of disciplines and institutional settings. The project was undertaken as part of the National Climate Change Adaptation Research Facility (NCCARF, Australia) Synthesis and Integrative Research Programme.

Based on the results of a critical review of recent adaptive capacity publications, an online survey of 299 researchers and decision-makers in the field of climate change, and interviews with key informants, we argue that the concept of adaptive capacity continues to evolve through recognition of the importance of context and system linkages. Further, the approaches and methods used for published adaptive capacity research suggest a paradigm shift from determinism to complexity and from mono-disciplinarity to trans-disciplinarity, multiplicity and participation. Consistent with its evolving, complex nature, researchers in the field report a gap between the theoretical development of adaptive capacity and its practical application by institutions with responsibility for developing and implementing adaptation plans. The utility of adaptive capacity for decision making goes largely unquestioned in the published literature, with much recent focus on refining tools for its application. An exploration of the perceptions of climate change researchers and decision makers reveals that despite a large proportion of the climate change adaptation research community feeling pessimistic about the future generally, most consider applications of adaptive capacity to be somewhat effective. Decision makers in the same field express a slightly higher assessment of its utility.

We conclude that the utility of adaptive capacity could be improved by concurrently addressing multiple issues including knowledge gaps, communication of transferable adaptation lessons, and institutional transformation through multi-scalar approaches.

## Vulnerability of Forest Ecosystems and Forest People to Climate Change in Nepal

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A number of research and studies have been undertaken in Nepal to find out the extent of vulnerability causing due to climate change. Almost all studies have indicated that there is gradual rise in temperature, flooding, risk of glacier lake outburst, reduced food crop production, loss of flora and fauna, reduced water availability. Drawing from research and technical studies this paper presents the state of impact of climate change on forest ecosystems and people elaborating the pattern of temperature change, rainfall variation, change in forest coverage, agriculture production, water resource, melting glaciers, and impact on human health and livelihoods. It also presents some of the existing adaptation strategies and recommends potential adaptation strategies to cope with climate change. Studies have shown that Nepal is one of the high risk countries affected by climate change as it is evident from the average temperature rise of 0.09 Degree Celsius per year. In one of the projections, IPPC indicates that it would be 4 degree Celsius warmer in winter and 2.5 to 3 degree Celsius warmer in summer. The rise in temperature causes increase in evapo-transpiration which means change in vegetation and grasslands. As a result, the tropical wet forest and warm temperate rain forest will gradually

disappear, and cool temperate vegetation will turn into warm temperate vegetation, and a doubling in carbon-dioxide would see an emergence of rainforest in tropical and sub-tropical regions in Nepal. Studies show that the warming is more manifested in the high altitude regions of Nepal, while it is significantly lower or even lacking in the Terai and Shivalik region. Also, the warming is more pronounced in winter as compare to other seasons. The rising temperatures in high altitude region have caused glaciers to melt and retreat faster. Due to receding of glaciers there is an increased risk of the sudden flooding following glacial lake outbursts. Similarly, the analysis of precipitation data has shown distinct cyclic characteristics with significant peaks at 2.5 and 10 years periodicities. The 2.5 year peak is related to El Nino phenomenon, whereas 10 years peak is related to solar cycles. It is revealed from the studies that there is strong correlation between precipitation in Nepal and Southern Oscillation Index (SOI). Likewise, the correlation was found between Indian Ocean Sea Surface Temperature (SST) and the precipitation in Nepal (Shrestha et al., 2000). Likewise, due to the continuing melting of glacier and increasing size of glacial lakes in high altitude areas increased the possibility of glacial lake outburst floods (GLOFs) which may cause a huge human and environmental loss in downstream. One recent example of Glacier Lake outburst is in Langmoche valley of Khumbu region in eastern Nepal, which caused a serious damage to Namche Hydro Power project, bridges, infrastructure and cultivated land in 1985. Against this backdrop this paper analyses the vulnerability causing due to changing climate regime and the adaptation measures taken by the local people and their effectiveness. This paper also presents some recommendations to cope with increasing adverse effect of climate change in Nepal particularly in high Himalayan region.

## Historical trends in fruit tree chilling in Australia

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Fruit trees annually enter a dormant phase over winter to guard against damaging effects of cold temperatures. To break dormancy, trees must be exposed to a certain amount of cold temperatures. This process is known as vernalisation or chilling. Insufficient exposure to chill can cause poor and/or extended flowering which leads to poor fruit set and low yield.

The amount of chill required differs between and within fruit varieties. As well as this, different temperatures contribute with varying effect to chill accumulation. Temperatures below 0°C are ineffective chill temperatures and high temperatures have been shown to reverse previous chill accumulation. It is the interpretation of the effective chilling temperatures that is explored here.

Several chill models are available to calculate chill exposure. Three common models are the mathematical Utah and 0-7°C models and physiologically based Dynamic model. Historical trends of chill accumulation in key fruit growing areas in Australia will be presented to consider the impact of recent warming on this trait. Three different chill models will be utilised to demonstrate differences in models and implications for interpretation. Such a historical analysis has not been conducted in Australia, nor has investigation of several chilling models concurrently.

## Adaptation strategies to alleviate the climatic impacts of the “Melbourne 2030” planning strategy

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Global population projections indicate that by 2030 more than 60% of the global population will reside in urban areas and with only 0.2 % of the earth’s surface covered by urban areas, many cities worldwide including Melbourne, Australia have adopted the compact city planning approach in response to combating urbanisation growth. Although viewed as a sustainable urban form, the compact city urban morphology promotes high diurnal temperature variations as a result of the “Urban Heat Island” UHI effect and this may also be superimposed by projected global climate change. Thereby, increasing urban temperatures as well as potentially inducing human thermal stress. Cities worldwide have already demonstrated a 5 to 11°C increase in temperatures over the last century compared to that of suburban and rural areas These observed temperatures exceed that of the predicted rise in global temperatures of 1.8 to 4.0°C by 2100 due to climate change Adaptation planning to counteract the rise in urban temperatures as a result of the UHI and climate change is one of the most cost effective and sustainability beneficial means for cities to adapt to climate change Adaptation measures ranging from implementing vegetative surfaces into the urban landscape and building design can offset UHI conditions by reducing local temperatures by 0.5°C to 1.0°C and irrigation practices can also ameliorate urban temperatures by 2.0°C.

The lack of consideration for potential climate change impacts in compact city planning strategies such as in Melbourne Australia’s, Melbourne 2030 planning approach signifies the importance of integrating climate change adaptation measures into urban areas to improve climatic conditions and the quality of life for urban dwellers. Therefore, the main objective of this study will be to assess a range of adaptation strategies via the implementation of urban greening, irrigation practices and reflective surface to improve micro-climate conditions and the outdoor human thermal environmental resulting from climate change impacts and proposed changes in urban morphologies (i.e. high density mixed used activity centres) as highlighted in the Melbourne 2030 planning approach. The analysis will be conducted using the ENVI-met three dimensional micro-scale numerical modelling suite. ENVI-met calculates detailed climatic and bioclimatic information over a diurnal cycle for surface-plant-air interactions between parameters in the urban environment including complex urban structures, surfaces, vegetation and the atmosphere for each point within the model domain.

Model results from this study found that by implementing adaptive measures into the compact city urban morphology, reduced air temperatures brought upon when accounting for the average increase of Melbourne’s temperatures by 0.8°C by 2030 and the modification of the urban areas into a compact city. Adaptive measures ranging from implementing ground vegetation and irrigating vegetative surfaces as well as improving building design to include green roofs and reflective

surfaces reduced urban temperatures by an average of 2°C across a range of Melbourne 2030 activity centres.

The outcomes of this study could be used to advise climate change adaptation planning and to assist in developing policy suggestions for improving Melbourne's urban micro-climate and offsetting the likely temperature impacts from climate change and increasing urban densities in 2030, an aspect which has not yet been considered in Melbourne policy initiatives.

## Adaptation policy in Germany and multi-level governance

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The German Federal Government resolved in its 2005 Climate Protection Program to initiate the necessary steps for development and implementation of a comprehensive national concept on adaptation to climate change in Germany. In December 2008 the Federal Government presented a German Strategy for Adaptation to Climate Change and creates a framework for national adaptation to the impacts of climate change. Thus, the government established a transparent and structured medium-term process which, in conjunction with the relevant actors, will progressively ascertain action needs, define appropriate objectives, identify and resolve conflicts of objectives, and develop and implement potential adaptation measures.

Adaptation policy in Germany is characterized by two main aspects:

The German strategy for Adaptation is linked to other national strategies, e. g. the Sustainability Strategy, the Biodiversity Strategy, the National Strategy for Sustainable Use and Protection of the Sea, the Integrated Coastal Zone Management Strategy. The synergies or (possible) conflicts between these strategies and the linked measures are not analyzed in detail up to now.

The responsibilities for adaptation in Germany are fragmented – on the one hand the national level with its competence setting the framework, on the other hand the federal states (Bundesländer) and the municipalities. Allocating responsibilities in the shaping of federal policy and carrying out adaptation measures require close cooperation between the federal government and federal states. For this reason the Conference of the German Federal and State Environment Ministers decided in spring 2007 to support the federal government in its efforts to identify and implement a German adaptation strategy. The road to this decision as well as the current and future process to identify this national adaptation strategy can be considered as a governance process.

The strategy requires further specification on the basis of a broad discussion with the federal states and societal groups. The Federal Government is developing an Adaptation Action Plan drawn up jointly with the federal states by April 2011. This is to include aspects such as:

- An overview of concrete measures by other actors
- Information about financing, especially through integration of adaptation in existing assistance programs
- Suggested concepts for progress review
- Further development of the strategy, and next steps.

In our contribution we give a description of (1) who is adapting at national and subnational level in Germany, (2) the monitoring system which should be established in 2013, and (3) the main drivers and the governance structure of adaptation policy in Germany.

Up to now adaptation policy in Germany is predominantly guided by governmental actors – due to this fact we find a differentiated structure of actors from politics and administration but no differentiated governance structure including civil society. Thus, the challenge for the next years is to initiate and establish a broad discourse considering public needs for adaptation. This challenge requires not only general information activities about climate change and impacts, but also detailed information systems such as monitoring programs and indicator systems. Such an indicator system should have two pillars: state of art-indicators and process-indicators. State of art-indicators represent climate change and climate impacts as well as consequences of adaptation measures and their implications on vulnerability; process-indicators point out whether the policy process is successful or not. Both types of indicators are relevant for the progress report of the adaptation strategy in 2013 – they (should) indicate the achievement of adaptation goals: reducing the vulnerability of sectors and individuals or groups, and enhancing the adaptive capacity.

## Applying resilience thinking to the governance and activities of Australia's National Climate Change Adaptation Research Network for Marine Biodiversity and Resources

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This paper reports on the application of resilience thinking by Australia's National Climate Change Adaptation Research Network for Marine Biodiversity and Resources (a.k.a. the Marine Adaptation Network) to frame and integrate its activities.

The Marine Adaptation Network comprises a holistic framework that cross-cuts climate change risk, marine biodiversity and resources, socioeconomics and policy, and includes ecosystems and species from the tropics to Australian Antarctic waters. The organisational governance of the Network, which is framed around five interconnecting marine themes (integration, biodiversity and resources, communities, markets, and policy), is designed to replicate the governance characteristics of a complex adaptive system – it is multi-level and polycentric, integrative and networked, adaptive, participatory and collaborative, and it is interdisciplinary and draws on diverse sources of knowledge. The governance structure encourages interdisciplinary collaborative research, data-sharing, communication and education, and the synthesis and advancement of climate change adaptation

knowledge to assist policy and decision-makers in developing climate change adaptation strategies to build adaptive capacity.

The Network's synthesis activities are informed by the resilience paradigm in seeking to understand marine social-ecological system (SES) dynamics, to identify the potential for unexpected change, and in using these understandings to generate strategies for enhanced resilience of the marine system. Other Network activities using this thinking include the development of interactive tools to aid decision-making, promotion of a meta-data repository for data-sharing across all marine disciplines, and building the adaptation skill base through targeted involvement of early career researchers and policy-makers.

More particularly, this paper details the Network's efforts to examine case studies detailing the resilience of the Australian marine SES. The case studies involve social-ecological systems analyses of climate-induced range shifts in marine species, the edible oyster industry, the rock lobster industry, and marine tourism on the Great Barrier Reef.

The principal objectives of this work are to determine the: (i) main issues of concern for the marine SES to identify the most valuable and vulnerable assets of the marine system; (ii) critical feedback mechanisms in operation and their implications for marine SES instability; and (iii) critical factors driving change in order to understand not only the conditions of stability and instability but also possibilities for innovation and adaptation. The overall aim of understanding system dynamics in this way is as a necessary prerequisite for appropriately targeted adaptation interventions.

This work is interdisciplinary in that it seeks to combine a range of different disciplinary understandings in order to provide innovative answers to the complex problems of climate change impacts on the marine SES. It is transdisciplinary in that it seeks to involve marine system operators and policy-makers in processes of building new knowledge and innovative adaptation solutions.

Preliminary conclusions suggest that the marine SES will need help to maintain and build inherent resilience to climate change effects and socioeconomic changes that would damage its capacity to adapt to future climate change.

## Key barriers and potential solutions for developing climate change adaptation strategies for infrastructure

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The need to adapt infrastructure to potential climate change impacts is increasingly on the agenda of various infrastructure sectors in Australia. There is general recognition that potential climate change impacts and the uncertainty surrounding these impacts present a significant challenge to achieving sustainable infrastructure development. Where there are plans to deliver new or upgrade existing infrastructure, it is important to ensure that the process for delivering that infrastructure includes an adaptation strategy that meaningfully addresses potential impacts. Yet the process for developing and implementing such a strategy presents significant challenges. Specifically, project owners and those involved in project delivery are faced with a complex issue that needs to be addressed in the context of complex project delivery processes. In consideration of the importance of adaptation to the longevity of infrastructure and increasing interest within various infrastructure sectors to better understand adaptation, this poster explores the key barriers to the development and implementation of a climate change adaptation strategy in the delivery of infrastructure and offers solutions through lessons learned from rail infrastructure case studies in Australia.

Key barriers to be discussed include:

- Difficulties in translating climate science and projections into technical solutions.
- Difficulties in communicating on the issue to stakeholders.
- Risk adverse behaviour associated with unknown costs and overall uncertainty.
- A lack of ownership of the issue in a project team.
- That climate change may not be considered in the initial feasibility studies associated with infrastructure planning.
- That governance structures affect the ability to implement adaptation initiatives.
- That a lack of suitable regulations, tools or standards that provide a process for developing an adaptation strategy can make project level adaptation unpalatable.

Solutions to be discussed include the need to:

- Develop formalised early stakeholder engagement.
- Identify delivery processes that can be adjusted to account for potential impacts, such as design processes.
- Capacity build project managers and other relevant stakeholders.
- Obtain ownership at the management level using targets and other performance tools.
- Ensure that an adaptation strategy sits within a broader sustainability framework that is integrated into project delivery processes.
- Focus adaptation strategies on implications for operations and social impacts including accessibility.
- Develop a multi-disciplinary industry network for knowledge-sharing where project experience can be built on.

This poster will be of interest to researchers, policy makers and practitioners working within the climate change adaptation and infrastructure sustainability areas. The case studies in particular provides useful lessons to other jurisdictions and infrastructure sectors on the challenges and potential solutions for the development of project-specific climate change adaptation strategies - solutions which may be transferable to the development of more standardised industry or regulatory approaches.

## Managing sea level rise and coastal hazards in an era of climate change, Wellington region, New Zealand

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Managing sea level rise and coastal hazards is becoming an increasingly pressing issue in maritime countries such as New Zealand, Australia and the Pacific Islands, where a large proportion of the population lives in coastal locations. Climate change and coastal hazard issues cross boundaries – physically and politically. Decision making needs to be integrated across these boundaries if there is to be any hope of adapting well to climate change. Furthermore, tackling these issues will be a long-term exercise. In many respects this presents the greatest challenge, as there is often a desire for fast, visible results, especially within a 'term-of-office' time frame. There is also a perceptual risk of the issues becoming too large to manage, which leads to procrastination and deferment of the problem. These are challenges now confronting local authorities in New Zealand, including Greater Wellington Regional Council.

The Wellington region, in the lower part of New Zealand's North Island, is one of the most populous parts of the country. The area is administered by eight city and district councils and one regional council; Greater Wellington. Greater Wellington has responsibility for managing the natural resources of the region, including the coastal marine area which encompasses over 500 km of shoreline. Much of the interior is mountainous, and this has led to development being concentrated on flat land at the coast, much of which is exposed high energy shoreline. Thus, there are significant areas of investment at risk from sea level rise and coastal hazards.

In order to overcome these difficulties, Greater Wellington is adopting a multi-disciplinary and multi-agency approach to managing coastal hazards. Experience at Greater Wellington has taught that adaptation to these risks needs to be incorporated into every aspect of the planning and decision making process. In this way, it breaks the problem down into manageable proportions that can be tackled incrementally. One of the key ways in which Greater Wellington is setting the direction for coastal management is with a Regional Policy Statement. This document contains a range of strong policies that will govern how development is allowed to proceed in vulnerable coastal areas. It also mandates a programme for research and information sharing with the community and local authorities.

Research into coastal hazards to identify vulnerabilities will be critical in supporting the aims of the policy document. This information will feed directly into policy and decision making, for example in the granting of building consents or developing hazard maps for district planning. A major project has recently commenced that will model region wide storm surge and coastal inundation, taking into account a range of sea level rise scenarios.

Another aspect of this work has been identifying coastal dune areas suitable for restoration. A series of plans have recently been developed that aim to strengthen natural beach defences by planting with native sand-binders. An important component of this work is carried out by volunteer care groups funded by the council. Working with volunteer groups presents good opportunities for community education, which is a core part raising awareness of climate change issues.

The lessons learnt at Greater Wellington show that long term results will only be achieved by cooperating and working with a wide range of agencies; lessons applicable to any coastal city in the world.

## Effectiveness of adaptation to climate change in the Netherlands: A sub-national case study at six meters below sea level

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Climate change increases the vulnerability of low-lying coastal areas. Through the implementation of planned anticipatory adaptation policies this vulnerability can be reduced. The assessment of the effectiveness of adaptation options plays an important role in the development of a sub-national adaptation policy. The assessment includes the identification of adaptation options and an ex-ante evaluation of the effectiveness of the adaptation policy through the analysis of the costs and benefits of the adaptation options. A sensitivity analysis gives further insight into the robustness of the adaptation policy.

We present a sub-national case study on adaptation to climate change in the Netherlands, with a special focus on spatial planning. Climate robust spatial planning is needed to reduce the vulnerability of society to current and anticipated climate change, including uncertain extreme climate change events. Currently the sub-national government plans to develop an area located at six meters below sea level in the south-western part of the Netherlands for residential construction and intensive greenhouse horticulture. The investment decisions on spatial planning and infrastructural development will be impacted by future climate change. This requires adapting the new spatial plans for the region for climate change, as sketched in the climate change scenarios from IPCC and the Royal Netherlands Meteorological Institute (KNMI).

The assessment of the adaptation options is done by determining the effects of climate change on the area (determining what the decision-makers are adapting to), using climate change scenarios from IPCC and KNMI. The climate change scenarios are projected on the area to identify which effects of climate change occur in which parts of the polder and

the reference situation is described, i.e. the situation without the implementation of the adaptation policy. Furthermore the threshold probability (exceedance probability) and probability of flooding related to extreme climate change events is determined under the current circumstances and for anticipated climate change. The extreme climate change events relate to the increase in flood risk in the area due to excessive precipitation and high water levels in the river.

The direct and indirect effects of the adaptation options are assessed and where possible quantified and monetarized. This includes the net benefits and net costs of the adaptation options. Most important elements are the investment costs and avoided damages. The expected damages avoided by the adaptation policy are estimated through calculation of the difference between the climate change-induced damages with and without adaptation. Uncertainty is taken into account in the economic analysis, and several parameters are subject to a sensitivity analysis.

An iterative planning process, with active involvement of stakeholders has resulted in an adaptation policy for the area, which includes four adaptation options for different locations. For these four adaptation options (e.g. flood proof housing and adjusted infrastructure) the costs and benefits are identified, and a cost-benefit analysis is carried out. The initial results show that especially high investment costs of structural adaptation options outweigh the long term benefits, due to the low probability of flooding and the discounting effect.

Sub-national governments that are adapting to the impacts of climate change need to have insight in the costs and benefits of adaptation options in order to make effective decisions. Through a transparent assessment process of the adaptation policy, including a social cost-benefit analysis, presentation of intermediate results and a detailed sensitivity analysis, decision-makers and stakeholders gain insight into the development of adaptation policies, thus preventing possible mal-adaptation. It is however difficult to quantify all direct, indirect and external effects of an adaptation policy and incorporate the effects of different types of uncertainty into the results of the cost-benefit analysis. Our study shows that it is important to assess the costs and benefits to evaluate the effectiveness of adaptation options, however the results of a cost-benefit analysis are a starting point and not an end point for the assessment of an effective climate robust adaptation policy.

## Facts and values in climate change science and adaptation policy

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This presentation makes two, fundamental, yet little acknowledged, observations about 'facts' and values in the context of climate change research and policy and elaborates on the important bearing these observations have on climate change adaptation. These proposals draw on some well established viewpoints within social science.

The first proposes that values can influence what are deemed to be 'facts' and vice versa. Scientific and social uncertainties associated with climate change science provide a particularly conducive environment to players making conscious or unconscious selective choices concerning what constitutes convincing evidence in relation to human-induced climate change.

The second proposes that values strongly determine belief in climate change and what are considered as reasonable and appropriate adaptation responses. This observation draws on the emerging public framing of climate change in terms of 'believers', 'skeptics' or 'disbelievers'.

Both observations have an important bearing on public engagement with climate change science and associated adaptation policy. Two points for consideration are detailed below.

One is the emerging diminishment of public confidence in the science of climate change. Many of the skeptics' arguments highlight uncertainties in the science rather than representing outright refutations. These uncertainties assist in fueling public doubt, where arguments along the lines of 'given x is not as certain as has been made out, perhaps y and z are also not certain?' get magnified and repackaged as disbelief. Public willingness to engage with climate change as a serious and urgent issue therefore decreases, with the possible implication that not just support for mitigation action is reduced, but also that there is less preparedness to take adaptive action. Some of the more direct refutations of the science, such as the 'Himalayan glacier incident' only serve to further amplify this present fall in public confidence.

Another is the importance of accommodating multiple perspectives on what constitutes appropriate adaptation responses within policy. Given the present uncertainties characterising climate change science, adaptation policies would benefit from being able to cater for the range of present views concerning climate change ('believers', 'skeptics', 'disbelievers'). Similarly, adaptation policies would also benefit from being able to cater for the diverse and often conflicting range of views concerning reasonable and appropriate adaptation. This latter point is pertinent irrespective of the degree of uncertainty surrounding climate change. Deemed appropriate adaptations to climate change are necessarily linked to differing geographical impacts, uses and values assigned to environments, and the economic and cultural means to cope or adjust to changes.

These points have important implications for the framing of and underlying approach to adaptation policy making. One is that uncertainty about climate impacts, and consequently uncertainty about the relevance of particular adaptation measures, needs to be clearly explained. This area is gaining in profile, with a range of other scholars making similar calls. Climate change adaptation can then be more clearly understood as an exercise in risk management. Another relates to framing relevant policies in terms of both addressing an established

environmental problem (e.g. drought) as well as addressing possible impacts associated with climate change. This ensures a greater chance of arriving at sound adaptation policy and supporting appropriate individual adaptive behaviours, with less interference from polarised debates between 'believers', 'skeptics' and 'disbelievers'.

## Migration, environment and climate change

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Climate change is a major concern for the international community. Among its social and human dimensions, its impact on migration is the object of increasing attention from both policy-makers and researchers. Greater resource scarcity, desertification, risks of droughts and floods, and rising sea levels could drive millions of people to migrate. Yet, despite the interest in the links between climate change and migration, research and policy development on the issue remain limited. There are uncertainties surrounding the mechanisms at stake, the number of persons affected and the geographical zones concerned and there is disagreement between those who stress the direct impact of the environment on population flows and those who rather insist on the social, economic and political contexts in which such flows occur. Most importantly, the impact on policy-making remains largely unexplored. This presentation will provide a comprehensive overview of the climate change migration nexus, based upon a research project underway at UNESCO on the impact of climate change on migration. It will provide empirical evidence on the links between climate and migration by bringing together case studies and analysis from different disciplines. It will investigate the key policy issues raised by climate change and migration, including states policy responses and the views of different institutional actors; critical perspectives on the actual relationship between the environment and (forced) migration; the concepts and notions that are adequate to address this relationship; gender and human rights implications, and finally the ethical dimension, international law and responsibilities. Core messages are: The international community needs to address the social and human dimensions of climate change, taking full account of the relevant ethical principles. The international framework for the management of migration flows in relation to climate change needs to be further developed. Experts from both the natural and social sciences need to work more closely together to understand the impact of climate change on migration. Better data on the social and human dimensions of climate change needs to be collected to monitor environment-related migration.

## The role of place attachment in understanding and managing community adaptation to climate change

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Climate change is likely to cause extensive change to human settlements and natural environments, for example where existing settlements in coastal areas may be impacted upon by local flood events and permanent loss of land. This prospect raises many important questions about how such changes may be anticipated, prepared for, managed and responded to. Failure to adequately prepare for environmental change raises the possibility of 'knee-jerk' responses by institutions to immediate threat, magnifying rather than minimizing the negative outcomes associated with such events and increasing the probability of conflict between state institutions and affected communities and individuals over the acceptability of specific management strategies and actions.

This paper discusses an issue that has hitherto been rather neglected in the literature on climate change adaptation - the role of place attachments in understanding and managing adaptive responses at the community level. In drawing connections between the literatures on adaptation and place attachment, our aim is to develop a framework to direct research in this area that will have outcomes informative to policy and decision-making.

Place attachment refers to the typically positive emotional bond that arises between people and certain familiar, valued locations or places. Research has shown how attachments become particularly salient at moments of disruption or displacement, leading to feelings of loss and grief. Changes to place attachments that are extensive and uncontrolled (for example, those arising from unanticipated environmental events such as floods, landslides or earthquakes) have been labeled psychologically 'disruptive' because they force change to the self-concept, threatening underlying principles of identity processes such as self-esteem, self-efficacy, continuity with the past and distinctiveness from others. We argue that knowledge from previous research on the identity dynamics of forced relocation can be utilized to better design policy responses to climate adaptation.

The framing of adaptation in terms of 'managed retreat' from areas designated as vulnerable to change has been found to be deficient in reflecting the emotional and cultural significance of specific environments as places that individuals and communities form strong attachments to. Burley et al. (2007) have shown how place attachments to coastal areas of Louisiana were based upon familiarity with natural ecosystems that were akin to forms of 'traditional environmental knowledge', but ignored by natural resource managers charged with managing change. Feelings of alienation from decision-making by local residents reflected boundaries between local residents and external experts and managers, decreasing trust.

The literature suggests that decision-makers need to be better aware of the implications of place attachments and place identities for the design and implementation of institutional responses to environmental changes. However, at present we are



only beginning to understand how disruptive events may be anticipated and responded to, and how our understanding of place attachments may be embedded within attempts to manage such changes. As a consequence, this paper aims to deepen understanding by identifying key aspects of the literature on place attachment disruption that relate to issues of climate change adaptation and present a framework of key questions that can guide future research.

## The Weakest Link: The uptake of knowledge on vulnerability into decision making

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As the dimensions and reality of climate change have become more evident in recent years, attention is now beginning to focus on the issue of adaptation. While much attention has been focused on estimating future impacts from climate change on various sectors and parts of the world (e.g. WGII IPCC 2007), much remains to be understood about the barriers to successful adaptation. These barriers include lack of knowledge about what to do and lack of capacity (whether financial, institutional or human) to act (Adger et al 2007).

However, many may assume that given knowledge about how to reduce negative outcomes, and given sufficient societal capacity, society will take action to adapt to the risks of climate change. From existing research about the response to hazards, even without the prospect of climate change, we might have reason to doubt this assumption. As Mickey Glantz and colleagues wrote, “lessons learned” might more appropriately be called “lessons identified”-- only until someone actually applies the knowledge to reduce the risks associated with future hazards do they actually become lessons truly learned (Glantz et al. 2009).

White, Kates and Burton published an important review of where hazards scholarship stands on the “situation in which more is lost while more is known” (White et al. 2001). While the good news is that losses of life are decreasing, property damage is increasing, in both developing and the developed countries. Losses of life, while declining, also remain unacceptably high given the number of preventable deaths especially in developing countries.

With respect to the role of knowledge in improving outcomes with respect to hazards, White et al. (2001) briefly review five potential explanations for why, in face of ever-growing knowledge about hazards and their natural and social causes, losses continue to mount. The possible explanations they offer include:

- a. knowledge is still lacking;
- b. knowledge is available but not used;
- c. knowledge is used but ineffectively or with unintended consequences;
- d. there is a lag time between the effective use of relevant knowledge and improving the situation; and
- e. all best efforts to use knowledge have occurred but background increases in vulnerability swamp any positive gains.

White et al. conclude with a plea for more appraisal of the “actual results of applying the best available knowledge in the best possible way” and better integration of knowledge of hazards into the practice of sustainable development.

One of the key barriers to successful adaptation that must not be overlooked, therefore, is the uptake and use of knowledge about reducing vulnerability in decision making processes. Otherwise, as Mickey Glantz has written, we reach the situation where “lessons have been identified, but not learned” meaning that knowledge gained even as a result of disaster or tragedy, is not acted upon to improve future outcomes. This paper sets forth a theoretical framework to underpin case studies examining three related questions for adaptation:

1. Is lack of information a barrier for successful adaptation measures?;
2. What are the barriers to the successful uptake of information for adaptation in policy?; and
3. Are there limits to the use of information for improving outcomes?

## Modelling and Simulation of Consumption Behaviour Dynamics to Support Climate Adaptation

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Climate change projections suggest that many Australian cities will become hotter and drier resulting in an increased use of resources such as energy and water. As a result, urban planners and policy makers may wish to explore climate adaptable urban planning and promote sustainable consumption, while communities may wish to see different options for their consumption, capability to adapt, and impact.

To enable this, we are developing a proof-of-concept digital platform to simulate consumption behaviour dynamics and their interactions with the environment. The platform will provide visualisation of what-if scenarios and generate insight to support decision-making.

The project is funded by the CSIRO Climate Adaptation Flagship and undertaken by a team of computer scientists, socio-economic scientists and domain experts. The existing development has focused on modelling and simulation of mobility-related consumption behaviour in climate adapted urban development, and the links to socio-economic and attitudinal factors, urban patterns and climate extremes.

Mobility-related consumption behaviour is influenced by urban form, accessibility, transport choice and socio-economic factors. For example, an automobile-oriented suburb will result in high level car use, energy consumption and larger carbon footprints. The research will look into an urban planning way to promote consumption behaviour change and reduction of carbon footprints.

The research will also investigate how demographic characteristics and environmental attitudes are linked to behaviour. It will develop an understanding of how consumption behaviours may vary in different segments of society, habitats and urban patterns, particularly under a changing climate with increasing weather extremes (e.g. heat stress).

Modelling and simulation capability will be established through a prototype multi-agent simulation and 3D visualisation. Socio-economic and attitudinal variables related to transportation choice will be integrated into the agent-based model to support understanding of decision-making processes and simulation of behaviour dynamics.

The simulation will enable “what-if” analysis on a range of adaptation choices under different planning and climate change scenarios. It will provide local governments, industries and planning authorities with a useful tool to support well-informed decisions.

## **A Balancing Act: How Small Island Developing States are balancing climate change and development**

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Climate change is an important issue in the field of development, one that has the potential to change the way in which countries interact with one another. Each country will be impacted differently from the effects of climate change though the consensus among those in the environment and development field is that developing countries will be heavily impacted due to other socioeconomic, geographical, and political factors. Therefore balancing development efforts and climate change efforts is important. Small Island Developing States (SIDS) are a category of countries that have to deal with the effects of climate change now, and plan for the future effects that scientists are predicting. The issues that are of major concern for SIDS include (but are not limited to): sea-level rise, access to clean fresh water, tropical storms, salt water intrusion, and health issues. These climate change issues are putting heavy strains on many SIDS which are already struggling to make ends meet. Small Island Developing States must tackle similar barriers when dealing with development challenges. These barriers may be expanded and resources exhausted because of the effects of climate change, given that Small Islands are particularly vulnerable to climate change because of their small size, and their high ratio of shoreline to land area. This paper looks at how small island developing states are balancing development initiatives and climate change adaptation. Within each Small Island Developing State there are different perspectives of what should be the optimal balance between climate change and development. This is an important factor in the balance since the priorities set by the government for the allocation of time, effort, and money is not always in the same sequence as the people in the country. These issues are explored with a particular focus on the Pacific island country of Tuvalu.

## **Critical Review of Resilience Definitions in Theory and Practice: Towards Measurable Definitions of Resilience to Disasters and Climate Change Impacts**

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Climate change impacts are acknowledged to be one of the main threats to the environment and society at the moment. Thus communities urgently need to start developing and building resilience to these threats. Most studies agreed that resilience concepts originated from ecological studies in 1970s and expanded to current studies on complex inter-linkages between human and environment. The most current conceptual resilience theory are based on three system characteristics of (i) the amount of change that a system can absorb and still retain the same structure and function; (ii) the degree to which the system is capable of selforganisation; (iii) the degree to which the system can build and increase capacity for learning and adaptation (Carpenter, et al., 2001).

The concepts of resilience have now been used extensively in interdisciplinary work concerned with interactions between people and nature such as those on vulnerability, impacts of climate of climate change, natural hazards and disasters and sustainability (UN/ISDR, 2002; IHDP, 2003). It is widely acknowledged that the adoption of term resilience by the UNISDR (2005) in its Hyogo Framework for Action for 2005 – 2015, strengthen the importance of the resilience concept in managing the ever increasing impacts of disasters including those of climate change. There have been many reviews on resilience definitions and their applicability in managing disasters and unpredictable impacts such as those from climate change. However, a comparative overview and analysis of how resilience is translated into practice by organisation trying to manage disasters has so far been underexplored. This paper will advance these

discussions through outlining how various organisations, working on disasters resilience, define it based on their own experiences / activities. We review and categorise fortyseven (47) of conceptual resilience definitions as well as examine another thirteen (13) defined by organisations working on promoting resilience to disasters. These definitions are further categorised based on their domains of analysis and break down further into its a) end result, b) unit of analysis, c) process, d) outcome and e) driver impacting on systems in question. This leads to discussion on their similarities, differences, and strength, weaknesses as well as knowledge gaps between concepts and practices.

After examining and comparing these conceptual and practical definitions, we infer that:

- Resilience is considered as attribute of communities in which they are resilient when they have capacity or ability to face disasters,
- Resilience is considered as an inherent part of the community by which individual as well as collective capacity determine the resilience of the community as a whole,
- There are various mechanisms that the community can go through in facing disasters which reflected disaster management cycle of mitigating, preparing for, and recovering from disasters,
- Resilience enables community to bounce back and adapt to adversities which should put them in a better and more positive outcome after disasters,
- Lastly, these experiences will be used so that communities are in a better, comparable capacity to face future adversities and disasters.

## Linking Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA): The Experience from Indonesia

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The need to link DRR and CCA has recently been gaining momentum. The Bali Action Plan of the United Nations Framework Conventions on Climate Change (UNFCCC) Parties recognises that existing knowledge, experience and capacities for reducing vulnerabilities and increasing preparedness to extreme weather events must be harnessed in adapting to climate change. The need for convergence is strong because there is significant overlap between the theory, policy and practice of DRR and CCA. But despite the synergies and opportunities, linking the two approaches is difficult in policy and practice.

In this paper, we explore how international initiatives, programmes, policies and institutions guide DRR and CCA in Indonesia and the role of the 2004 Indian Ocean Tsunami in bringing about positive change in terms of creating political will, providing financial resources and strengthening commitment to efforts aimed at reducing disaster risks and adapting to climate change is of particular interest. Furthermore, the authors review the roles and responsibilities of government agencies, non-government organisations (NGOs), civil society organisation (CSOs) and the public sector involved in DRR and CCA, and explore how these different actors relate to each other. Finally, we examine lessons learnt on how to improve policy and practice to achieve synergistic applications of DRR and CCA in Indonesia.

We suggest three key areas for action in linking DRR and CCA in Indonesia:

*Area 1: More effective integration of disaster risk considerations into sustainable development policies, planning and programming at all levels.*

The foremost challenge is the establishment of clear coordination mechanisms between different governments operating at all levels. DRR is managed by The National Agency for Disaster Risk Reduction (BNPB) while The National Council for Climate Change (DNPI) is responsible for managing CCA. Moreover, because DRR has been progressively developed at national and sub-national levels and CCA is still in its early stage, we argue, that CCA should build as much as possible on existing strategies and tools developed for DRR in order to avoid duplication in institutions, policies, funding and processes and to achieve better integration.

*Area 2: Development and strengthening of institutions, mechanisms and capacities at all levels.*

DRR and CCA intervention should focus more on strengthening the capacity of local actors and creating an enabling environment for community-based action. NGO stakeholders are important actors in improving awareness of DRR and CCA amongst the public and linking DRR and CCA activities with other local priorities, such as poverty reduction, livelihoods improvement, and natural resource management.

*Area 3: Systematic incorporation of risk reduction approaches into the design and implementation of emergency preparedness, response and recovery programmes in the reconstruction of affected communities.*

Lack of awareness among governments and politicians of the long-term impacts of climate change pose a hindrance to the inclusion of CCA into the development agendas of sub-national governments. DRR and CCA need to be framed not as additional burdens for sub-national authorities. Rather, the benefits to poverty reduction, livelihoods improvement, natural resources management, tourism and general sustainable development need to be emphasised.

## A HECS on all your houses: financing climate-induced retreat from coastal inundation

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Climate projections suggest increased inundation of beachfront property on the east coast of Australia over the coming century. Intermittently Closed and Open Lagoons such as those at Pittwater and Manly in Sydney are examples of areas at risk.

The emphasis in Australian policy discourse has to date been on the 'protect' and 'accommodate' phases of adaptation to coastal inundation. Protective measures such as sea walls, and accommodation to the effects of flooding (such as raising houses) offer initial lines of defence, but managed retreat will ultimately be required for some property owners. However, current risk-management and disaster management frameworks offer little policy guidance on who should pay for retreat, or when or how. In particular, conventional risk management frameworks are predicated on at least some knowledge of the nature and degree of risk, but climate change is characterised by significant uncertainty that precludes realistic assessment of Knightian risk.

Ordinary insurance, catastrophe insurance, group (index) risk insurance, catastrophe bonds and reverse mortgages offer potential solutions, but are ultimately impractical or flawed in various ways. Direct government subsidies, for example, through purchase of chronically inundated properties by local councils, is a possibility, but raises issues of equity and potential fiscal churn if everyone subsidises everyone else for all effects of climate change. Correlated risk is a problem in terms of insurance. Reverse mortgages require preservation of equity and are therefore unsuitable as a means of generating funds to relocate.

The Australian Government assists students who cannot obtain commercial loans by making loans available through the Higher Education Contribution Scheme (HECS), a form of income-contingent lending that is repaid on the basis of income level, rather than a fixed temporal schedule. While conventional commercial loans must be paid back on schedule, irrespective of the borrower's ability to pay, income-contingent loans need to be repaid only once the borrower is earning sufficient income to do so.

Many coastal residents subject to inundation may not have sufficient income (for example, retirees) to allow them to borrow commercially to abandon their coastal residence and purchase alternative accommodation. Income contingent loans are therefore inappropriate. We therefore examine an innovative approach in the form of mortgage (asset) contingent loans which would minimise government involvement, and therefore the risk to taxpayers, in assisting residents in low-lying coastal areas to seek alternative habitation in the face of climate-induced inundation.

If it is to offer a practical solution, a mortgage contingent loans scheme would need to identify address the challenges of adverse selection and moral hazard. In the case of retreat from threatened coastal areas, there is a further issue that needs to be addressed, that of financial responsibility for demolition of abandoned houses and any other environmental hazards. Some hypothetical empirical examples have been developed for illustrative purposes.

Little attention is currently being given by governments to formulating principles that might underpin future adaptation, particularly in regard to who should pay for what, and when. This paper seeks to initiate rational discussion before short-term political pressures result in the development of ad hoc, inconsistent policies.

## Weather Extremes: Assessment of Impacts and Hazards for European Regions

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Climate change is beginning to be measurable and, no matter what we do to mitigate it, a rise of global temperatures by 2°C to 4°C within this century is no longer avoidable. The consequences will be more extreme events such as hot and dry summers, heavy winter storms, storm surges, floods and landslides. The need for adaptation is recognised, but the magnitudes and consequences of these changes in the weather system are not yet well understood. Therefore, the WEATHER project aims at analysing the economic costs of climate change on transport systems in Europe and explores ways for reducing them in the context of sustainable policy design.

The WEATHER project aims at analysing the economic costs of more frequent and more extreme weather events on transport and on the wider economy and explores adaptation strategies for reducing them in the context of sustainable policy design. It further relates adaptation strategies to the question of appropriate crises prevention and management systems. With the support of an international panel of experts of scientists and transport professionals and intensive case study works the project seeks to develop practically applicable adaptation strategies and related cost and benefit estimates.

The research is carried out by an international team of eight European institutes, lead by the Fraunhofer-Institute for Systems and Innovation Research (ISI). The project is funded by the 7th RTD framework program of the European Commission and runs for 30 months from November 2009 until April 2012.

## Observing insects: Traditional entomological knowledge, climate change and adaptive responses in tropical rainforests

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Impacts of climate change on tropical rainforests are lesser known than impacts on other biomes. Firstly, amplitudes in climate fluctuations are moderate in rainforests that also face lesser occurrences of catastrophic extremes. Secondly, there is more pending uncertainty regarding trends on climate change in humid forests, which seem to be more resilient than other ecosystems to climate disturbances. Lastly, effects of climate change are overshadowed by deforestation, which constitutes a much heavier threat on rainforests.

Because the incidence of climate change in tropical forests is subtle and poorly understood, we need to investigate forest dwellers' perceptions with much greater attention. Indigenous peoples and local communities (IPLCs) may play a fantastic role as sentinels of the forest as they would help the scientific community to better document the effects of climate change in places where these effects are poorly known.

We propose to focus our presentation on bio-temporal signals that are determining events upon which IPLCs have acquired the capacity to anticipate on climate fluctuations. Bio-temporal signals are from different kinds: visual, sonorous, olfactory, tactile, etc. IPLCs mobilize a beam of converging signals, a combination of determining events upon which they organize the calendar of their activities and take their decisions to invest in some activities and not in others.

Among the various sources of bio-temporal signals that forest dwellers refer to, insects are probably the most accurate and the most fascinating. Insects are sensitive to very subtle fluctuations of climatic conditions not perceptible to humans. Pollinating insects play a keystone role as natural ecosystem engineers by maintaining a high biodiversity. Around 80% of the flowering plant species on our planet are known to reproduce by pollination. Many pollinating insects are under threat and alerts us about the damages caused by humans and induced climate change on terrestrial ecosystems. Countless species of—sting as well as stingless—bees also produce honey and equally serve biodiversity. Similarly ignored are the countless forms of traditional ecological knowledge that are mobilized throughout the tropics to hunt wild honey or to keep beehives in a sustainable manner, through various and extensive proto-domestication practices. Bees—and other pollinating insects alike—act as prominent bio-temporal signals, which efficiently alert IPLCs on subtle environmental disturbances.

The analysis of traditional entomological knowledge may be an efficient way of approaching forest dwellers' perceptions of ongoing climate change and their induced adaptive strategies to adjust their livelihoods and mitigate their vulnerability.

We advocate in favour of a greater involvement of IPLCs into the process of assessing the poorly visible impacts of climate change on tropical forests. Through their extensive knowledge and know-how, IPLCs could play a determining role as “sentinels” by providing first-hand and accurate observations and supplying databases that dramatically fail at incorporating anthropological data into the elaboration of predictive models on climate change.

## Policy processes, institutional systems, and adaptation

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Most research literature and policy discussion on adaptation to climate change and variability is strong on general aspirations and desired end states, but weak on the actual policy and institutional means of achieving these. This is especially the case with respect to mechanisms to implement climate policy integration or mainstreaming. While this is to be expected given the relatively recent focus on adaptation (compared to mitigation), this paper argues that it is also caused by a somewhat closed, self-referencing literature and policy discourse, and a failure to connect with highly relevant bodies of existing theory and practice in cognate sectors including disaster management, natural resource management, regional planning, sustainable development and environmental policy integration. Moreover, there has been insufficient reference made to generic bodies of knowledge in public policy, institutional theory and public administration. The paper will detail this situation, and survey existing bodies of knowledge and practice to identify actual and proposed policy and institutional structures and processes that may serve to achieve incorporation of adaptation imperatives across portfolios, jurisdictions and policy sectors. The paper's contributions include both a general reorientation of focus in adaptation research and policy, and specific policy and institutional mechanisms with evident potential to be used to advance adaptation policy integration. The latter contribution uses known types of policy and institutional structures and processes, and extant, described examples from SE Asia and Australasia, including in areas such as administrative structures, strategic assessment regimes, sub-national institutional change, regional planning, and cross-scale governance mechanisms. These examples offer the prospect of progress with adaptation policy that is quicker, more efficient and more effective than appears possible on the arguments and evidence in most adaptation literature and policy debates. The paper extends the analyses and propositions in Dovers (2009) *Normalizing adaptation*, *Glob Env Change*, 19; and Dovers and Hezri (forthcoming) *Policy and institutions: the means to the ends of adaptation*, *Wiley Interdisciplinary Reviews Climate Change*.

## Communities dealing with transformational change: Insight from a social network approach

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There is a growing body of research investigating adaptive capacity and decision making processes of primary industries across the globe due to climate change. The focus of that research has mainly been on the successful and unsuccessful impacts of incremental adaptation across various sectors and levels of analysis. For some agricultural sectors, the ineffectiveness of short term incremental tactical responses is no longer a valuable strategic approach in securing their future survival. Instead, some Australian primary industries are starting to investigate or actively implement transformational adaptive change in order to achieve sustainability.

From a community perspective, dealing with long term planning and decision making can be an overwhelming and tremendously complex process. There are many factors that affect decision making processes and this project aims to explore these issues, through case studies of major, adaptive shifts in response to climate change. The framework for conceptualising transformational adaptation is a combination of the theory of transitions and transition management. Our research question is: what information sources and social support systems assist communities to make more significant, transformative shifts?

Data was collected from 24 semi-structured interviews from key stakeholders in the Sunraysia and Wimmera communities. Participants were asked to indicate what sources of information and support and advice channels they use in relation to the potential impacts of climate change. In addition, interviewees were asked to identify which people or organisations are the most influential in terms of the adaptation process. Data was analysed using social network analysis, which is a means to represent the interconnections and interdependencies that occur between varieties of relationships. The results show a visual representation of the observed networks reported from an actor-oriented perspective.

Networks among farmers were important in engaging others in adaptation to climate change. Innovative individuals led the way and others observed. There was a shift of knowledge and information occurring as farmers travelled north to learn the farming practices in a drier climate to apply in their own region. Farming groups provided an environment for information sharing and learning amongst farmer members, which was then transferred to the wider farming community. In the Sunraysia case study, local government, education institutions, hospitals and economic development boards had an important role in the adaptation of the community, seeking to expand the economic base of the region by attracting new industry and developing a whole of community plan. As a result of these adaptations at different scales, there was a greater level of community-wide acceptance and conversation around climate change. In the Wimmera for example, interviewees said the community as a whole had recently been making the link between sustainability and productivity. Community support for the Wimmera-Mallee pipeline was an example of the community recognising that significant change was needed. In summary, this first stage of data collection allowed us to gain insight into the various information and support and advice systems participants, from two communities, utilise in order to address the issue of climate change.

## Climate Change and sustainable development in Botswana

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Climate change is the strongest signal ever indicating that the global economic growth experienced since the 19th century has not been based on the principle of sustainable development. The impacts of global warming will be severely felt locally, affecting most developing countries such as Botswana due to low development, widespread poverty and numerous socio-economic and environmental challenges already being experienced. Adaptation to climate change is a priority for Botswana because climate change adds yet another source of stress over and above the existing vulnerabilities resulting from climate variability and socio-economic factors. The country experiences periodic drought resulting in a large part of the development budget diverted to drought relief programmes. At a global scale the country was ranked number 76 out of 131 countries in the 2007/8 Global Competitiveness Ranking report with the worst ranking, of 119, in education and health which are key to the development process.

Current indications are that there will be increased aridity over Botswana in future due to climate change. This paper argues that because the country is already under semi-arid conditions, most measures required to adapt to climate change also serve to address current needs such as water conservation, food production and diversification of rural economies to minimize urban migration. Investments in pro-active disaster risk reduction measures from exposure to hydro-meteorological hazards such as drought, floods, fires and hailstorms will be of benefit to both short-and long term development plans. As a result synergies among adaptation, coping with climate variability and development can be created. However, to achieve a sustainable development pathway adaptation and climate change mitigation in Botswana needs to be interlinked and tailored to national development goals. For a developing country with limited resources, investments in mitigation should be based on carefully selected cost effective emission reduction measures that are of long term economic, social and environmental benefit. Government has a critical role of facilitating mitigation and adaptation by for example, supporting research and creating awareness, providing subsidies and regulatory measures for the private sector, building human resource capacity and infrastructure including institutions and setting condition for increased demand for low carbon goods and services.

Botswana is only beginning to acknowledge that climate change solutions lie not with environmental ministries but with those dealing with economics and development issues including the private sector. A number of policy instruments addressing economic diversification, rural development and poverty alleviation, disaster management exist in Botswana

but need to be reviewed and integrated for use as a basis for addressing climate change mitigation and adaptation. While that is so, a number of these policies do not take into account climate variability. Systematic incorporation on climate change adaptation and mitigation into the development process will be best achieved where a climate change policy framework and a national climate change strategy is in place to guide the integration of climate change adaptation with response to climate variability and link these with mitigation under the national development goals. A clearly defined strategy will need to incorporate a system for monitoring and evaluating mitigation and adaptation strategies to ensure that the measures applied remain cost effective and have positive feed back on sustainable development.

## **Supporting Adaptation in Least Developing Countries: The International Geosphere-Biosphere Programme (IGBP) Synthesis, Integration, and Exploration (SIE) Activity**

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The United Nations recognized, since the 1960s, a group of extremely poor countries that have acute susceptibility to external economic shocks, natural and man-made disasters, and that suffer structural handicaps which require special international attention. These countries, known as the Least Developed Countries (LDCs) are currently 49 in number out of which 33 are found in Africa, 15 in Asia and the Pacific and one in Latin America. LDCs suffer multiple stressors emanating from complex inter-linkages between local and global environmental and socio-economic challenges. Climate change will, above all these, add yet another complex layer of challenges to the LDCs. Changes in patterns of vector-borne diseases and other environmental health problems due to changes in temperature, rainfall and relative humidity will combine with food insecurity, water scarcity and other socio-economic problems to present profound challenges enhancing the already precarious state of human well-being in LDCs. Increasing frequency and intensity of climate extremes, such as hurricanes, cyclones, floods, wildfires, drought and windstorms will reverse and constrain whatever progress had been achieved in LDCs making efforts to meet Millennium Development Goals even more remote. LDCs are a global concern given the heightened global interconnectedness i.e. low development in one part of the world is both a result and a source of global vulnerability. Without appropriate intervention the global community is more likely to face heightened problems of e.g. environmental refugees and disease epidemics emanating from these severely disadvantaged areas.

While Parties have proposed a “knowledge-based adaptation,” and a number of LDCs have completed their National Adaptation Programmes of Action (NAPAs) it is not clear how far these were supported by up to date locally relevant scientific information which will also be required for implementation. Global Environmental Change (GEC) science outputs generated by various international organizations have great potential to contribute towards addressing challenges of LDCs but this information is usually provided on a broad scale, is fragmented and lacks immediate local context for policy applications. LDCs do not have capacity to develop their own context-specific GEC information, nor to assemble and synthesize available findings relevant to their needs. Because of this, major policy-driving assessments such as IPCC reports lack adequate coverage of LDCs; this further constrains LDCs negotiations for greater international support for adaptation to climate change.

This paper reports on the International Geosphere-Biosphere Programme (IGBP) Synthesis, Integration and Exploration (SIE) activity to be carried out between 2010 – 2014. One of the IGBP SIE themes is focused on LDCs with special attention on natural hazards such as drought, floods and fires; human health and environment with particular reference to food security and water resources; and on the role of indigenous knowledge systems in adaptation. The LDCs SIE is designed to provide an opportunity to integrate global based scientific findings on climate change and GEC in general with relevant outputs or ongoing work at the local/national level to address pertinent policy needs of LDCs, and identify new areas that are of value to these countries for further development. As a result the synthesis will facilitate cross fertilization of scientific information produced at different scales by IGBP and its partners (IHDP, ESSP, WCRP etc) and local experts, and provide interaction between global and local LDCs scientists thus facilitate capacity building through “learning by doing”. The out put will be a coherent synthesis of key GEC issues in LDCs that can be of value to the IPCC process and hence help policy directions under international frameworks such as the UNFCCC as well as addressing local needs.

## **Household level adaptation: saline intrusion and migration in the Mekong Delta, Vietnam**

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Since the release of the IPCC's Fourth Assessment Report in 2007, changing attitudes have resulted in a general acceptance of climate change at a global level and have subsequently resulted in a heightened interest and shift in discourse about the relationship between environmental changes and human migration. There has been a shift in discourse which recognises that greater research and policy attention needs to be given to environmental causes of migration (as opposed to a focus on avoiding discussions on, or denial of, the “environmental refugee” problem). Additionally, increasing emphasis is being placed on recognising the potential of migration as an adaptation strategy for individuals and communities directly impacted by climate change with leading climate change adaptation scholars stating that, “migration may be one response of people whose livelihoods are undermined by climate change” (Barnett and Adger 2007:643).

Viet Nam is a country prone to water or water-related disasters which are thought to be increasing due to the influence of climate change. According to the results of a World Bank study released in February 2007, Viet Nam will be one of the

countries most severely impacted due to potential sea-level rise. A scenario of a 1 metre sea-level rise by the year 2100, modelled by the Queensland-based International Centre for Environmental Management, showed that 85% of the sea level inundation affecting Viet Nam would affect 12 provinces and cover approximately 12,000 km<sup>2</sup> (30%) of the Mekong Delta resulting in an increase of salinity in surface waters and groundwater of the Delta. Climate change aside, saline intrusion is the main factor already limiting agricultural production in the Mekong Delta region with dry season salinity currently affecting close to 45% of land. Activities upstream in the Mekong River such as the diversion and extraction of water for dry season irrigation and industrial purposes as well as the construction of hydro-power dams on the river mainstream and tributaries can also worsen the effects of saline intrusion in the Mekong Delta. Understanding current responses to salinity intrusion could provide insights for future adaptation strategies to adjust to the impacts of sea level rise.

This paper focuses on household level adaptation of people living in areas prone to saline intrusion in the Mekong Delta of Viet Nam. Specifically, this paper will present preliminary field research results of a PhD study examining whether salinity intrusion and its related impacts in the Mekong Delta of Vietnam are factors which can trigger migration and population relocation. Initial findings from qualitative social science research conducted during April to June 2010 investigating coping mechanisms of households in a saline-prone commune of Cai Nuoc district, Ca Mau Province will be provided. This district is naturally prone to salinity intrusion but there is evidence of increasing salinisation of surface water and soils within the last 10 year period in large part caused by the transformation of coastal freshwater-based rice fields into salt-water based monoculture shrimp farms. A sustainable livelihoods approach is adopted to understand the role of migration in the lives of people living in saline prone areas of Cai Nuoc district. By focusing on migration/displacement as one coping response amongst many in the face of environmental stress may serve to provide further insights into ad hoc adaptation strategies that people adopt when faced with slower and ongoing processes of environmental change.

## **Towards Climate Change Urban Adaptation in Indonesia: Climate Change Vulnerability Assessment for Cities in Java Region**

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In many urban areas in Indonesia, city development and urbanization enhances the impact of climate related hazards. Jakarta, the capital city of Indonesia, is subject to flooding every year due to increases in rainfall intensity and duration. In 2007, all river basin communities in Jakarta suffered from such climate related disaster events. Moreover, Jakarta is considered the most vulnerable city to climate change in the South East Asian Region. This research aims to provide a better understanding about climate change risks and adaptation in urban areas in Indonesia, particularly in urban communities in the Java region. This research projects changes in climate variables (rainfall, temperature), water availability and sea level rise in Java Island and Jakarta; and identifies the climate related hazards in urban coastal area in Jakarta, as well as the impacts, the local adaptation and its challenges.

This research combines top down and bottom up approaches. A top down approach represented by the climate modelling method using scenarios A1B, A2, and B1 of the Metrological Research Institute (MRI). Statistical downscaling with non linier regression model and bicubic interpolation were applied as the base for data accuracy. Climate change vulnerability assessment, particularly on water scarcity issue, for Java region was done by combining the factors like Human Development Index (HDI), unemployment, poverty index, number of people working on agriculture sectors, population density, and percentage of family with safe water access. The result of the climate change vulnerability assessment was displayed by Geographical Information System (GIS) map. Aside from the top down approach, this research also conducted a bottom up approach by using Participatory Rural Appraisal (PRA) tools to observe the current climate risks and present adaptation strategies including the challenges for an urban coastal community, Kelurahan Kamal Muara.

The study found that all scenarios predicted temperature increase in Java region and Jakarta province from 2010-2100 with the highest increase shown by the A2 scenario which is 3.67oC, and the smallest increase shown by the B1 scenario which is 2.09oC. Meanwhile for rainfall projection, the results indicate a strange pattern for the A2 scenario for 2010, the pattern should indicate a monsoonal wet season in the period of dry seasons which are December-January-February (DJF) and June-July-August (JJA) period, but the JJA period is predicted to be the dry season. This condition occurs only in 2010 in Java Island; while for DKI Jakarta this unusual pattern will happen again later in 2100. Based on the A2 scenario, the water surplus and storage volume projection will decrease in 2050 and then increase in 2100. For sea level rise, it is projected that there will be inundation as far as the area of Central Jakarta which will cause very large socioeconomic impacts. From the climate change vulnerability assessment, 14 districts in Java region were nominated to be the districts with a very high vulnerability on water scarcity issues.

This study also found that the climate related hazards most frequently predicted to occur in Kamal Muara are sea level rise, sea water flooding or high tidal wave, and climate uncertainty. Climate change impacts were observed and reported by the community such as sea water flood and indirect impacts on health such as diarrheal issues, environmental degradation, and also dengue cases. Factors that may enhance the vulnerability level to climate change is lack of drainage system,



lack of clean water, poor hygiene, land and space issues, and unstable economy in households. To deal with the impacts, some local efforts have been implemented the communities such as adjusting their houses, preparing for secondary livelihood such as become motorcycle taxi driver or become sea shell labour should their primary livelihood is disrupted, and cleaning houses in the aftermath of sea water flooding. However, many challenges that will be faced in developing the communities adaptation to climate change are habit and attitude change, difficulties in finding and preparing for a secondary livelihood, lack of drinking water availability, lack of financial resources and also coordination amongst the stakeholders.

## **Linking Disaster Risk Reduction and Climate Change Adaptation: Best practices of the Red Cross societies in delivering its assistance to support the flood prone areas in Indonesia**

**F Dwirahmadi<sup>1</sup>**

<sup>1</sup>International Federation of the Red Cross, Red Crescent Societies, Indonesia

Indonesia is identified as one of countries with a high risk of deaths due to multiple hazards, with 40 percent of population living in high risk areas. With a population more than 230 million people, this means more than 90 million people are vulnerable to disaster and climate change threats. Floods, drought, tropical storm, landslides and forest fire are climate related hazards which often befalls Indonesia. One of the main climate impacts in Indonesia is the ENSO (El-Nino Southern Oscillation), causing extreme weather conditions.

In order to reduce deaths, injuries, or losses due to disaster events or climate change impacts in Indonesia, the strategy of disaster risk reduction (DRR) and climate change adaptation (CCA) should be bond together for a better implications and effective implementation. Neither DRR or CCA is a stand alone approach, yet is a cross cutting approach which complementing each other.

Indonesian Red Cross (or Palang Merah Indonesia – PMI), with support from the Climate Centre of Red Cross Red Crescent Centre, has effectively integrated DRR and CCA into a comprehensive approach program, called Integrated Community Based Risk Reduction (ICBRR). ICBRR aims to strengthen the capacities of the vulnerable communities at the targeted locations, and reduce their vulnerabilities to natural hazards, including the negative impacts of climate change. ICBRR is driven by the strategies of participatory, local capacity building, advocacy & socialization, community awareness and sustainability. The community, facilitated by the Red Cross volunteers, will be enabled to analyze their current local issues related to disaster events and climate change, which then will come up with the adaptation measures based on local context. These adaptation measures such as micro financing which aims at increasing family resilience in the risk transfer mechanism, flood water rescue training for the community, waste management, community waste recycling training, biophory hole to increase the capability of the soil to absorb water which in other hand also to increase the quantity of ground water, mangrove plantation and other small scale no regret mitigation activities which based on the local capacity, tradition, and need.

The purpose of this case study is to extract some best practices from PMI in linking DRR and CCA strategies together to support the most vulnerable people in Indonesia, so that lessons learned can be taken and shared to a broader community, particularly to DRR and CCA practitioners. This case study is significantly required for a better DRR and CCA community based integrated program in the future not only in Indonesia, but also worldwide.

## **Adaptation responses and costs for Australia's critical energy network infrastructure – a case study**

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Australia's energy network infrastructure is a critical element of the national economy, delivering electricity and gas to over 13 million customers across the country. Energy network infrastructure is characterised by assets that are often highly exposed to climatic events, are geographically dispersed, are required to operate at very high levels of reliability and can potentially pose significant economic consequences in the event of failures or outages. For these reasons it is important to evaluate the impacts of climate change on energy networks and the adaptation measures that the asset-owning businesses may need to undertake.

Parsons Brinckerhoff undertook a detailed study on behalf of the Energy Networks Association to investigate the risks, challenges and opportunities that climate change poses for energy networks. The study assessed the predicted changes in climate that will affect network infrastructure around Australia and quantified the commercial effect on network businesses in adapting to the physical climate impacts; mitigating their own greenhouse gas emissions; and managing the changes that are likely to occur in the national energy industry as a result of government policies and other instruments to mitigate Australia's emissions.

A key element of the study was an assessment of the total cost of climate change adaptation that energy network businesses are likely to need to undertake. The methodology behind this assessment comprised a number of stages: development of credible composite scenarios to account for variability on external factors, developing a commercial impact model to relate external factors to business consequences, undertaking a risk assessment for each composite scenario, undertaking a detailed costing exercise for the adaptation actions that a business may undertake in light of the risks and commercial impacts identified.

It was found that there are significant risks to energy network businesses from climate change in all regions of Australia. The highest of these risks would come from bushfire, tropical cyclones and a change in the mix of generating technologies that will connect to the electricity network. Lesser risks were identified due to the increasing impact of floods and droughts as well as an increase in peak electrical demand.

The costs of specific adaptation activities were found to be relatively independent of the related risk magnitudes. For example, bushfires were assessed to be a high risk, but the response in terms of retro-fitting components and other measures was relatively low cost. Conversely, a large proportion of total cost was found to be due to the expected increase in electrical demand from a higher penetration of air conditioning in response to the forecast increasing frequency and severity of heatwaves. However, given that responding to demand is within the core business of an electricity network, the risk that this poses to the business is relatively low.

In total, the adaptation cost to energy networks from climate change was estimated to be \$2.5bn over the next 5 years. It was found that the costs would be incurred mainly on electricity transmission and distribution networks, with gas distribution networks affected to a lesser extent and gas transmission networks to a negligible extent. The expected costs of climate change were found to be greater in tropical regions and those regions that have not historically experienced cyclones, but are forecast to be susceptible to cyclones in future.

## Adaptation to climate change in the transport sector

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In this paper the state of the art in adaptation to climate change in the transport sector is assessed by a systematic review of peer-reviewed papers and other available documents (studies, policy and business documents). Risks for this sector are considerable for overall social welfare, since transportation is essential for multiple further economic, public and private activities. However, while the transport sector received much attention with respect to mitigation of greenhouse gases, studies on adaptation in the transport sector are rare.

For a systematic description of adaptation and to clarify our basic assumptions we propose an action theory of adaptation that is used for the review. The use of an action theory helps to specify the nomenclature and guides the analysis. It is designed to systematically assess the actors involved in adaptation. The theory additionally serves to develop accompanying economic arguments by specifying actor constellations (exposed actors, operating actors and actors that are affected by adaptations). Thereby, we're aiming to shed light on some crucial adaptation problems. Special interest is directed to the question whether and under which circumstances the public should assist these (private) actors in adapting to climate change.

The paper shows that adaptation in the transport sector is still in a stage of infancy. This contrasts the actual need for considering adaptation in this sector since it operates on the basis of long-lasting infrastructures as roads, railways or airports. Long planning horizons require early consideration to make these infrastructures resilient against future or already occurring climate changes. Retrofitting transport infrastructure can be very costly. Without anticipatory adaptation this is likely to become necessary, since the transport sector is highly sensitive to changes in climate and to extreme weather events in particular. The review shows that adaptation in the transport sector involves a substantial diversity of actor constellations. This complexity may partially explain missing action. The (potential) adaptations identified by the review also show that some established categories as, e.g., autonomous and planned adaptation, do not have the necessary clarity for understanding adaptation. Ecological changes in natural systems are typically considered as autonomous, while government programmes are planned. Between these extreme there is a spectrum of further relevant actors, systems and institutions, e.g. technical infrastructure, companies, markets, local authorities, educational institutions or NGOs. Which actors should be accounted for as exercising planned adaptation? We show how the proposed action theory sheds some light on such questions.

## Why are Utilities Reluctant to Adapt to Climate Change? - A Survey in the Energy and Transportation Sectors

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Whereas the field of mitigation in the transport and energy sectors is comparatively well scrutinized, the analysis of adaptation is still in its infancy. Although the infrastructure in the two sectors is highly relevant for society and economy, and although estimates show very high costs for adapting to climate change, the question of how utilities should adapt to climate change has not been deeply investigated so far. Adapting energy and transport related infrastructure definitely requires anticipatory action, as large parts of infrastructure are designed for comparatively long periods. To understand how utilities can act, it is necessary to know how vulnerable these infrastructures are and what strategies, if any, utilities already follow to deal with the impacts from climate change. Therefore an analysis of efforts already taken, future potentials and current problems of adaptation of utilities to climate change may give a first insight into adaptation processes.

The study presents the results of a survey of utilities in the German transport and energy sectors complemented by a

series of stakeholder workshops. For the purpose of theory development, a qualitative-explorative approach is chosen and combined with quantitative analysis. The first objective is to identify to what extent utilities have already started to realize the need to adapt. Comparing the results of the survey with existing vulnerability analyses allows us to show if the current adaptive engagement of utilities to climate change is in an adequate range. Further it enables to better understand barriers that may explain missing action or stakeholder frames for adaptation. The second objective is to understand the organizational, decisional and regulatory structures that shape corporate strategies on adaptation.

We come to the conclusion that there is a basic awareness on the need for adaptation rising in the utilities investigated, but that this awareness falls short of the current requirements for action. The results indicate some explanations for this observation: (i) the cross cutting nature of adaptation measures resulting in high transaction costs, (ii) missing incentives from regulation, owing to the problem that infrastructure often has the character of a public good and (iii) the physical properties of climate impacts (uncertainty, singular extreme-events, gradual change). Getting an insight into the catalysts and barriers of adapting utilities to climate change will help transfer the result of the study to other sectors.

## Climate change adaptation in mangrove systems

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Mangroves are valuable coastal resources, providing coastal protection, wood, and fishery resources to many tropical developing countries, though many countries have lost 50% of mangroves in the last 20 years to conversion and degradation. Mangrove ecosystems are also sensitive to climate change impacts, particularly to associated relative sea-level rise. Inter-tidal mangroves are most extensively developed on sedimentary shorelines, where mud accretion determines their ability to keep up with sea-level rise. The IPCC 4th Assessment projected a global sea level rise of 0.18-0.59 m by 2099 (1.5-9.7 mm a<sup>-1</sup>), and mangrove accretion rates are usually less than this, resulting in dieback at the seaward edge, and inland recruitment. Rise in temperature and the effects of increased CO<sub>2</sub> levels should be largely beneficial by contrast, combining to increase mangrove productivity, and continue expansion of mangrove species ranges into higher latitudes. While these climate change impacts on mangroves are well known, vulnerability assessment approaches and adaptation options to date have been speculative. With support from the UNEP Global Environment Facility and in close collaboration with a range of stakeholders and local communities, WWF is working in large mangrove systems of Cameroon, Tanzania and Fiji to build and strengthen the capacity of local managers to assess mangrove vulnerability and use results to adapt to climate change. Detailed vulnerability assessments are being conducted, which combine remote sensing, species zone mapping and micro-elevation determination, stratigraphic analysis of long term relative sea-level trends where sites lack tide gauges, monitoring of mangrove structure and productivity, mangrove condition and human interaction. Approaches differ from many existing climate change vulnerability assessments, because the key vulnerability is to relative sea-level rise rather than temperature or rainfall changes. Vulnerability assessment results are being used to formulate and test a range of adaptation strategies. These include the designation of strategic protected areas and improved management of sustainable use areas, rehabilitation of degraded areas, reforestation with "climate-smart" mangrove species, more integrated land-use and marine planning, as well as collaboration with local communities to improve resource use efficiency. Testing vulnerability assessment approaches and adaptation methods in geographically diverse locations within a common habitat type aims to increase their generic usefulness, so that project results can be usefully transferred to other mangrove areas around the globe. Through these trials WWF is developing a generalized methodology for assessing vulnerability in mangrove ecosystems and developing adaptation strategies, to be made available to management practitioners around the world. Currently we are sharing lessons and testing approaches with other mangrove areas in the WWF network and other agencies, including in SE Asia and the Caribbean.

## Integrating Climate Change Adaptation and Coastal Zone Management: A Capacity Driven approach for the Republic of Kiribati

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Human induced climate change into the next century is unequivocal. The impact of this changing climate on Island Nations is also widely accepted. In particular, small islands exposed to natural hazards (storm surges, extreme tides and strong winds and wave action) and anthropogenic pressures (rapidly expanding population) will be most at risk. The Pacific island of Kiribati falls within this category and has consequently been the subject of a focused Climate Adaptation Project (The Kiribati Adaptation Project, KAPII) funded by the World Bank.

A key component of the KAP II Project has been the development of an integrated and coordinated approach to coastal management that explicitly addresses the potential impacts of climate change. Coastal management in Kiribati is primarily reactive in response to issues at a local scale. Formulation of a framework focussed on achieving proactive coastal management while remaining cognisant of on-the-ground capacity constraints. The overall approach to developing the framework was based on the core principles of Integrated Decision Making in the coastal zone, namely:

- Appropriate direction-setting guidance (policies, plans and strategies);
- Adequate institutional arrangements; and
- Comprehensive coastal management planning.

In addition, the framework incorporates elements specific to the identified needs to Kiribati:

- Regulation and enforcement; and
- Capacity building.

The resultant framework outlines a simple step-wise approach to achieve Integrated Coastal Zone Management (ICZM) in the Republic of Kiribati. In this respect, it represents a key tool in implementing ICZM in resource-constrained environments. Despite its simplicity, it ensures rigour by outlining the actions and associated resource requirements needed to move from a reactive approach to a coordinated, integrated and proactive approach to coastal management. Climate change action is couched within the 'coastal management planning' component of the framework.

An additional component of this work involved practical trials of the framework in climate change risk assessment and adaptation planning by Government of Kiribati staff. The outcomes of this work provide insight into broader implications for climate change adaptation in the Pacific and elsewhere, focusing on:

- Capacity building approaches for climate change impact assessment and adaptation planning.
- Evaluating and prioritising impacts and adaptation strategies to address the effects of climate change (focussed on sea level rise and inundation) on atoll environments.
- A step-wise approach to achieve ICZM in resource constrained environments.

The outcomes of the work reported on here reinforce that climate change adaptation is most effective if conceptualised within a wider coastal management framework that addresses multiple stresses on coastal resources and the communities that depend on them. Only then can practical climate change adaptation actions be designed and effectively implemented within the day-to-day development challenges faced by I-Kiribati.

## Supporting adaptation network through knowledge sharing – a business model

S Etti<sup>1</sup>

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Environmental Resources Management (ERM) is one of the world's leading providers of environmental consulting services, delivering innovative solutions for eminent business and governmental clients. In 2007, ERM invested in and implemented a knowledge sharing program to improve global knowledge dissemination in order to help meet clients' needs more effectively. ERM's knowledge sharing platform, Minerva, uses Web 2.0 technology to provide a flexible intranet and collaboration platform.

ERM recognized that provision of Climate Change services represented a major opportunity for the company, given the scale of the Climate Change crisis and the need for the international community to take action. ERM has accelerated and supported the growth of the Energy and Climate Change (E&CC) practice by investing in training, service offering development, sales support, and knowledge management. The innovative approach to proliferating knowledge sharing across the E&CC community of practice over the last three years has helped to accelerate growth.

ERM addresses many of the emerging Climate Change mitigation options and adaptation strategies. Within the E&CC community of practice, an adaptation network amongst staff world-wide has been established to link up practitioners across different regions and countries. This has helped ERM to reduce the degree of separation between consultants by encouraging them to work together across geographical boundaries.

The objective of knowledge sharing in the adaptation community of practice is to ensure that practice members have access to high quality, reliable information in order to provide sales support and to build ERM's capabilities and market position around Climate Change and adaptation strategies. ERM is doing this through a combination of:

- Expert list management,
- Facilitating communication between members (and beyond),
- Proactive content management,
- Training and learning.

An expert list in the form of an adaptation member directory ensures that members can share their knowledge, experience and skills within ERM. The directory acts as a kind of expert "yellow pages" for the network. Each member contributes key information summarising their individual knowledge, experience and skills.

A bi-monthly global adaptation forum ensures a global platform to share the latest developments and opportunities, and to explore lessons learned through case studies for members.

A comprehensive document library, which increases the visibility of local work, good practice, project experience, winning proposals, background information, and internal/external presentations is available to all practice members and is continuously kept up to date.

Various learning activities are in place across the practice in order to improve access to and enable faster connectivity with experts globally. Participants can gain insight into project experience, allowing them to relate it to future opportunities. The learning activities help to drive sales and enable practitioners to expand their knowledge on an ongoing basis.

The adaptation network helps the organization to remain at the forefront of opportunities associated with different Climate Change threats. By using the outlined organization design, technology design, content design and training design, an integrated knowledge management approach is achieved that aligns with business goals, strategies and opportunities.

## Hawaii Island Climate Adaptation and Policy- Regional Initiatives

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Hawai'i sits at the hub of the Pacific's climate change intersection, serving to illustrate climate change impacts and an example of progressive climate adaptation policy. Since voyaging to the islands, native Hawaiian culture has closely studied the flow of water, the patterns of waves and winds, and the nature of our island climate. Using this knowledge, islanders adapted their use of the land and ocean to the perpetually changing conditions. However, climate trends are shifting. Climate change impacts are widespread and now islanders are faced with a new set of climate challenges. This distinct combination of cutting-edge science and traditional knowledge highlights the strength of solutions that Hawai'i brings to the uncertain future climate change poses for small islands.

Established in 2009, the University of Hawaii Sea Grant College Program Center for Island Climate Adaptation and Policy (ICAP) facilitates a sustainable, climate-conscious future for Hawai'i, the Pacific, and global island communities. The Center emphasizes effective communication of climate adaptation information through innovative, interdisciplinary research and real-world solutions. This information is directed towards island decision-makers and focused on practical adaptation solutions and strategies with relevant science-based policy implications. As a focal point for University of Hawai'i climate expertise, the Center serves as a two-way conduit between the university and island communities to catalyze climate change adaptation and resiliency.

The Center strives to identify opportunities to harness traditional knowledge and utilize new or existing strategies, tools, partnerships and projects that can be used to support the communication of information for adaptation. An example of this approach is illustrated in the revitalization and application of the traditional Hawaiian resource management practice known as the Ahupua'a watershed management. This traditional Hawaiian watershed concept is characterized by sustainable watershed management and encompasses land use and resource allocation within the entire watershed from the mountain top to the reef.

This kind of project is illustrative of ICAP's larger mission and real world results. The Center offers original work products in the areas of science, policy, and planning to mitigate and adapt to climate change while embracing the wisdom of local, traditional cultures. ICAP also addresses barriers and challenges to the communication of climate adaptation information by identifying the viable science-based policy approaches and offering extant models from other jurisdictions that are successfully implementing climate adaptation strategies. The focus areas for ICAP fall into the following categories:

**Policy.** Research and develop innovative policy solutions to climate change that fit the unique needs of island communities through white papers for legislative bodies, government resource agencies, and private entities to address climate threats and other climate change issues.

**Projects.** ICAP improves island community climate change resiliency through partnerships that improve our adaptive capacity with emphasis on communicating these results as decision-support tools to local planners and government officials. Other relevant ICAP accomplishments include a suite of reports, white papers and briefings related to climate adaptation and coastal hazard mitigation for the Pacific region. ICAP offers a number of climate adaptation case studies that can be used as examples to support the communication of information for adaptation in other coastal and Pacific Island regions.

**Extension/Education.** Public outreach activities that link UH expertise directly to climate adaptation opportunities and challenges. ICAP offers graduate education opportunities that prepare future island leaders for roles in the growing field of climate adaptation, resiliency, policy, and planning. Through the development of a library of "best-practice" mitigation and adaptation solution-sets, the Center increases its ability to craft tailored policy responses for individual island communities at national, state, and county levels. The extension and education components serve a critical function of communicating adaptation information to increase the resilience of communities most vulnerable to climate change.

**Next Steps:** ICAP recognizes the need to identify the roles and responsibilities for the communication of information for adaptation as well as the need for strong leadership to implement appropriate adaptation strategies. The identification of leadership and adaptation responsibilities is an inherently political process but needs to be well-founded in scientific and economic principles. ICAP serves as an independent non-governmental institute that provides interdisciplinary climate adaptation support for the Pacific region and serves as a portal for international collaboration on regional climate adaptation information of mutual interest.

## Expectations and experiences of keeping cool in the Illawarra

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Air-conditioning seems to encapsulate a sharp paradox: increasing desires to artificially control micro-climates are in tension with increasing calls to relinquish these desires for the good of the global climate. Elizabeth Shove has usefully highlighted that a key issue for understanding environmental change, and perhaps starting to untangle the apparent air-conditioning paradox, is to focus on the co-evolution of technologies with changing social norms. In this context, mapping uneven expectations and experiences of cool air, and how these are shaped by 'pro-environmental behaviours', is an important exercise. How are

spaces of cool air created, valued and 'policed' among a climate-engaged population? To this end, we consider issues of equity and cool air among people in the Illawarra, New South Wales, few of whom own air conditioning units. We document their expectations of thermal comfort and experiences of keeping cool, using results from a household survey and preliminary findings from a longitudinal ethnographic study. For those in good health, a strong desire to artificially control domestic micro-climates using air-conditioning is often absent, with many expressing and practicing an ethic of simplicity or resource stewardship. Siestas, ventilation, breezes, stillness, uncooked food, and handheld or electric fans are valued over air-conditioning units in the home. For those who have air-conditioning units, moments of air-conditioned comfort are highly regulated and experienced as a guilty pleasure. It is important to bring into visibility the contextual detail of everyday practices of comfort among those who do not have easy access to, or a desire for, constant 'manufactured cool air' or 'eco-smart' building design in order to promote an equitable balance between adaptation needs and mitigation responsibilities in climate change debates.

## Impacts of climate change on coastal recreation and public safety

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<sup>1</sup>Surf Life Saving Australia (SLSA), Australia

Issues:

- Australian beaches are well known across Australia and many parts of the world as being integral to Australia's outdoor lifestyle
- The impacts of climate change are currently affecting Australian beaches and will continue to do so into the future, the extent to which is open for debate.
- Risk management, vulnerability mapping and response planning provide opportunities for understanding the actions that should be taken to protect the recreation and safety attributes of Australia's beaches.
- Surf lifesavers and lifeguards have played an important role in beach safety for over 100 years, a role that will grow in need as the impacts on our coast become greater.

In many countries of the world people have settled by the coast. For example in Australia more than 85% of the population live near the coast and our tourist beaches alone receive an estimated 100 million visitations every year. The 56,000km coastline of Australia, along which there are more than 11,900 beaches, while an attraction for living and visiting, has inherent and largely unpredictable risk.

The coast and beaches of Australia are also favoured by locals and tourists alike for recreation whether for bathing, swimming, surfing, boating and a range of other activities. In a recent study by SLSA, it has been estimated that more than 100 million annual visitations are made to Australia's beaches.

The impacts of climate change that include sea level rise and increases in severity of storm events will impact access to and safety of affected beaches.

In the past 103 years Surf Life Saving has saved over 550,000 lives at our beaches across Australia and continues to rescue more than 12,000 people every year. However, of the 11,942 beaches identified by the Australian Beach Safety and Management Program (ABSAMP), less than 400 (3.4%) have a lifesaving service.

These services are largely provided by volunteers, but supported by paid lifeguards during periods when volunteers are not readily available. Over the past 103 years, surf lifesaving Clubhouses have been constructed during periods and at locations where regulatory processes and environmental focus were less developed than in 2010.

What will the emerging future bring to beach access, recreational use and to the safety of the people who use them? Changes will be many and varied and will most likely include:

- Length and width of beaches will change due to sand movement
- Hazards that are currently well known and visible, may be hidden under sea
- Wave breaks and surf zones may shift Regular studies will be needed in future years in five to ten year terms to better understand leisure needs and allow modifications to beach-based recreation and safety services to ensure Australians and tourists continue to receive the social, economic and environmental benefits provided through the use of the beach.

Will we see an increase in drowning mortality and morbidity due to impacts of climate change on our coast and with the increase in immigration of people from nations unfamiliar with open coastline, with limited swimming ability and lacking in knowledge of surf conditions?

Not if SLSA, allied organizations and scientists collaborate and respond to the challenges ahead.

## Impact of climate change on wheat yields in Western Australia. Will wheat production be more risky in the future?

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<sup>1</sup>Department of Agriculture and Food, Western Australia, Australia

Climate change projections for the mid 21st century of increase in temperatures and decrease in rainfall could have adverse impacts on many agricultural systems, but may also offer new opportunities in some areas. Downscaled climate data from the Global Climate Model CCAM was used as input into the APSIM simulation model, to study the impact of climate change on wheat production in the

wheatbelt of WA. The APSIM-Wheat (v. 4.1) model was run with current and future daily climate data to simulate grain yield. Simulations were run for 27 locations and 3 soil types. Changes in average yields are presented as maps for different soil types in the wheatbelt of WA. Changes in yield distribution are discussed in the context of changes in reliability of wheat production in different rainfall zones of Western Australia. The climate model simulated annual rainfall reductions of 5-11 per cent for the period 2035-2064 compared to the period 1975-2004, with the greatest rainfall reductions in the April-June period. Simulation results showed future yield decline for most of the wheatbelt. Without taking into account the possible effect of changes in technology, varieties and other adaptation strategies, future yields were lower at most locations. However, future yields were higher in high rainfall locations and waterlogging prone soils, where the decrease in rainfall meant a reduction in waterlogging. Yield changes across 27 locations were simulated to range from a 14% yield increase to 24% yield decrease. The biggest yield increases were found in prone waterlogging soils in high rainfall locations and the biggest yield decreases were found on heavy soils in low rainfall locations. Yield distribution will change in the future, with increase in the frequency of years with low or very-low yields in low and medium rainfall locations, making cropping a risky business in many low and medium rainfall locations. The yield decreases were due to lower rainfall and higher temperatures, which caused shorter growth duration and more water deficit in most locations. Lower rainfall in autumn delayed sowing, which led to a reduction in growth duration, and increased chance of severe water deficit during grain filling. In most locations the positive effect of increased CO<sub>2</sub> was more than offset by the negative effect of lower rainfall, delayed sowing and increased temperature.

There were differences between soil types, with heavy soils experiencing more negative yield penalties in the future, compared to light textured soil types. The impact of reduced rainfall on grain yield was more severe on heavy soils which hold more water in the topsoil and therefore lose more water to evaporation than light soils.

In summary, assuming current practices, future wheat yields would be lower than current yields in most of the wheatbelt. However, future yields could be higher in some high rainfall locations and waterlogging soils. Heavier soils are more vulnerable to climate change than light textured soils. Wheat cropping on low rainfall locations and heavy soils will be more risky in the future than under current climate.

## Rapid assessment of the impacts of climate change (RAICC)

A Fenech<sup>1</sup>

<sup>1</sup>Environment Canada, Canada

There are many expert tools in climate change science (software, websites, statistics, models, indices, archives, networks and processes) that can equip communities in assessing the impacts of climate change. Although many methodologies exist for climate change impact assessment, there is no approach available to put climate change science expert tools together in an integrated fashion for this task. RAICC is about developing an integrated approach that is fast and simple; builds on existing expert tools; is linked to the climate change impacts scientific literature; and allows for a relative risk assessment. The approach is named the Rapid Assessment of the Impacts of Climate Change, or RAICC (pronounced race). The development of RAICC is an attempt at navigating through the great deal of climate change information available to community decision-makers. RAICC tries to place the disparate information sources of climate change information in a coherent and systematic form, in an attempt at improving the management of climate change information. RAICC uses 5 major steps. In the first step of the approach - Building a History of Climate Extremes - a climate history of temperature, precipitation and extremes is built for a region using an analysis of observational records. In the second step - Selecting a Climate Model for Future Scenarios - global and regional climate models are evaluated for their ability to model future climate change, and then a model is selected based on criteria provided by the Intergovernmental Panel on Climate Change for climate change impact studies. In the third step - Building a Future of Climate Extremes - a climate future is built for a region from scenarios of future climate change for the next 100 years using the same temperature and precipitation extremes. Comprehensive climate change impact studies examine many economic sectors and various aspects of the natural environment including forests, fisheries, energy, transportation, agriculture, tourism, human health, water quality, biodiversity and the built environment. Each of these sectors is sensitive to extremes of temperature and precipitation at some level. These sensitivities are triggered at certain climate thresholds above which result in significant changes that may require some form of human interventionist adaptation. These adaptation thresholds are identified in the fourth step - Identifying Climate Change Adaptation Environmental Prediction Thresholds - through a literature review. The final step - Ranking the Relative Risks of Climate Change to the Region - uses an accepted process (known as the Hazard Identification and Risk Assessment (HIRA)) amended to identify priority eco-sectors at risk from climate change relative to other eco-sectors at risk. This allows managers to target areas for further intensive study and, in further steps, develop prioritized response plans for humans to intervene and adapt to future climate change. The approach was applied to the Halton Region of Ontario, Canada, a regional municipality west of the City of Toronto. Halton Region was selected for study as it is Canada's fastest growing municipality; it has large areas of both rural and urban development; it is bounded by the large climate influence of Lake Ontario to the South; and the ecologically-significant Niagara Escarpment runs through the municipality. Climate observations show increases in temperature, and decreases in precipitation over the past 28 years. Future climate modelling projects continued increases in temperatures for Halton Region on average 3.8°C by the year 2100, mostly in minimum temperatures. Also, the climate models show that changes to precipitation levels eventually level off by mid-century with a slight increase by the year 2100. Overall, results from applying the approach to the Halton Region showed that climate change is an important issue to Halton, and its importance will increase over the 21st century. The study identifies the built environment, agriculture and tourism as areas of Halton Region's economy and ecology that need to be focused on for more in-depth study and subsequent action. The RAICC approach provides a means of rapidly assessing climate change impacts at the local level.

## The Canadian Climate Change Scenarios Network: Linking Global Climate Models to Local Decision-Making

A Fenech<sup>1</sup> and N Corner<sup>1</sup>

<sup>1</sup>Environment Canada

The Canadian Climate Change Scenarios Network (CCCSN) is Environment Canada's interface for distributing climate change scenarios and adaptation research for Canada and around the world. The CCCSN contains the most recent results from climate model science to help practitioners of climate change impacts and adaptation and the general public who wish to know more about climate change projections across Canada and the world. The CCCSN supports climate change impact and adaptation research in Canada through the provision of Global Climate Model (GCM) scenarios, Regional Climate Model (RCM) scenarios, data, and downscaling tools. Climate change scenarios are provided from numerous international research centres, in support of the Intergovernmental Panel for Climate Change (IPCC) assessments. In addition, the CCCSN provides support on the use of scenarios and downscaling for impacts and adaptation research through email feedback and training sessions on the appropriate use and selection of scenarios. The CCCSN supports academic researchers as well as other stakeholders in government and private industry nationally and internationally who require scenario information for decision-making. The CCCSN has a wealth of information including climate change model maps, data download, scatterplots, downscaling methodologies/data, and bioclimate profiles to support impacts and adaptation science. The CCCSN is expanding, with current nodes in Toronto, Montreal, Regina, and Whitehorse, supported by university research partners. Future node activity includes the development of new automated tools for model validation and projection selection, as well as downscaling and extremes research for future climate. The CCCSN. CA remains the only tool for easily accessible downloadable and queryable climate scenarios from all 24 global climate models in the Intergovernmental Panel on Climate Change's 4th Assessment Report. On average, CCCSN receives over 2 million accesses per year and there is a growing desire for a neutral source of climate projection information and guidance in a user-friendly format. The network supports the Environment Canada mandate to provide Canadians (for example, decision and policy makers within communities, organizations, the private sector and government) with information they can use to achieve sustainability today and under climate change. This paper will present the value of the CCCSN in linking global climate models to local decision-making, how it has been used in research across Canada, and provide information on how all can access its tools for climate change impacts and adaptation research in Canada and around the world.

## Better understanding the risks of climate change to the City of Toronto

A Fenech<sup>1</sup> and N Corner<sup>1</sup>

<sup>1</sup>Environment Canada

One of the first steps to adapting to climate change is understanding the where, when and by how much temperature, precipitation and other climate factors will change. In its 4th Assessment Report, the Intergovernmental Panel on Climate Change utilized 24 different global climate models (GCMs) to provide scenarios of future climate change. These different models also produced at least three future greenhouse gas emission scenarios totalling almost 75 possible futures for temperature, precipitation and other climate factors. Given the range in certainties and availability of detailed data regarding the future of the City of Toronto's climate, many researchers are using different methods to come up with a 'vision' of Toronto's future climate. More detailed and reliable knowledge of these anticipated changes about Toronto's climate are required by City divisions as well as businesses operating in and around Toronto. Due to the overwhelming number of possible future scenarios of climate, consensus on how to approach such possible future scenarios of climate change and present something useable and beneficial for the planning of the City is worthwhile. A common set of assumptions regarding Toronto's future climate would provide a common starting ground to be included in future or long-term plans. The City of Toronto has engaged a group of local scientists in recommending a common set of ranges for future climate parameters (e.g. temperature, precipitation, wind events, indices, extremes for model periods 2020s, 2050s and 2080s and for the three major emission scenarios (A1, B2, A1B)); in communicating the best available knowledge on future climate extremes, including an indication of the likelihood (using IPCC language of probability) of these projections to those involved with projects requiring the use of future climate projections (i.e., long-term strategic plans); in recommending a range of other model periods and range of emission scenarios to examine; and in consolidating and strengthening cumulative efforts to determine the future vision of Toronto's climate. This presentation will detail the results of this exercise, and how important it is for cities to follow a similar process.

## Island Adaptation: Linking Knowledge, Management and Communities in American Samoa

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Pacific islands will be disproportionately impacted by climate change. Their overall contribution to greenhouse gas emissions is much lower than many other nations, yet they will be among the first to experience negative impacts. Coral reefs are recognized as ecosystems that are severely threatened by climate change impacts, including coral bleaching and ocean acidification. Coral reefs are critical to Pacific Island states and American Samoa in particular.

In American Samoa, there have already been several documented severe mass coral bleaching events and some locations now experience annual coral bleaching. Coral reefs not only provide vital shoreline protection from storm surge and wave



action in American Samoa; they also have the potential to contribute significantly to tourism and fisheries. As sea levels rise and mass bleaching events kill corals, coastal areas will become increasingly prone to erosion and inundation from wave action. Additionally, our reefs are unique in their coralline algae proportion. Coralline algae will suffer ocean acidification affects prior to corals, and American Samoa's reefs contain more coralline algae than other reefs in the region. Both coralline algae and corals are major reef builders, and acidification impacts can result in potentially severe impacts.

To guide our efforts in addressing the climate change threat, American Samoa has created a Local Action Strategy (LAS). The LAS was developed through collaboration between seven government agencies and identifies our vision for the future of American Samoa's reefs in the face of climate change and highlights objectives and actions that will fulfill our vision. The LAS vision is to "Sustain healthy coral reef ecosystems and build related socio-economic conditions which are resilient to climate change". This strategy has taken a three-pronged approach to tackling climate change impacts through information gathering, adaptation, and mitigation activities. The LAS goal is to "Address critical knowledge gaps, evaluate strategies, translate information into active management actions, and improve monitoring and predictions". The five LAS objectives are:

- Objective 1: Increase research and monitoring to implement and support management strategies for reducing climate change and its impacts.
- Objective 2: Establish adaptive management strategies to maximize coral reef ecosystem resilience.
- Objective 3: Foster adaptation and resilience of human communities and economic systems to climate change impacts.
- Objective 4: Reduce American Samoa's carbon footprint and encourage progress towards a sustainable low carbon economy.
- Objective 5: Create a climate change informed populace, actively taking steps to reduce climate change causes and impacts.

These objectives will increase our understanding of climate change impacts on the territory and assist us in identifying the most successful adaptation strategies.

To fully understand future climate change impacts and what actions will most effectively address those impacts, we are supporting work on coral bleaching mitigation. There are experiments currently underway examining both cooling and shading corals to determine affects these techniques may have on coral bleaching. Early results are encouraging, and forthcoming results can translate directly into management actions.

Communities in American Samoa depend on coral reefs, and community engagement is a vital part of planning for climate change impacts. Projects are underway working at the village level to increase village understanding of their vulnerabilities and risks from climate change, and then determine methods to adapt to the future, including planning for alternative livelihoods, physical relocation, and infrastructure improvements. These projects combined with upcoming PLA (Participatory Learning in Action) workshops and a summit focused on climate change planned for fall 2010 will capture community input in managing for climate change impacts.

Mitigation activities at the territorial level include continuing implementation of an Executive Order reducing American Samoa's carbon footprint.

Our collaborative efforts and combination of information gathering, adaptation, and mitigation activities are preparing ourselves for a future with adverse climate change impacts on our islands. Coral reefs are fundamental parts of island cultures and ecosystems and we must work to adapt our behaviors and minimize impacts.

## Adapting to Climate Change at Multiple Governance Levels: Insights from Australia

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Enhanced adaptive capacity includes increased ability of individuals, groups, organisations and governments to make and implement decisions in anticipation of or in reaction to climate disruption. Adaptation responses include creating and changing institutional arrangements, such as policies, regulations, decision-making processes and property rights. Priority research includes understanding how institutions are responding to climate change, and what lessons can be learned from different institutional arrangements, particularly in consideration of the management of specific types of natural environments. To date, research has mostly focused on national and international responses. Adaptation processes, however, operate at different spatial, temporal, social, and administrative scales. Therefore, to truly understand what contributes to effective adaptive capacity, adaptation processes need to be investigated at multiple levels. This includes the interactions between and among institutions located at these levels (i.e., institutional interplay). In this paper we provide an analysis of how formal institutions at local, regional, state and federal levels are responding to climate change in Australia, by using the Great Barrier Reef (GBR) region as a case study. Our investigation also examines the distribution of roles, responsibilities and capacities of the federal, state and local governments and regional natural resource management (NRM) bodies to respond to climate change. The Australian case examined in this paper highlights the importance of considering multiple and nested levels of governance in policy adaptation. In order to improve adaptive capacity, cross-level interplay

needs to be fostered so that adaptation can benefit from synergetic interactions between and among institutions. In this context, a more strategic framework is also needed to clearly define objectives, responsibilities, costs, and strategies for adaptation across governance levels. Furthermore, arrangements at the higher levels need to provide a supportive context for local and regional-level strategies in order to enable critical adaptation to emerge. For example, political, financial and technical support from federal and state governments is required to facilitate meaningful adaptation at local and regional levels. The analysis of institutional interplay and the governance attributes that facilitate (or otherwise) adaptation has significant implications to institutional design, not only to the GBR but to other policy arenas in Australia and elsewhere.

## Mapping Population and Climate Change Vulnerabilities: Challenges of Reaching Policy Audiences

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Climate change is likely to grow in intensity, but the future impacts on human health, economies, and the natural environment remain uncertain. At the same time that climate impacts intensify, the world's population is projected to grow significantly over this century, and is an important determinant of the scale of human vulnerability to climate change. However, population projections rely on assumptions of improved access to and use of family planning which are not occurring in many areas. Therefore, in some locations, rapid population growth is likely to subject greater numbers of people to climate risk.

The uncertainties associated with population change are rarely considered in vulnerability assessments or adaptation planning. This lack of attention to the compounding effects of population (and the role that improved access to and use of family planning plays in population growth) could, in part, be attributed to a lack of tools and information targeted at policymakers that show how population and climate change will interact over time. Through the visualization of data via maps, this research illustrates that the relationships between climate change impacts, demographic trends and family planning needs are likely to affect ability to adapt to climate change in a number of countries.

Population growth rate is the key variable of the eight mapped by Population Action International, in collaboration with the Joint Global Change Research Institute (JGCRI). Also important is the Vulnerability-Resilience Indicators Model (VRIM or "Resilience"), developed by JGCRI which compiles 17 physical, social, and economic indicators that assess a society's resilience to anticipated climate change impacts and scores countries based on the results. Another variable, projected change in agricultural production, assesses the possible impacts of climate change on the world's production of four major cereal crops (wheat, rice, corn and soybeans). The rate of unmet need for voluntary family planning as measured through household surveys is also important because it identifies countries where additional support for family planning and reproductive health may be best applied as a policy response to rapid population growth.

After analyzing data and generating a sequence of maps, a simple combination system was developed to isolate population and climate change "hotspots." This simplified "index" pinpoints specific countries that are projected to experience high increases in population, in combination with high declines in agricultural production, low resilience to climate change, or both. "Hotspots" are visually represented on a global map through color-coding: countries in yellow have both high population growth rates and a projected high decline in agricultural production, countries in orange have high population growth rates and low resilience to climate change, and countries in red, or "hotspot" countries, are expected to experience unfavorable conditions for all three variables. After utilizing a range of colors to identify such countries, the key policy message is indicated by marking, with green dots, those countries that also have a high unmet need for family planning.

This sequence of maps, which was launched in an interactive database in December 2009 to coincide with COP15 in Copenhagen, aims to provide policymakers with a tool to recognize the importance of population and the need to include voluntary family planning and reproductive health in discussions around adaptation to climate change. In particular, given limited resources and the need for prioritization, these maps highlight specific areas where the combination of climate and population change may create the highest demand for comprehensive adaptation funding and programs. Preliminary results suggest that the interactive website has been assessed by a range of stakeholders and that it was draw for policymakers at COP15. The database is published online and can be viewed by visiting the following web address: [www.populationaction.org/climatemap/](http://www.populationaction.org/climatemap/)

## Assessment of climate change impacts and development of adaptation options in Kakadu National Park

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The National Climate Change Adaptation Framework identifies key strategies to build capacity to deal with climate change impacts and reduce vulnerability in key sectors and regions. Consistent with the Framework, the Australian Government Department of Climate Change has undertaken the National Coastal Vulnerability Assessment (NCVA), which aims to assess the potential impacts and consequences of climate change for Australian coastal communities, and to describe the benefits and costs of adaptation.

This presentation describes one component of the NCVA; a case study of potential impacts, risks and adaptation strategies for the South Alligator River catchment in the Kakadu National Park of the Northern Territory.

The internationally recognized natural and cultural values of Kakadu are viewed as being particularly susceptible to sea level rise and the increased intensity of storms and flooding associated with climate change. The case study modelled the hydrodynamics of the South Alligator River to assess the risk of salt water intrusion and extreme rainfall events on low-lying floodplain wetlands and the implications of government planning, management and policy responses. The adopted approach provided a basis for assessing the potential impacts and risks of various climate change scenarios at 2030 and 2070, and the development of adaptation options for implementation within the South Alligator River catchment in consultation with the site manager (Parks Australia), Traditional Owners and key stakeholders.

This presentation provides an overview of the main components of the adaptation planning approach used in the study including the development of a tool kit of adaptation options developed for the site and an acceptability framework to provide an observational-based structure for implementation of adaptation options.

In terms of broader implications and significance, the study developed and refined a risk assessment and adaptation planning process that could be used for similar assessments of coastal systems elsewhere in tropical Australia. In particular, in addition to the review of implications on natural values such as habitats and notable wetlands species, the case study was able to describe and assess impacts on cultural values based on indigenous cultural knowledge and information about the wetlands provided by the Bininj people of Kakadu through consultation and involvement with Traditional Owners and Parks Australia staff.

## Dealing with uncertainty in climate change adaptation planning and developing triggers for future action

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The temporal uncertainty presented by climate change can be a significant deterrent to implementation of adaptation plans and associated actions, particularly given the barriers to the implementation of many longer term actions. These barriers typically relate to cost, but can also relate to community opposition, the need for legislative or regulatory changes, the need to engender political will or as a result of a general lack of knowledge or information about the issue to be managed (or options to treat the associated risk).

As such, current adaptation planning studies for climate change under the Commonwealth Government's Local Adaptation Pathways Programme (LAPP) and National Coastal Vulnerability Assessment (NCVA) studies and similar initiatives have tended to focus on actions that are 'no-regrets' or 'win-win' type actions. Complex or controversial actions are often delayed for future implementers to address in the undefined 'long term'. However, if climate change adaptation is to be effective, there must be a recognition as part of such adaptation plans that much more difficult decisions that affect tradeoffs will need to be made in the future – particularly as the impacts of climate change become more evident.

Invariably, these adaptation plans will need to address issues both proactively in terms of what can be done at the current time (eg. in the short term such as data gathering) as well as reactively as particular aspects of climate change begin to manifest themselves.

This paper outlines a simple but effective planning tool that has been developed from combining climate change vulnerability assessment concepts used internationally with wetland management approaches used in Australia. The tool assists in adaptation planning initiatives that can be used across a range of climate change issues and scenarios. The tool operates along a time continuum and seeks to identify three stages for each climate change parameter or impact being assessed:

Stage 1: The baseline (current condition) of the climate change parameter being examined at the time of plan preparation

Stage 2: The undesirable end-state of the climate change parameter being examined (eg. what are the impacts from climate change that are trying to be avoided); and

Stage 3 The identification of one or more trigger points along the time continuum that flags to the planning or responsible management agency that more aggressive or decisive adaptation actions need to occur prior to the undesirable impact occurring.

The innovation of the temporal model addressed by the tool is the ability to 'trigger' particular adaptation actions in the future but prior to the climate change impact occurring. For example, use of the model for sea level rise can be applied at a local scale to define the current extent of inundation (stage 1), define the undesirable level of inundation where damage or loss of property is certain (stage 3) and an interim trigger level (stage 2) whereby more significant action and decision making is required such as the need for particular properties to be relocated, the construction of a seawall or other capital works or a combination thereof.

In this context, setting a trigger level is critical to adaptation as it gives the management agencies adequate time to act prior to realizing the unacceptable impact (including undertaking adequate consultation about possible treatment options); it prevents the management agency from acting prematurely before impacts are certain (reducing maladaptation); it helps to provide certainty to decision makers over a longer period of time; and it demonstrates to the public a level of preparedness for the future such that as trigger points are approached there is capacity and political will building within the organisation to act.

The presentation will discuss the tool, some of the key thoughts behind its creation and how it has been used in various climate change planning projects throughout Australia undertaken by the authors.

## Institutional Adaptation: A framework for climate change adaptation

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Significant change has occurred in people's perception to and understanding of climate change. As many agriculturalists understood climate change to be part of a larger natural cycle, management practices consisted of planning for seasonal to seasonal variation. Recent research highlighted the need for longer term planning horizons involving diversification of enterprises, an emphasis on higher education and whole farm planning, investment in infrastructure, increasing biodiversity and others.

As a diverse set of personal values and beliefs underlie each individual's perceptions of climate change, these perceptions impact the centrality of climate change in planning decisions. Whilst values can be slow to change, the evidence that this is occurring more rapidly is supported through research that identified innovative policy development along with associated practices identified above. Emphasis on a systemic approach was also evident as consideration of the human system and its association with the natural world becomes more familiar.

Personal values influence – or bias – decision making in regards to climate change, therefore an organizations' policies and processes display a particular set of values. Factors influencing decision making in relation to climate change form a complex amalgamation of values that are rarely documented or made transparent. Furthermore, an organisation that wishes to embed climate change in its strategic decision making will benefit from ensuring that sustainability is central to its organisational culture.

These findings form part of the research of the Institutional Adaptation theme of the Victorian Climate Change Adaptation Program (VCCAP). The theme is concerned with the socio-cultural and economic aspects of climate change adaptation that places emphasis on understanding the rules of the game – the underlying factors that influence decision making. An institutional approach is used to analyse differences in people's understanding of climate change, to consider how an understanding of climate change is being constructed within institutions, the way in which ideas of climate change impacts are being communicated and their influence on shaping adaptation and mitigation responses.

Over three years, VCCAP focussed its research on one region, south west Victoria, so that the development of methods and methodologies could enable an integrated analysis at the regional level to inform state government policy. As climate change threatens assets and livelihoods differently, a focus on building the capacity of regional institutions to adapt to climate change is at the heart of VCCAP whilst ensuring that a regional focus informs state and federal policies.

A framework has been developed aimed at highlighting the nature of the interactions between a series of component parts. The features of the framework include: an analysis of institutional values and how these values inform adaptation practices; the study of institutional networks undertaken through social network mapping to identify sources of trust and distrust; economic modelling to highlight the value of the agricultural sector to the regional economy; application of an Adaptive Capacity Index to identify the key socio-cultural, political and economic aspects of adaptation. An important feature of the framework is to ensure that each component part builds the capacity of regional institutions to manage change as well as identifying current governance arrangements whilst considering the role of government in an adaptive governance environment.

Whilst adaptation can be defined as the "adjustment of ecological, social or economic systems in response to actual or expected climatic stimuli and the effects or impacts of climate change; (Smit et al 2001; Smit and Pilifosova 2003), the related concept of adaptive capacity refers to the 'potential or ability of a system, region or community to adapt to the effects or impacts of climate change; (Smit et al 2001; Smit and Pilifosova 2003). Planned adaptation is a key feature of this research as we seek to embed long-term planning into an iterative decision-making process that informs policy across all levels of government.

## Building Climate Change Resilience and Adaptive Capacity in Australia's Community Sector Using Social Media and Technology Innovation

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Public and private sector organisations worldwide are putting strategies in place to manage the commercial and operational risks of climate change. However, community organisations are lagging behind in their understanding and preparedness, despite them being among the most exposed to the effects of climate change impacts and regulation. This poster presents a proposal for a multidisciplinary study that addresses this issue by developing, testing and applying a novel climate risk assessment methodology that is tailored to the needs of Australia's community sector and its clients. Strategies to mitigate risks and build resilience and adaptive capacity will be identified including new opportunities afforded by urban informatics, social media, and technologies of scale making.

Many climate change impacts are now considered by the scientific community to be unavoidable and will require adaptation over the coming decades, even if efforts to control emissions avoid more serious effects in the later part of the century. Private and public sectors are now moving with increasing momentum to identify risks and implement adaptation strategies. However, the community sector is left behind even though many of the people who this sector supports will be amongst the first and most seriously affected. The process of climate change adaptation and resilience requires information and preparedness. We can often adapt effectively if we know what we are adapting to. Based on this premise,

this cross-disciplinary study proposes to make a significant contribution towards exploring and better understanding the opportunities for enhancing and accelerating adaptation using tools, interfaces, methods and practices of social and mobile technology that have already proven effective in enabling participation and engagement in other areas.

## **Community adaptation to heatwave: equitable policy responses to extreme weather in Victoria, Australia**

**J Fritze<sup>1</sup> and D Healy<sup>1</sup>**

<sup>1</sup>Victorian Council of Social Service (VCOSS), Australia

There is widespread recognition that climate change will impact most heavily on people living in poverty and those who are disadvantaged due both to limitations in individual and community adaptive capacity, as well as higher exposure and sensitivity to climatic change. While inequalities in climate change impacts and adaptation are most frequently discussed at the international level, people socially and economically marginalised within relatively affluent communities such as Australia are also at higher risk. As adaptation policy decisions occur within complex social, environmental and economic contexts and multiple scales of governance, decisions risk leading to unintended and maladaptive outcomes.

In January and February 2009, southern Australia experienced record heatwaves in which an estimated minimum of 374 additional deaths were recorded in the state of Victoria alone. The heatwave also placed health and emergency service systems under extreme pressure leading to increased waiting times. In addition, Victoria experienced widespread failure in essential infrastructure including energy and public transport systems. These system failures exacerbated the impact of the heatwave and limited the capacity of many households to adapt.

There is a growing body of international evidence identifying population groups vulnerable to heatwave, social factors contributing to risk and resilience and evaluating relevant policy options. However, there is limited evidence about the impacts and experiences of heatwave and heatwave adaptation for vulnerable population groups at the local level to inform policy development or responses. In particular, little is understood about the impact of social risk factors such as poverty, housing quality and access to transport and their interaction with personal risk factors such as age or poor health.

State and local level policy responses following the 2009 heatwaves have attempted to ameliorate risks to the community, with some focus on population groups facing higher risks. Initial analysis of Victorian state policy responses to date shows a strong focus on public health messaging, development of warning systems, remote monitoring of people identified as vulnerable and limited targeted interventions particularly directed towards older people.

The Victorian Council of Social Service (VCOSS) is the peak organisation for the community sector in Victoria. VCOSS undertakes both policy advocacy in the interests of low income and disadvantaged Victorians and community sector capacity building.

Between February and May 2010 VCOSS will be conducting policy analysis and interview based qualitative research with community sector organisations working with vulnerable population groups in order to:

- document the experiences of heatwave and heatwave adaptation for vulnerable population groups facing multiple risk factors;
- investigate the impact of heatwave on social determinants of health including access to services;
- identify gaps and strengths in current policy and programmatic responses; and
- recommend policy and programmatic options which combine structural reform with community based adaptation.

Policy and programmatic responses to heatwave in Victoria illustrate both the complexity of, and potential for, community adaptation to climate change. Current limitations in policy response demonstrate the challenges of coordinating effective responses across different scales of governance in response to a complex multi-factorial policy problem.

## **The east coast Tasmanian rock lobster fishery: vulnerability to climate change impacts and adaptation response options**

**S Frusher<sup>1</sup>, G Pecl<sup>1</sup> and C Gardner<sup>1</sup>**

<sup>1</sup>University of Tasmania, Australia

Climate change adaptation research requires inter-disciplinary studies to underpin the policy required to manage both biophysical and human systems.

In marine domains, climate induced changes in water temperature and ocean currents can change the productivity of resources which in turn alters the spatio-temporal distribution of users (e.g. fishers) with social and economic flow-on effects to communities. This presentation is based on results from the recently completed report for the Australian Government's Department of Climate Change on the rock lobster fishery of Eastern Tasmania in Australia. The study demonstrates the importance of considering the links between biophysical and human systems and the interactions in terms of assessing potential impacts and adaptation options. This fishery, located in a region predicted to be the fastest warming in the southern hemisphere, provides early warning signals for consideration in fisheries globally. Direct impacts relate to forecast changes in growth and recruitment whereas indirect impacts, already in full swing, affect ecosystem services through major changes in ecosystem resilience. Although climate change adaptation is often viewed by managers and industry as a future decision because incremental changes appear small, climate related impacts are already affecting this fishery. Current resource assessments and the evaluation of future management strategies need to account for climate change impacts to produce the best long-term outcomes for the fishery.

## Strategic local government planning and decision-making on climate change adaptation: Experiences from local councils in Australia

H Fuenfgeld<sup>1</sup>

<sup>1</sup>ICLEI Oceania, Australia & School of Land and Food Resources, University of Melbourne, Australia

An increasing number of local governments have embarked on addressing the current and future impacts of climate change at the local level, using a multitude of approaches for planning and decision-making. Awareness in the sector is growing that local government will inevitably be at the forefront of protecting residents, businesses, community assets and services from the unavoidable negative impacts of increasing average temperatures, changing rainfall patterns and sea-level rise. Some cities and regions are also exploring options for harnessing the emerging opportunities of climate change.

City administrations are in the process trialing a number of approaches of treating climate risks. Detailed climate risk assessments can be crucial for understanding a local government area's exposure and its community's vulnerability to the effects of climate change. However, such spatial assessment are costly, and translating assessment results into effective action and generating political support for these is often challenging for councils, due to the lack of a structured process, limited internal capacity and anxieties about financially and politically costly adaptation decisions that are based on limited information.

This paper argues that in order to successfully tackle the impacts of climate change adaptation in local government, qualitative and quantitative risk assessment studies need to be embedded in an organisation-wide strategic process for climate change risk management that is able to facilitate collaboration of key staff from all major departments. Experience of working with local government in Australia has shown that carrying out qualitative assessment of corporate and community climate change risks can be a suitable entry point for city administrations to work strategically on climate change adaptation.

Internally focused identification, analysis and evaluation of climate risks and opportunities is key to this strategic risk management process. Not only does a focus on internal capabilities and knowledge of climate risks kick-start planning and decision-making for adaptation, it also raises staff awareness and knowledge of climate change issues by pooling valuable internal organisational expertise on climate change risks across departmental silos. Based on identified data and information gaps, an organisation may subsequently decide to carry out or commission additional studies, for example detailed spatial risk and vulnerability assessments.

The paper draws on experiences gained during the ongoing implementation of the Adaptive and Resilient Communities (ARC) Program in Australia. ICLEI – Local Governments for Sustainability Oceania launched this capacity-building and decision support program in July 2009 to assist local government in establishing and implementing a systematic process for climate change risk management. The program uses a tested climate change risk management process that enables local governments to develop adaptation responses in line with their strategic organisational objectives.

In this paper, preliminary findings from implementing the ARC Program are presented and discussed, including an overview of key adaptation challenges many local governments face and tested solutions for overcoming some of these challenges. The paper includes reference to examples from some of the Australian local governments currently participating in the program.

## A systematic vulnerability assessment: analysing the vulnerability of sea turtle nesting grounds to climate change

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Human-induced climate change is as a major threat to the survival of many species and the integrity of broader ecosystems. There is already empirical and anecdotal evidence that biodiversity has been affected by climatic changes, with predictions of further and more severe impacts as climate change progresses. A particular ecosystem or species may be directly and/or indirectly affected by different and multiple climatic processes at different temporal and geographical scales. This will cause considerable challenges for natural resource conservation and management since for logistical, financial and political reasons, managers cannot address all of these threats simultaneously; thus priorities must be allocated. In order for managers to efficiently prioritize their resources they will require to understand: (1) the cumulative and relative impact of various climatic process on a particular specie; (2) the spatial variation of the cumulative impact of climate change on the species distributional range; and (3) how the vulnerability of the specie to climate change will alter if impacts from a specific climatic factor is mitigated. However, most of the studies conducted to date does not provide this information as they are limited in scale, because (1) they predict how a single climatic process will affect a particular specie, yet processes are likely to occur simultaneously and cause cumulative effects, and (2) they typically focus on only one habitat or location used by the specie and this approach does not provide a full understanding of how a population, (management unit) will be affected. Consequently, there is a need for a structured approach to investigate how multiple climatic processes may affect the full range of habitats used by a particular species or population. This study addresses this by using a vulnerability assessment framework to assess the cumulative impact of various climatic processes on the nesting grounds (n=7) that represent the nesting habitat for 99% of the northern Great Barrier Reef (nGBR) green turtle population, the largest green turtle population in the world, under a conservative and extreme scenario of climate change for both 2030 and 2070. The framework used is based on the IPCC framework for climate change and is described as a function of sensitivity, exposure and adaptive capacity. The framework used allowed: (1) an assessment of how multiple climatic factors will affect sea turtles nesting grounds, (2) investigation of which climatic process will cause the most impact to each nesting ground, (3) identification of which nesting grounds will be the most

vulnerable to climate change, and (4) investigation of how mitigating different climatic factors individually or simultaneously can influence the vulnerability of the nesting grounds. The vulnerability assessment indicated that Milman Island and Bramble are the most vulnerable nesting grounds to climate change. Further, this study also indicated that in the short term (by 2030), sea-level rise will cause the most impact on the nesting grounds used by the nGBR green turtle population. However, in the longer term, by 2070 sand temperatures will reach levels above the upper transient range (30.8°C), where only female hatchlings are produced, and cause relatively more impact on the nGBR green turtle population. Thus, in the long term, a reduction of impacts from sea-level rise may not be sufficient, as nesting grounds will start to experience high vulnerability values from increased temperature. Therefore, a stronger focus on mitigating the threats from increased temperature will be necessary for long term management. Indeed, this study indicated that addressing the impacts from increased temperature will cause the greatest reductions in the cumulative vulnerability of nesting grounds to climate change. If the impacts from increased temperature are mitigated, all rookeries will experience very low levels of cumulative vulnerability in the future. The framework used in this study proved valuable to assess how multiple climatic processes will affect the reproductive output of sea turtles and provided key information for managers to direct and focus management and conservation actions to protect turtle populations in the face of climate change. This framework can be easily adapted if new information is obtained, and can be transferable to different species and populations provided the necessary data exist. Thus, it may be key in future management of species as climate change progresses.

## **Adaptive Pathways for the Future: Indigenous Peoples, Traditional Knowledge and Climate Change**

**K Galloway-McLean<sup>1</sup> and A Ramos Castillo<sup>1</sup>**

<sup>1</sup> United Nations University, Traditional Knowledge Initiative, Darwin, Australia

The increasing uncertainties of global environmental change highlight the interdependencies between people and the natural environments. Diversities within and between human cultures are a critical resource in envisioning sustainable futures and in supporting the diverse human potentials necessary for successful adaptations. Indigenous Peoples have unique repositories of learning and knowledge on successfully coping with local-level climate change and effectively responding to environmental changes. Historically and currently, Indigenous Peoples play a fundamental role in the conservation of biological diversity, management of water, land and other natural resources. This paper critically analyzes Indigenous adaptive response to climate change around the world focusing particularly in the areas of water resources and food security. It draws out common elements of success and suggests how Indigenous Peoples' knowledge on climate change can substantively enrich scientific knowledge and suggest adaptive pathways for the future.

## **Climate Variability and Food security: Mitigating the impact of Soil Salinity in a Changing Climate in Sri Lanka**

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<sup>1</sup> Disaster Management Centre, Sri Lanka

Sri Lanka Since climate change has particularly severe impacts on rural agrarian communities, it is important to strengthen their livelihoods and re-establish the conceptual links between poverty (defined as the lack of stable purchasing power to maintain decent living standards), livelihood, and environment. However, focusing on communities is not enough: if community initiatives do not become a part of government policies, it is difficult to sustain local efforts, which means that the problem has to be addressed from both ends. Perhaps the most important prerequisite for creating sustainable livelihoods and for achieving sustainable development is good and accessible governance. Thus, the links between the community and local, state, and national governments are of utmost importance. The aim of this study is to survey climate change impacts and local perception of climatic hazards including assessment and analysis of capacities and coping strategies; inventories the available technological advances to combat soil salinity; formulate adaptation strategies to reduce the vulnerability to agriculture salinity through a participatory mechanism; develop appropriate extension tools; and establish demonstration sites in collaboration with relevant technical agencies with selected adaptations. Experiments were conducted at Angiththamkulam yaya in Puttlum district to find out measures to reduce salt effect and to improve the productivity of salt affected paddy fields. A technical package including preparation of drainage canals, leveling of land, maintenance of water at 2-3cm through the growing period, transplanting of seedlings was used to alleviate salinity effects for rice plants. It is revealed from the soil analysis that paddy fields at Angiththamkulama yaya were affected with salinity mainly due to Na, Mg and Ca salt and electric conductivity values were so much higher (2-17dS/m) and normal growth of rice varieties was difficult. Adopting the technical package reduced the electrical conductivity and maintained it at a minimum level (Bg 352) due to reduction of salt affect and salt tolerant lines(11-139,5-110,4-91) produced yield levels above 6T/Ha vital role in increasing productivity in the salt accumulated rice lands.

## **Designing Reserve Networks to Facilitate Species' Adaptations to Climate Change: An Urban Biodiversity Case Study**

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Global climate change is occurring more rapidly and intensely than ever before. Although the direction and magnitude of climate change impacts on species remains uncertain, it is expected that species will either: thrive, adapt, or decline/

go extinct. The ability for species to adapt is particularly important for their long-term persistence under rapid and intense climate change, as species that are unable to adapt quickly enough will be at risk of declining/going extinct. The call to action therefore is no longer limited to prevention and mitigation, but also necessitates facilitating species' adaptations.

One adaptation mechanism of particularly importance in the face of climate change is the ability for species to shift their geographic range to match shifting environmental suitability. However, many species that would typically adapt through range shifts may be unable to do so adequately given the rate and intensity of climate change, coupled with additional impacts such as human-induced habitat loss and fragmentation and urban development. Consequently, without appropriate planning, such species may join those at risk of decline/extinction due to climate change. Devising and implementing strategies which facilitate species' adaptations to climate change, by providing opportunities for species to shift as needed, will be a critical challenge for protecting biodiversity in the long-term. Reserve networks (protected areas) are increasingly being recognised as an important strategy for facilitating species' adaptations to climate change. These areas provide habitat and resource refugia for many species and their legal and legislative governance ensures long-term, conservation-centric management. Within Australia, reserve networks are considered a critical component of an integrated conservation strategy, with a high degree of investment being placed on them for protecting biodiversity into the future. Given such focus and investment, we must carefully consider whether the current reserve network is adequate for achieving long-term goals in the face of climate change.

This project aims to assess how well the current reserve network protects species diversity now and under alternative climate change scenarios, and to identify an approach which specifically incorporates climate change impacts into reserve design decisions. The main questions addressed will be: (1) How adequate is the current reserve network for protecting species now, and under alternative climate change scenarios?; (2) How might the reserve network design change in order to adequately protect species now, and under alternative climate change scenarios?; and, (3) How might the reserve network design change under alternative urban scenarios (e.g. land-use change or altered funding availability)? A systematic conservation planning approach using a modified gap analysis combined with reserve design modelling is proposed to address the project aims. These methods are individually well used and accepted, but their combined application for informing reserve design processes in the face of climate change is considered a novel approach.

Being able to answer such questions is essential for informing the effective and efficient design of a reserve network that maximises our successes in protecting biodiversity in the long-term through providing adequate opportunities for species to shift as needed in order to adapt to climate change.

## Benchmarking the level of adaptation planning in Australian organisations

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Research into the current level of adaptation planning in Australian organisations is being conducted jointly by CSIRO's Climate Adaptation Flagship (CAF) and the Australian Government Department of Climate Change and Energy Efficiency (DCCEE). The research involves a longitudinal survey of public- and private-sector organisations that would ideally play a significant part in Australia's efforts to adapt to the impacts of climate change. The project is designed to benchmark current level of adaptation activities in sampled organisations, to allow for tracking of changes in adaptation activities, and to attribute observed changes to the impact of the DCCEE, CAF, and other agencies where appropriate. The project is also intended to raise levels of awareness climate adaptation in general.

Initial telephone surveys were conducted in late 2008, and included local government groups, infrastructure management organisations and a variety of industry representatives and individual businesses. The survey measured the type and extent of adaptation activities these organisations are currently undertaking. Survey results indicated that although most businesses recognise the challenge posed by climate change, and accept that both mitigation and adaptation are important, the nature and extent of adaptation activity was highly variable, with only 59% of surveyed organisations having conducted formal vulnerability assessment, and less than 40% having implemented any specific planning for adapting to future climate change impacts.

A second series of interviews were conducted with 19 state and federal government agencies that are involved in adaptation activities. These interviews indicated that state and federal government entities typically incorporate climate adaptation within a broader climate change framework, rather than having separate policy directed at adaptation. Further, the major area of activity related to adaptation was gathering further information, suggesting that adaptation planning is still in its early stages within these entities. Commonly cited barriers to adaptation activity were lack of information, lack of clear responsibilities and coordination across jurisdictions, and uncertainty regarding funding, although this latter issue was more often identified by state/territory entities. Federal entities also cited lack of community engagement and the presence of climate scepticism as barriers to adaptation planning.

A third series of 16 in-depth interviews were conducted with businesses and other non-government organisations to gather more information about drivers and barriers to adaptation activity. Organisations with both low and high levels of adaptation activity were targeted for these interviews, to allow for examination of the differences between them. Drivers for adaptation planning that were identified included a growing awareness of climate change, a sense of vulnerability to climate change impacts, and a response to pressure from external stakeholders. Barriers to adaptation planning



included a lack of information and resources (money, people and time), a lack of policy clarity and/or government support, scepticism about climate change impacts, and a culture of conservatism within the organisation.

It is noteworthy that the drivers and barriers to adaptation activity identified by both types of organisations were similar – this suggests that there are not extensive qualitative differences that are preventing organisations from taking action. Rather, the differences seem to involve the relative scale of drivers and barriers: if the drivers are extensive enough in an organisation to overcome the barriers, then it appears likely that the organisation will take action on adaptation issues. In particular, it appears that once organisations develop a sense of vulnerability to climate change (and overcome scepticism, lack of information and a lack of resources), they are then likely to take action.

The expected drivers and barriers identified in a review of adaptation literature were largely supported by both the quantitative survey findings and the qualitative interview results. It appears that adaptation planning is more likely to occur if an organisation:

- has more knowledge of climate change in general,
- has conducted formal vulnerability assessment,
- has prior experience with longer-term strategic planning,
- has contact with external organisations to provide information and assistance.

Further, it appears that adaptation planning may be less likely if the organisation:

- is waiting for someone else to take responsibility for adaptation planning,
- has an organisational culture that does not support change,
- has a lack of information or physical resources (money, staff, time),
- has a degree of scepticism about climate change in general.

The three processes of data collection will be repeated in mid-2010, to allow for the tracking of changes over time and to provide some assessment of the impact of work conducted by the Climate Adaptation Flagship in the intervening period. Once the second set of survey data is collected, it will be possible to identify how, and to what extent, various organisations in the sample have changed over time. It will also be possible to identify organisations that have changed markedly, and compare them to those who have not changed; this approach will allow a further examination of the range of barriers and drivers of adaptation planning in Australian organisations.

### **3 (influential but) misleading ideas about adaptation to climate change**

**B Garnaud<sup>1</sup>, R Billé<sup>1</sup>, F Gemenne<sup>1</sup>, and A Magnan<sup>1</sup>**

<sup>1</sup>IDDRI (Institute for Sustainable Development and International Relations), France

However interesting the definition of adaptation and adaptive capacity proposed by the IPCC may be, others could also be useful like for example the one proposed by G.C. Gallopin (2006) where “adaptability or adaptive capacity of human system can also be defined as the capacity of any human system from the individual to humankind to increase (or at least maintain) the quality of life of its individual members in a given environment or range of environments”. As the first definition focuses on the climate change context, the second refers more to the sustainability issue and induces the need for a large conception of the adaptation process and its influential factors. Here, a strong reference is made to social, cultural and economic features of societies, which requires from scientists a global and systemic approach. It then invites to develop contextualised studies and to see general considerations on adaptation processes and underlying factors with caution.

Despite the recognition by scientists that this nuanced approach is crucial, the scientific as well as “grey” literature too often remain leaning on some generally accepted ideas about adaptation. Such non-contextualised views induce misunderstandings concerning adaptation mechanisms and underlying factors. Furthermore, these misunderstandings tend to cloud the issue and strongly constrain the identification of realistic and pragmatic adaptation options. Indeed, to be realistic, adaptation strategies and actions must be built on the identification of the strengths and weaknesses of a specific society/territory; in other words on its true adaptive capacities and exposure to hazards.

The communication will discuss three of these generally accepted ideas: “The poor have low adaptive capacities”, “Development favours adaptation” and “Adaptation will be easier in developed countries”. We will not aim at demonstrating that these received ideas are always false or counterproductive, but rather that they must be considered with caution and not applied in all contexts without being previously debated. For each of these three ideas, the communication will briefly address (i) the main reasons that explain why it has emerged, (ii) the main stakeholders and arenas which are its “vectors”, (iii) what makes it deceptive, and (iv) the associated risks it entails. Beyond deconstructing these common beliefs, the aim here is to bring out the subtle dimensions of the complex relation between adaptation to climate change and the specificities of human communities, arguing that to be realistic, adaptation must lean on a contextualised approach.

### **Adaptation to climate change and development cooperation in North Africa**

**B Garnaud<sup>1</sup> and R Billé<sup>1</sup>**

<sup>1</sup>IDDRI (Institute for Sustainable Development and International Relations), France

In recent years, adaptation to climate change has gained serious momentum in development practices, with many development agencies and NGOs launching adaptation projects and programmes. While most of these organisations decided to start ‘doing’ adaptation three to four years ago, the available knowledge on what to do and how to do it was not particularly

satisfactory. With a 'trial and error' mindset, it was thus argued that starting at that time would allow such organisations to 'learn by doing'. We are now entering an uncertain phase where on one hand there is a need for critical review of what has been done so far in terms of adaptation projects and programmes, and on the other hand a very strong push is being felt to rapidly scale up the current initiatives in response to both much more pressure and much more financing. This push is related to the international context of climate change, and most obviously to the talks under the UNFCCC: the momentum around adaptation has been growing since COP11 in Montreal (2005) and has sped up since COP13 in Bali (2007) and COP14 in Poznan (2008). Yet the two terms of the adaptation equation – first a need to pause for reflection, and second the push to go faster and to scale up – are more contradictory than compatible. In practice, it seems that the need to review what has been done so far in order to draw lessons from this 'learning by doing' phase is something that often falls off the agenda.

The aim of this communication is thus to draw lessons from several years of adaptation implementation by development cooperation agencies and NGOs in North Africa, and contribute to the requirement for re-evaluating these first years of 'learning by doing'. We focus here on four North African countries, namely Algeria, Egypt, Morocco and Tunisia. First screening adaptation projects financed by development cooperation agencies, we apply an analytical grid in order to come up with a classification of existing projects. This in turn allows us to identify gaps, potential opportunities and threats to implementation, drawing lessons and recommendations for development cooperation practitioners.

## Adapting the industry to climate change: the role of climate services

B Garnaud<sup>1</sup>

<sup>1</sup>IDDRI (Institute for Sustainable Development and International Relations), France

The concept of climate services has come to the forefront of the international discussions on adaptation since World Climate Conference-3 held in Geneva in September 2009. The term 'climate services' covers a wide array of potential utilisation of climate science and data, ranging from climate information and education to the provision of climate model data and to more complex interactions between climate scientists and end users. The necessity of providing simple access to sound climate information has been well understood, but there still is a need of pushing the interaction between the climate sphere and end users further in order to make sure that this information is used adequately and the demands of the end users are met. In this context, this communication presents INVULNERABLE, an initiative launched in 2007 that aimed at experimenting innovative ways of evaluating industrial vulnerabilities through a close collaboration between industrials and climate scientists.

Led by the Institute for Sustainable Development and International Relations (IDDRI) in partnership with climate scientists and leading industries, INVULNERABLE generated from the growing will of some multinational industries to understand how their activity will be impacted by climate change and how they can adapt accordingly, and seized the opportunity laid by the abundance of climate data consequent to climate modelling activities led by major climate research centres (CERFACS, IPSL, Météo France). The project developed an original way of building and informing indicators of vulnerability, trying to bridge a lasting gap between actors of the industrial sector and climate scientists and placing the needs of the industry in the centre. The aim of this communication is to share the experience and lessons drawn from the project. We will detail the methodology we used through the presentation of three case studies involving three different industries and climate-related vulnerabilities.

## Climate Smart Sanctuary: Bridging the Gap between Scientists and Communities in American Samoa

E Gaskin<sup>1,2</sup>

<sup>1</sup>Fagatele Bay National Marine Sanctuary

<sup>2</sup>National Oceanic and Atmospheric Administration

South Pacific island nations and territories are particularly vulnerable to changes brought about by global warming. Climate induced changes will unduly impact Pacific islanders whose activities contribute little to global warming, and whose practical options for coping with impending change are limited. Although Pacific islanders have successfully adapted to changing environmental conditions for centuries, recent rapid climatic shifts are testing their resiliency. When planning for the impacts of climate change, traditional leaders and village residents are often sidelined in the planning process. Enabling them to participate with local governments and build on the synergy between traditional wisdom and modern knowledge may assist islanders to manage change rather than become victims of it.

The Fagatele Bay National Marine Sanctuary (FBNMS) in American Samoa recognizes the immense value of community-based management and has adopted a participatory approach to climate change adaptation planning in the territory. In an effort to promote community resiliency and protect coastal resources from the potential impacts of climate change, FBNMS is implementing Climate Smart Sanctuary process to help inform climate change planning in the territory. The Climate Smart Sanctuary process was developed by the Office of National Marine Sanctuaries (ONMS) in the National Oceanic and Atmospheric Administration (NOAA) to guide climate change planning at national marine sanctuary sites across the United States.

The Climate Smart Sanctuary process includes the development of a sanctuary climate site scenario to describe possible climate change impacts and a climate action plan designed to address those impacts. The climate scenario is designed to present a picture of what a site might look like in thirty to fifty years. FBNMS is working with local and regional climate scientists to gather existing information on the main climate change impact drivers and the potential impacts to ecosystems, heritage/cultural resources, and communities.

NOAA is hosting a climate workshop in American Samoa to encourage the sharing of climate change planning experiences, knowledge, and skills among participating managers and community members. Participants will engage in sharing case studies and lessons learned, give presentations, and work together on both group and individual projects and problem solving exercises. Coastal managers and community leaders will work together to develop an adaptation planning framework as a model for addressing areas in American Samoa that are vulnerable to the affects of climate change.

The climate scenario and the climate workshop will inform the climate action plan for sanctuary sites in American Samoa. We anticipate that the action plan will contain both scientific research and monitoring initiatives, as well as several projects local villages can implement at the community level. FBNMS staff will work closely with coastal villages to support climate activities and ensure the successful implementation of the projects over time.

The poster will present the stages of the Climate Smart Sanctuary process and the steps we have taken to apply the process in American Samoa. Particular attention will be made to the outcomes of the workshop and what has been done at the village level to increase community resilience to climate change. Information will include lessons learned and recommendations about how Climate Smart Sanctuary process can be applied to other marine protected areas throughout the Pacific.

## **Adapting to climate change in the UK: UKCIP's Adaptation Framework**

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<sup>1</sup>United Kingdom Climate Impacts Programme

Climate change has been described as a 'wicked' issue that is not amenable to an elegant solution as it is not a discrete problem. It may also be characterised as an 'unbounded problem' as there is some uncertainty about the scale of the problem, there is uncertainty and ambiguity as to how it should be addressed, and there are no limits to the time and resources it could potentially absorb. It follows that there are many different ways of approaching climate change adaptation. It may be seen variously as a process of learning, an issue of equity, or an issue concerned with improved decision making. This plethora of interpretations and approaches, combined with the highly contextual nature of adaptation, presents a challenge to those organisations at the front line of adapting to climate change.

The UK Climate Impacts Programme (UKCIP) has been helping UK organisations adapt to climate change for over ten years. Over this time, we have developed a wide range of tools, resources, information to support organisations adapt to climate change, and have gained first-hand experience of the process organisations move through as they address the adaptation challenge. Our learning has been encapsulated in the UKCIP Adaptation Framework.

This poster will share the lessons we have learnt through working with UK adapters, and in particular, offer a framework that may be valuable to others that are seeking a practical and pragmatic way to address the wicked issue of climate adaptation.

## **Adapting to climate change in broad-acre irrigated farming systems – Case studies from the Riverina region of South East Australia**

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Worldwide, there is increasing competition for water resources between agriculture and other sectors, combined with reduced total water availability in many regions. One of the most significant impacts of climate change in Australia's irrigated Riverina is likely to be on broad-acre irrigation allocations. Over the past decade, these have fallen from historical norms of 100% to average levels below 30%. Studies on future stream-flows under a range of climate change scenarios also point to significant long-term reductions in available irrigation water. It is clear that irrigation farmers in the region must consider both incremental adjustments to practices and tactics, as well as more transformational changes, in adapting to a reduced and more variable future supply of irrigation water.

There are numerous potential strategies an individual farmer might consider when determining how best to use a limited supply of irrigation water on-farm. Options such as full- versus partial-irrigation; changes to agronomic practices such as rotations, residue management, crop species and varieties; changes to proportional sharing of water between winter and summer crops; as well as more transformational changes such as investing in new irrigation technology, or disposing of water on the free market and conducting their entire farming operation for the season (or permanently) as a rain-fed enterprise. All these aspects need to be considered in the context of a warming climate with increasing atmospheric CO<sub>2</sub> concentrations.

The comparison between these options is complex, as it depends on a range of bio-physical, economic, environmental and social variables, e.g. degree of change in water allocations, farm size, soil types, climate, relative prices (commodity, inputs, and water), and farmer preferences. When analysing complex systems, traditional field-scale methods of farming systems analysis are inadequate to answer questions relating to the sharing of limited resources (eg. water) between competing objectives. In irrigated systems, adaptation options which produce enhanced results at the field level may deliver reduced performance at the whole-farm level. Similarly, adaptation options which result in sub-optimal performance of an individual field can result in enhanced productivity and profitability for the whole farm.

Here we evaluate climate change adaptation options on two irrigated case-study farms from the Riverina region of South Eastern Australia. Participatory engagement with farmers was employed to ensure realism of the adaptation scenarios considered, and systems modelling tools (APSIM) were used to generate new discussable information on the behaviour of these complex systems, facilitating understanding on pathways to achieve more resilient farming systems design. A spectrum of potential water reduction scenarios, cost-price relationships and cropping/irrigation options were examined, with the objectives of: (i) evaluating the benefit of applying more integrative whole farm systems modelling analyses; and (ii) quantifying trade offs between profitability, economic risk, and environmental outcomes for alternative incremental adaptation options, and more transformational changes in the face of climate change.

## Rural livelihood vulnerability and adaptations to climate change in South Central Ethiopia

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Impacts of climate change in Sub-Saharan Africa in general and in Ethiopia in particular are increasingly observable. In the Sahel region, rainfall has decreased significantly over the last three decades, while frequencies of drought, declining water volumes in rivers and reservoirs, lowering of agricultural production, flood events, pest incidences, biodiversity loss and competition on resources have been intensified. The impacts are exacerbated for two main reasons: first is due to the governments' poor capacity and economy to quickly put in place adaptation strategies acceptable to the vulnerable communities, and second resource degradation and other associated multiple non-climatic stressors such as population pressure that lower capacity to cope with the impacts. Vulnerable communities might have developed diverse strategies to cope with impacts of climate change. However, despite the increasing recognition of the impact of climate change there is significant gap in our understanding and knowledge regarding the nature and severity of impacts, endogenously evolving adaptation strategies, and the effectiveness of these strategies in safeguarding community livelihoods. The main objective of this ongoing research is, therefore, to investigate the vulnerability of rural communities in the South Central Ethiopia to the coupled effects of climate change and resource degradation and their adaptation strategies. More specifically, the research is trying to explore communities views on climate change impacts and traditional monitoring systems employed to describe the realism and severity of climate change; investigate the coupled effect of climate change and resource degradation in exacerbating communities vulnerability to climate change and limiting their coping strategies; investigate effects of household resource endowment with regard to capacity for coping and developing effective adaptation strategies, and sort out which segments of the communities are more vulnerable and which are not; and evaluate the appropriateness of existing national and regional policies and their implications to adaptations at local level. The research is underway in two Peasant Associations (PAs) in Arsi Negelle Diristrict in South Central Ethiopia. The two PAs are selected in such a way that they represent two different agro-climatic zones (wet vs. dry) and different natural resource status (productive vs. less productive). So far only qualitative data were collected through participatory rural appraisal, historical narratives, key informant interviews and personal observation methods. These data were analyzed using a thematic approach, where the themes were identified after the review of the qualitative data. The preliminary findings of the study revealed that delay in precipitation, drought, heavy and unseasonal precipitation, and increase in temperature have become frequent that immensely hampered the livelihoods of most people in the area. Communities in dry agro-climatic zone and less productive areas felt such impacts severely than those in wet and productive areas. Nonetheless, in both PAs people have been taking some measures to cope with the impacts of climate change and variability that mainly focus on livelihood diversification: non-farm, off-farm and unemployment induced migration.

## Equity in the financing of adaptation: a perspective from distributive justice

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Most observers agree that equity is an essential condition for a new international agreement on climate change. However, equity is an equivocal concept, and different interpretations of equity clash with each other. Though equity concerns have been placed at the core of negotiations on mitigation efforts, they have been little addressed in the discussions on adaptation. As a result of this, the criteria that will be used to allocate the adaptation funding remain unclear and vague, which is detrimental for the negotiation process as a whole. This paper aims to offer a new perspective on this issue, departing from the traditional perspective inspired by retributive justice.

The fundamental injustice of climate change is well known: the countries that will be first and most affected by its impacts are those that bear the least responsibility for the atmospheric concentration of greenhouse gases. In order to fix this injustice, transfers from the North to the South will be needed to cope with and adapt to the impacts of global warming. On which criteria should such transfers be operated? Borrowing an expression from Baer (2006), who owns what to whom? Two different possible answers can be provided to this question. The first answer derives from retributive justice, which is the perspective on justice most commonly referred to in Western countries. Retributive justice is based on the idea that damages should be repaired by those who have caused them. The philosophy behind UNFCCC and the Kyoto Protocol is largely inspired by retributive justice, epitomised in the concept of 'common but differentiated responsibilities'. So is the concept of 'climate debt', put forward by campaigners for climate justice. A strict application of retributive justice to adaptation would imply that the countries with the greatest responsibility in global warming would transfer funds to compensate for the damages they have caused in countries that bear the least responsibility for these damages, and are the first and most affected.

Yet this paper aims to show the practical problems that would arise from an application of retributive justice to adaptation, and makes the case for a perspective inspired by distributive justice. Unlike retributive justice, distributive justice is not concerned with the identification of responsibilities, but rather with the equalisation of resources and benefits, according to the needs and capacities of each party. Equity lies at the core of distributive justice, which mostly seeks to resolve distributional issues. With regard to adaptation, a distributive view of justice would no longer be based on the levels of responsibility, but rather on the levels of vulnerability and adaptive capacity. This would bear important consequences for the allocation of adaptation funding, which are described in the paper. The paper also seeks to identify the political and practical obstacles in the implementation of distributive justice, and suggests some options to overcome these obstacles.

## **Migration doesn't have to be a failure of adaptation. An escape from environmental determinism**

F Gemenne<sup>1</sup>

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Massive population displacements are now regularly forecasted as one of the most dramatic possible consequences of climate change. Recent empirical studies, such as the EACH-FOR project ([www.each-for.eu](http://www.each-for.eu)), have shown that environmental factors were increasingly important drivers of migration movements, both forced and voluntary.

The dominant perspective on the issue, however, is rooted in environmental determinism: migration is conceived as a threat to human security, the only choice left when all other adaptation strategies have failed. Environmental 'refugees' are depicted as the expiatory victims of climate change, subjects of a humanitarian catastrophe in the making.

Empirical studies, however, reveal a different picture, where migration becomes an adaptation strategy for those who are affected by the impacts of climate change. Yet mobility often remains a luxury, unavailable for those who cannot afford to migrate. Hence the most vulnerable are often stuck in places heavily impacted by climate change, unable to seek higher grounds and a better life.

Building on case-studies conducted in Central Asia and Asia-Pacific within the framework of the EACH-FOR project, this paper refutes the dominant deterministic perspective and adopts a constructivist approach. It shows how policy responses to climate change impacts affect people's ability to migrate, and why these policy responses often matter more than the very impacts of climate change in their migration decision. Considering that migration can improve human security rather than hinder it, the paper makes the case for migration policies to be part of adaptation plans. In that regard, a key political challenge will be the restoration of the right to mobility for the most vulnerable, in order to enable their human security.

## **Environmental migration from small island states: why islanders should not be seen as 'canaries in the coalmine'**

F Gemenne<sup>1</sup>

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Reports on the impacts of climate change, including those of the IPCC, usually describe small island states as 'especially vulnerable to the effects of climate change, sea-level rise, and extreme events' (Mimura et al. 2007: 689). Over time, the threats posed by sea-level rise to the very existence of these states have been highlighted, and their inhabitants have often been described as the first potential 'climate refugees'. Most media reports now describe small island states as 'lost paradises' and their citizens as 'canaries in the coalmine' of global warming, a view that has often been reinforced by official discourses in climate negotiations. Though the reality of environmentally-induced population displacements in small island states cannot be ignored, describing islanders as climate refugees in the making, left with no other choice than fleeing abroad, fail to capture the complexity of environmental changes and migration flows. Migration, by nature, is a multi-causal process, which does not have to epitomize the failure of local adaptation strategies. As an example of this, empirical works have shown that migrants leaving the low-lying archipelago of Tuvalu to New Zealand did so for a variety of reasons, and not only in prevision of future impacts of climate changes (Mortreux and Barnett 2008; Shen and Gemenne 2010). Such reasons include the perspective of earning better wages, pursuing higher education or simply reuniting with family members.

Furthermore, portraying island citizens as disempowered victims of climate change might affect their resilience and resourcefulness, ultimately hindering their adaptation efforts. Community-based adaptation strategies, in particular, could be hindered if the inhabitants of small island states see themselves as doomed.

This paper aims to show why migration should not be conceptualized in a deterministic perspective, but rather as a process that can be activated by the migrants themselves, amongst other options. Drawing from fieldwork carried in Tuvalu, the paper highlights the detrimental effect of the 'canaries in the coalmine' rhetoric on the inhabitants' adaptive capacity.

In coalmines, canaries were used to alert about imminent danger, but were hardly rescued from the danger. Though many resort to this image in order to alert about the imminent threats of climate change, it might actually do more harm than good to the citizens of small island states, as adaptation measures are urgently required. The paper makes the case for these citizens not to be considered as the canaries in the coalmine, but as the miners themselves.

## Victorian farmers take positive action and stay informed about climate change and emissions

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The Victorian Government's Future Farming Strategy has an aim to help farm businesses plan for climate change and to provide farmers in key industries with new technologies and strategies to adapt their farming systems to future climate conditions. The Victorian Department of Primary Industries' project 'Planning for Climate Change' is contributing to this mission by enabling the sharing of positive stories of practical action, as well as increasing the capacity of service providers and farm businesses to stay informed about greenhouse gas emissions.

There are many examples throughout Victoria's rural community where positive actions and adjustments have been made to reduce greenhouse gas emissions while also preparing for the impacts of climate change and seasonal climate variability. The 'Farmers Taking Action' case study series has been developed and is continually expanded to demonstrate how agricultural businesses, industries, groups and individuals have taken positive and practical action towards adapting to and mitigating the likely effects that climate change will have on their businesses. Such actions include adaptive business decisions, the use of new processes and technologies, collaborative community action and changed farming systems. Sharing stories through the 'Farmers Taking Action' case study series has been a significant step towards encouraging all Victorian agricultural businesses and industries to consider proven practice changes, by demonstrating that positive action can lead to positive outcomes.

The Carbon Toolkits in Agriculture Network has been established to keep farm businesses and farm service providers up to date with the latest events, training, news, resources and accounting tools relating to agricultural greenhouse gas emissions. A concise monthly update is disseminated to over 270 network members, including farmers, farm consultants, farm accountants, Landcare coordinators, extension staff, researchers and training providers.

Information about 'Farmers Taking Action' case studies series and the Carbon Toolkits in Agriculture Network can be found at [www.dpi.vic.gov.au/climaterisk](http://www.dpi.vic.gov.au/climaterisk).

## Food security in the future may be compromised by lower nutritional value and increased toxicity of crop plants.

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Producing enough food to meet the needs of an increasing global population is one of the greatest challenges we currently face. To date the climate adaptation debate has largely focused yields but the nutritional quality of food is also of vital importance. Plants grown at higher concentrations of atmospheric CO<sub>2</sub> generally boosts plant growth and crop yields, so long as there is ample fertiliser. With increasing cost of fertilisers and the looming phosphate shortage, such increases in yield made not be achievable. Moreover, plants will almost certainly decrease in nutritional value (protein, micronutrients) and many will become toxic. Plants naturally produce toxins and digestion inhibitors to protect themselves against herbivores. Over half of all crop plants, for example, produce compounds that release toxic cyanide when the plant tissue is chewed. Important staples that are cyanogenic include cassava and taro, as well as other pasture plants such as clover and sorghum. Too much cyanide in the diet can cause permanent paralysis of the lower limbs such as Konzo, or even death, especially in children. Konzo is already epidemic in parts of southern Africa. At the moment this is only a problem when cyanogenic plants are droughted. When we grew different types of plants in different climate scenarios, we found that the concentration of cyanogens either increased, or increased relative to protein in the leaves. This was a direct response to increased atmospheric CO<sub>2</sub>, but similar increases occur in droughted plants and those experiencing high temperatures. Protein concentration of plants will also certainly also decrease in the future. This is serious because the ability of humans and other animals to tolerate cyanide and other natural toxins depends on adequate protein intake. Protein content of cereals such as wheat and rice, for example, is likely to decrease 10-15% in the coming century. Lower leaf protein means that grazing animals would need to consume more to satisfy their protein requirements, potentially also ingesting more toxins. In order to maintain food security and avoid increased outbreaks in diseases such as Konzo, new cultivars need to be developed. We are using a combination of plant breeding, agricultural practice and food processing methods to try to address this issue. If we are to achieve food security in a high CO<sub>2</sub> world, an integrated and multidisciplinary approach is needed.

## Climate Change: employment and social implications

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Climate change and its associated environmental challenges will have a considerable impact on the world of work and its participants. It is important that policy and actions in response to these challenges maintain economies and enterprises that are efficient, socially just and environmentally sound.

The negotiating text for the now unrealised UNFCCC Agreement for COP15 in Copenhagen acknowledged the important link between climate change and the labour market by including provisions for a "just transition". The International Trade Union Confederation (ITUC) in its Statement to COP15 articulated its forward agenda linking climate change to its collective bargaining program.

Governments across the globe have already committed to low carbon emission programs and in many cases significant reduction targets. Carbon trading and taxes are starting to, and will continue to have a pervasive effect on market and business behaviour. Consumers are demonstrating more preference for products that are “green”. This paper begins to explore climate change employment adaptation implications involving:

- labour markets,
- consultation and social dialogue with the social partners and communities,
- the role of collective bargaining,
- green and “decent” job creation,
- programs for skills development and training for workers in the area of new cleaner technologies, and
- adequate social protection.

Some of these are issues for government, some for the board room and some for the shop floor. Divisions of responsibility will need to be resolved. Inevitably, business will play an integral role in parallel to its role in implementing the policies and programs of government to reduce emissions. The paper concludes that implementation of the climate change responses must be sensitive to the priority of business to drive economic growth and investment if it is to deliver its commitment to employment and social policy initiatives.

### **Tree rings trends of pine and fir from the treeline zone of central Mexico**

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This work describes the main trends in tree ring width of two Mexican conifer species (*Pinus hartwegii* and *Abies religiosa*). Both species grow close to the treeline limit at 3000 m.a.s.l. or higher in mountainous areas of central Mexico. Tree rings were sampled in six forest zones located along a volcanic transect. Sampled trees of *A. religiosa* were relatively young (90-100 years) as logging practices are persistent in these forests. *P.hartwegii* ages are more variable with mean and standard deviation values of 151 and 63 years, respectively. This work is establishing a baseline for tree ring growth to measure the intensity of global change effects in forest ecosystems in the coming years. A profile of C, O and H stable isotopes for specific years of the sampling period will also be presented.

### **Retreat: Designing policies and pathways for resilient coastal development**

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Sea levels have been rising at an increasing rate and climate scientists expect this pattern to continue into the foreseeable future. A rise of 1.1m by 2100 is plausible. In Australia alone, this would put an estimated \$63 billion worth of dwellings at potential risk. Future development will increase the number of assets at risk – over half a million additional houses are being planned for in coastal South East Queensland by 2031.

While the provision of coastal defences may be popular with property owners, a long-term consequence of defending coastlines is that further development is encouraged in areas that are increasingly at risk and can only be protected over the long term with ever more expensive structures. Alternatively, a strategy of continual retreat of coastal settlements from rising seas can result in inherently safer and more resilient patterns of development. Besides moving communities out of harms way, planned retreat can continue to utilise coastal dunes, mangroves, and other coastal ecosystems as natural defences against storms. Natural defences offer inexpensive coastline protection, while also providing conservation and scenic values.

As the sea level rise ecosystems are able to shift landward as long as space is available. A process of planned retreat that maintains space for coastal ecosystems may therefore be appropriate for many coastal settlements. However landward movement of coastal ecosystems is likely to bring them into increasing competition for space with development in the very circumstances where they are valued for amenity and protection.

Current regulatory frameworks for coastal development are not designed to deal with rising seas, so do not have effective mechanisms to enable retreat. At its core, a regulatory framework that enables retreat is simple: it must specify and enforce conditions under which property must be abandoned. However the challenges in designing and implementing institutions that enable planned retreat are substantial. We describe three major challenges then discuss a research program that aims to enable society to implement effective retreat policies.

The first challenge is the nature of the decision problem. The cost of a retreat policy depends on the value of the built assets that will be lost under planned retreat. The decisions to invest in these assets are made by people with diverse values and time horizons, over long time frames and under significant uncertainty about sea level rise and its impact on the coast. Second, the magnitude and distribution of the potential losses means social justice and fairness will be important criteria for evaluation of any policy. This will be an issue both for the support for the policy by society in general, and for the behaviour and acceptability of those directly affected. Compensation and insurance mechanisms are likely to be required and this raises questions about unintended incentives for perverse behaviour by investors, failing or missing insurance markets, and the role of government in managing these issues. Finally any retreat policy will have to mesh with the complex existing social institutions for deciding appropriate land use. These

institutions include property rights systems that have evolved to enforce strong permanent individual rights under the assumption that land is permanent, and planning systems that have a complex and uncertain interface with property rights systems.

Our research approach focuses on: 1) Understanding the psychology of retreat and individual decision making under uncertainty and over long time frames. For example, perceptions of risk can be heavily influenced by recent and salient events, and regularly people undervalue distant future events. We expect that the response of individuals to retreat policies will therefore be complex and diverse, and in some cases inappropriate. Research can shed light on how people psychologically react to retreat policy options. 2) Designing and evaluating options for retreat policies. Policies such as rolling easements have been extensively analysed in theory. Surveys and experimental economics methods can be used to evaluate whether key assumptions of policies hold in practice. 3) Understanding and enabling policy transitions. This involves identifying barriers to regulatory change, building the capacity of communities and governments to change, and designing pathways for institutional change that enable low risk learning and adaptive management.

## **Towards systemic and adaptive governance: understanding framings and relational dynamics of 'climate change adaptation'**

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This paper reports research which investigates the framing of climate change adaptation research in relation to the projected scenarios by the IPCC and as interpreted and implemented within a Victorian state government department. Through this pilot study we seek to understand how future research designed and conducted under the rubric of 'climate change adaptation' research may contribute to delivering more systemic and adaptive governance regimes. In particular we are concerned to learn if systems thinking and practices can contribute to future cycles of R&D, including project and program management, by asking whether research does what it sets out to do and whether it is able to make a difference.

We build on the department's response to (impact) information and (adaptation) knowledge development from the perspective of recommendations generated by the Australian Public Service Commission's (2007) framing of 'wicked problems' as a systemic response to climate change. We approach the pilot study from the perspective that within department research and framing 'climate change adaptation' can be understood as part of a broader nested set of relationships. From here we argue that relational dynamics are important in the generation of information (understanding of impacts) and development of knowledge (adaptation responses) 'for' adaptation. Furthermore, we explore the implications of researchers taking a step back from this approach and invite consideration of other ways of thinking about adaptation 'with' and adaptation 'to' and using this shift in language as a means of understanding processes of realising a low carbon economy.

## **WINDSCREEN: A visualisation tool for engaging the community about water allocation decisions**

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Increasingly, decisions about water allocation are becoming harder as population increases, climate change impacts on water availability and supply is unable to meet the demands of all users. As such the decisions made by water authorities and governments are becoming more difficult, particularly as they impact on the economic, environmental and social condition of regions. Difficult decisions require effective methods of community engagement to engender community support for the decisions made. Therefore, the aim of our project was to develop a visualisation tool that engages the community in water allocation decisions, to enable water managers to understand the tradeoffs between different water uses that the community are willing to make as water becomes scarce. The tool developed, called WINDSCREEN, is designed to look like a car dashboard making it familiar to the community. Using water availability scenarios based on climate change predictions, it asks participant's to allocate water to three uses, farm, environmental flows and recreation. Local photos then demonstrate the impact that the participant's water allocation decisions would have on the local community and its environment. In doing so, WINDSCREEN not only provides a user-friendly community engagement tool to determine community preferences for water allocation, it also has potential as a tool for social learning about future climate change impacts on local water supply and the implications for water allocation.

The tool was developed and piloted in two communities in South West Victoria, Australia, in the Wimmera and in Camperdown. The Wimmera has a high variability in water availability and as such the community is experienced with water shortages, while Camperdown has high rainfall, so its community has had little to no experience with water shortages. WINDSCREEN was piloted to determine if the tool could be useful for community engagement and facilitate learning about allocation decisions. The tool was found to be user-friendly, with all participants feeling it was easy to use and understand. It enabled participants to demonstrate their preferences for water allocation and to discuss their feelings about water availability and use within their community. The outcomes of this pilot demonstrate the potential value of this type of interactive visualisation tool to assist water allocation decision making and facilitate social learning about water allocation and the potential impacts of climate change on water availability.



## The forgotten islands: climate change in the Torres Strait

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Indigenous Australians living on their traditional lands bear little responsibility for current or future climate change. Despite this, they are likely to be one of the most vulnerable groups to direct and indirect climate impacts. This vulnerability is due to their close cultural connection to the natural world, and their reduced socio-cultural and economic resilience. This paper focuses on one frequently overlooked group of Indigenous Australians in relation to climate change and adaptation. Torres Strait Islanders, particularly those living on islands with extremely low elevations such as Warraber Island, are extremely vulnerable to the impacts of climate change. Of the 18 inhabited islands in the Torres Strait, about one third are only a few metres above sea level. All islands have significant infrastructure built within metres of their rapidly eroding shorelines. Although shifting coastal zones are not new for Islanders, the observed increasing erosion rates are. Over recent decades, Islanders have reported increasingly rapid coastal erosion, higher sea levels and more variable weather. Islanders have also observed indirect impacts on the behaviour of land and sea flora and fauna. Since major inundation events caused by storm tides occurring between 2005 – 2010, Islanders have begun directly calling on the state and federal government to provide them adequate financial and human resources so they can design and implement short-term adaptation strategies to delay the erosion of their coastlines through revegetation activities, strengthening seawalls and protecting other basic service infrastructure already built on the islands. Recently, there have also been requests for assistance to make longer-term plans for relocation off the islands to be developed in parallel with on-island adaptation work so that the communities can be prepared for that eventuality. Despite a recent announcement for limited funds to support more scientific work in May 2010, so far no resources have been forthcoming for the adaptation plans suggested by the Islanders themselves. Therefore Islanders have had to use their own local knowledge to best defend their islands from inundation and coastal erosion. This paper, presented in collaboration with one Island leader explores what options might be available for short-term adaptation and longer term relocation strategies, as well as a direct request for action on this issue.

## Guiding principles for good practice in adaptation to climate change – Results of a European survey with 250 adaptation experts

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The EU target is to stabilize the global mean temperature to 2 °C above pre-industrial levels. But even a global increase of 2 °C will result in impacts to which Europe will need to adapt. Climate change impacts affect most sectors (e.g. energy, forestry, water management), different actor groups (government, business, NGOs, civil society), all regions (urban, rural etc.) and all levels of decision-making (local, federal, national, international). To avoid conflicts and create synergies between adaptation activities of different sectors, actors, regions and levels of decision-making coordinated and integrated adaptation governance and management is necessary.

To support coordinated and integrated adaptation action an ongoing project funded by the European Environment Agency (project consortium: Potsdam Institute for Climate Impact Research, the Environmental Protection Agencies of Austria, Germany and the Netherlands, AEA Technology) develops a set of generic guiding principles for good practice in adaptation to climate change, which shall serve as a common basis for coordinated adaptation of different sectors, actors, regions and levels of decision-making.

In a first step, literature on adaptation to climate change (including general guidance documents and sectoral approaches) was identified, analyzed and integrated to develop a set of 12 guiding principles for adaptation. These principles consist of a title and a short paragraph explaining the principle in more detail. The current titles are: Cooperate with all relevant stakeholders; Ensure commitment and leadership; Build awareness and knowledge; Deal with uncertainties; Explore and prioritize potential climate change impacts; Explore a wide spectrum of adaptation options; Prioritize adaptation options; Focus on win-win, low regret and urgent options; Avoid maladaptation; Mainstream adaptation within existing structures and processes; Realize adaptation at the most effective level; Monitor and evaluate systematically.

In a second step, the guiding principles were evaluated in an online survey by more than 250 adaptation experts from all European countries, from local to European decision making levels, from governmental institutes, non-governmental organizations, business organizations, and research institutes, and from 17 climate sensitive sectors such as civil protection, energy, forestry, health management, protection of biodiversity, tourism, water management.

The results of the survey confirm the generic nature and the wide applicability of the guiding principles. At all levels of decision making and in all sectors the experts agreed upon the usefulness of the principles for their fields of work. More than 80% of the experts agreed that the guiding principles integrate the most important aspects of useful adaptation action, give very useful orientation in realizing adaptation and that they could be used as a basis for cooperative adaptation activities of various actors and stakeholders in Europe.

Despite the high levels of agreements with the principles, many experts gave very useful comments how to further improve the guiding principles. These comments also revealed disagreements among the experts regarding various aspects of adaptation governance and management. For example, whereas some participants of the survey very much stress the importance of bottom-

up, participatory adaptation strategies others focus on top-down, regulatory and legislative measures. Based on the comments a final set of guiding principles for good practice in adaptation to climate change will be produced and made available in 2010.

## Future electricity demand projections for fast growing metropolitan regions in the context of climate change

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Peak electricity demand and electricity consumption are projected to rise substantially for many metropolitan regions due to climate change, population and economic growth. The increased electricity demand may intensify the existing stress in the electric power supply system and exacerbate the environmental impact in terms of greenhouse gas emissions. These issues of fast growing electricity demand are of high importance to policy makers, city planners and electricity utilities.

Usually the driving forces for these changing energy demand patterns are rapidly growing metropolitan regions, which are the focus of economic development and population growth. As with other fast growing metropolitan regions, such as Shenzhen and Beihai in China and Ghaziabad in India, South East Queensland (SEQ) in Australia is one of the fast growing regions in Australia (both in terms of population and economic activities) in the last decade. The SEQ region has an area of 22,890 km<sup>2</sup> (only 1.3 % of the land area of Queensland), had a population of around 2.9 million in 2009 (approximately 66 % of the state's population) and consumed 21,896 GWh of electricity in 2007-08 financial year (approximately 48 % of the total electricity consumption in Queensland).

Historically the electricity consumption in Queensland has been growing with an average annual rate of 3.7 % for the last ten years according to Energy Supply Association of Australia. The Australian Energy Market Operator estimates that the electricity energy for Queensland over the next 10 years will grow with an average annual rate of 1.5 %, 3.2 % or 6.1 % under assumptions for low, medium and high growth scenarios, respectively.

A special concern for the SEQ region is the rising peak electricity demand in hot and humid weather due to wide use of air-conditioners. Climate change is likely to intensify the growing peak electricity demand with increasing temperatures and stronger and more frequent heat waves. To meet the peak demand the electricity grid needs to keep a significant spare network capacity to be used only for such a small percentage of the time.

In this paper recent high-resolution electricity data at system and sub-station distribution levels for SEQ is analysed with a focus on the relationship between electricity demand and air temperature. These results will be used to make projections of future electricity demand.

Some coping strategies and adaptation options are discussed in relation to the future needs of the electric power system in SEQ to operate more resiliently under climate and demographic stress. These options include demand side response, a new electricity tariff structure that can counter peak demand growth and more widespread use of renewable and distributed generation.

This study is part of the South East Queensland Climate Change Adaptation Research Initiative.

## Observed and anticipated impacts in response to climate change on aquifer temperature

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Over the past decade, attention brought by climate change leads to produce a large body of evidences for observed and foreseen impacts on ecosystems. Many researches evaluate the impacts on fresh surface water bodies in terms of quantity, and quality and assess the potential threats on aquatic ecology. However, much less attention is paid on aquifer temperature. Groundwater temperature is one of the primary parameter regulating the ecological balance of the groundwater dominated ecosystems, and thus highly vulnerable to the effects of changing climate.

To evaluate the potential impact of global climate change on the aquifer thermal regimes in the Sendai plain, Japan, we observed the temperature-depth profiles in five locations. The U.S. Geological Survey's VS2DH numerical code was used to simulate the heat transport in the Sendai plain. For the convective heat transport, groundwater recharge was estimated by the water budget technique, where the estimations were verified with the results from two other methods; the water level fluctuation method and Darcy's method. Estimated groundwater recharge was used as a specific vertical flux in to the domain. Numerical model was run from 60 years back to the present (1947-2007) and the results were verified with the observed temperature-depth records. To incorporate the climate change impacts, three general circulation models (GCMs); HADCM3, MRI and ECHAM5 that gives output for 15 scenarios (A2, A1B and B1 for each model) were statistically downscaled to the Sendai metrological station. Observed climatic data with the GCM simulations for the period of 1927-1999 are used as the control to develop the cumulative probability distributions (CDF) in future. Downscaled temperature and precipitation were used in water budget technique and further applied in the heat transport model to estimate the future changes of ground water recharge and associate temperature distribution in the study area.

The magnitude of ground surface warming as evaluated from the observed temperature-depth (T-D) profiles in 5 locations ranges 0.9-1.3 °C. Considering the elevation of water table at different locations, 8m depth was used to

compare the temperature change by different scenarios. With respect to 2.0-4.1 °C warming (minimum in ECHAM5-B1 and highest in HADCM3-A2) and 3-371 mm/year precipitation rise (minimum in MRI-A2 and highest in HADCM3-A2) during 2060-2099 compared to 1968-2007 time periods, aquifer in the Sendai plain may warm in 1.6-3.7 °C range by 2099 with respect to the observations in 2007. According to IPCC AR4, approximately 20-30% of animal species are likely to be at risk of extinction if increases in global average temperature exceed 1.5-2.5 °C. Therefore, estimated range of aquifer warming will have a critical impact for the ecological balance in the Sendai plain. Land-use practices, such as reforestation have the potential to decrease aquifer temperature by increasing shading. Therefore, results in our study will be important to estimate the strength of mitigation measures and will guide the decision makers to come-up with more resilient decision for the ecological balance in the Sendai plain.

## **Linking institutional and agricultural adaptation to extreme dry conditions in the Canadian Prairies: The case of the South Saskatchewan River Basin**

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Of particular interest in the context of agricultural-based economies in semi-arid regions are vulnerabilities to drought and extended dry spells. Droughts often result in significant economic losses as well as environmental degradation and considerable social stresses. This situation is fairly evident in the South Saskatchewan River Basin (SSRB) of the Canadian Plains, where drought is a frequent and recurring feature of the natural climate. The majority of rural communities in this basin are heavily engaged in, and have economies largely centered on, agriculture. Many institutions have been created and subsequently evolved over time to address the challenges of coping with climate variability and drought in the basin. This paper discusses the ways in which institutions have facilitated and/or constrained adaptation in rural agricultural communities in the SSRB, Canada. This paper is based on the findings from a five year multidisciplinary project that focused on institutional adaptations to climate change and water stress in the SSRB through the lens of vulnerability.

Frequent exposure to droughts have facilitated the development of coping capacities to reduce the risks associated with these extreme events. The severe droughts of the 1930s sparked a wave of institutional adaptation that continues to influence vulnerability today. The Prairie Farm Rehabilitation Administration (PFRA) and the Prairie Provinces Water Board (PPWB) are among institutions created in response to the “Dirty Thirties”. The PFRA provided cutting-edge technical support to farmers allowing them to adapt their operations and practices to the Canadian Prairie climate. Agriculture was a relatively young industry at the time and was suffering from its reliance on techniques imported from Europe. The PPWB was another institutional reaction to water stress that sought to address inter-provincial governance concerns in multi-jurisdictional watersheds.

Producers in the basin manage climate and economic risks simultaneously. Producers have both proactively and reactively coped with climate variability, and have developed a suite of adaptive strategies from which they draw in times of stress. These strategies focus on maximizing economic returns while minimizing climate-related losses and ensuring the sustainability of their operations. Therefore they exhibit great resilience under the conditions that currently characterize the basin.

Notwithstanding these great achievements in vulnerability reduction, future climates may pose challenges to agriculture in the SSRB. Insights from the paleoclimate record indicate that the period of agricultural development in the basin occurred during a relatively wet period despite frequent dry conditions. Similarly, future climate scenarios project an increase in the frequency, severity and duration of dry spells. Current governance and management institutions have evolved in a time unrepresentative of both the natural and human-induced climate, and will need to adjust their approaches to accommodate future change, variability, and uncertainties.

Climate change and variability may produce conditions beyond the coping range of agricultural systems in the basin. Proactive drought-risk management could potentially alleviate some of the pressures from change and variability. It is likely that future adaptation will require an integration of institutional- and producer-driven strategies, while participatory planning and interdisciplinary perspectives will be key in guiding adaptation efforts into the future.

## **A New Paddy Planting System to Mitigate Methane Gas Emission**

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Climate change and global warming is a global phenomenon that is triggered by human activities primarily related to the use of fossil fuels, natural processes, and control of land-use activities. The process can produce gases that numerous in the atmosphere. Among these gases are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). These gases have greenhouse properties such as the continuing short-wave radiation, but absorbs and reflects long-wave radiation emitted by the earth that are hot that the temperature at the Earth's atmosphere increased. Nowadays, plating paddy is one of the main causes of the methane emissions increased 21 times more potential greenhouse effects than carbon dioxide, which causes damage to the ozone and the rising temperature. Most of countries in Asia are widely planted rice for the staple food consumption in the asia society. The cause of rice cultivation as one of the largest producers of methane gas is metanogenic bacteria. They produce methane gas as existing in the roots of rice, rice with more irrigation systems provide an ideal

environment for the process of methanogenesis or methane formation by anaerobic decomposition. Moreover, the variety of rice that is often planted have different morphological and physiological properties for each rice variety, longer periods crops to grow, more exudate and root biomass are formed so that emissions of methane are higher also the difference cavity diameter aerenchime, root oxidation power, and water management are thye critical factor to support methane production. Therefore, the problem solution is necessary to reduce emissions of methane gas produced by the rice without reducing the production of rice as the main crop. These steps can be done are first, by the aeration of the soil in a short time, this can reduce methane gas and it is also create efficiency irrigation water using. Intermittent irrigation will effectively reduce methane emissions ranged from 17 to 66% rather than continuous irrigation without reducing rice production. Second, by planting of new paddy varieties that emit low methane gas. IR64 rice types, SN90, and ciherang are known the most producing methane. These rice type can be reduced and replaced by varieties IR36, SN 60, or Maros which produces less methane, and the quality are not quite much different. Third, by fertilizing with enough nutrients, especially phosphore that is resulting in lower methane emissions. Fourth, by the provision of compost, because compost produces methane per unit of carbon is relatively lower than green manure or fresh straw. Giving the compost will not really increase methane emissions, while the rice straw is very really increase of methane emissions into the atmosphere. The use of organic ingredients cooked with the ratio C / N Low can reduce methane gas emissions. Fifth, by developing agro-forestry to reduce the concentration of CO<sub>2</sub>. By these various steps, the emissions of methane gas by paddy is expected to reduce the impact of global warming and significant climate change occur without reducing the quality and production of rice as a main crop. Keywords : Paddy, Methane Gas, Global Warming

## **Opinions about climate change and adaptation: A study using Q methodology to investigate the views of stakeholders in the livestock industry**

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Climate change is likely to pose significant challenges, as well as some opportunities, to the livestock sector in the United Kingdom (UK). Adaptation to the changes will undoubtedly be necessary to ensure continued success of the sector. However, little is known about stakeholder attitudes towards potential adaptations to climate change in the livestock industry. Attitudes are important in shaping behaviour, and without changes in behaviour, adaptation will not take place, leaving the sector vulnerable to changes in climate. Therefore understanding stakeholder attitudes is an important step in building a resilient livestock sector.

This study utilised an approach called Q methodology to investigate stakeholder attitudes towards adaptation to climate change, and thereby uncover the range of opinions relating to the topic. Stakeholders in the livestock industry consisted of representatives from industry groups and were asked to consider a number of statements relating to possible views about adaptation. The statements were gained from an earlier workshop and survey canvassing views on adaptation. Results reveal four positions relating to adaptation strategies in the UK livestock industry. The first position stresses that the answer to climate change adaptation depends on livestock farmers who know best how to manage their own enterprises, but also believes that, as this is a broader social problem, financial support should be provided. The second position emphasises that the answer lies in regulation and definitely not in GM technology. The third position believes that effective adaptation depends on education of, and information provision for, operators within the livestock industry. The fourth position believes that climate change adaptation should utilise technology, specifically GM. These four positions illustrate that stakeholders hold quite differing views on the best way to adapt to climate change. From a broader policy perspective, they need not be mutually exclusive. Position one strongly advocates freedom over decision-making, with financial support where necessary. Position two advocates that regulation be used as a safety-net beyond the autonomy provided by position one, to ensure that certain standards and safeguards are met. In reality, a compromise between positions one and two may be the most appropriate approach to ensuring effective adaptation without frustrating and perhaps disengaging stakeholders such as farmers who may be prepared to adapt anyway. Education provision can go hand in hand with both positions one and two, as can the development of technology. Other views may exist, but if they do, they represent additional positions not alternative ones.

## **Climate Change Environmental Health Indicators: devising a tool to measure and monitor human health vulnerability and the effectiveness of interventions for climate variability and change**

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New threats to human health, particularly the emergence and spread of diseases, are becoming a major issue associated with components of global environmental change (Confalonieri & McMichael 2006; Daszak et al. 2000; Derraik et al. 2007; Leisnham & Slaney 2009). Contributing to these human health threats is the role that climate variability and change, and extreme weather events, play in altering disease risk (Aron & Patz 2001; Cork et al. 2007; Ebi et al. 2005; Hennessy et al. 2007; Jones et al. 2008; Patz et al. 2005; Woodward et al. 2001). The role of climate variability and change is important as the process will compound the already significant burden of infectious diseases (e.g. vector-, food- and water-borne disease) on national economies and public health. Authorities need to be able to assess, anticipate and monitor human health vulnerability to climate variability and change, in order to plan for, or implement action to avoid, these eventualities. Climate change environmental health indicators (CCEHIs) provide one such tool to assess and monitor

human health vulnerability and measure the effectiveness of climate change adaptation and mitigation activities.

CCEHs are based on a known relationship between climate, an environmental exposure and health. They aim to enable the identification and analysis of the general consequences of climate variation and change on human health, and enable the inclusion of the myriad of possible impacts on natural and constructed systems that could have knock-on health effects. CCEHs will also provide baseline information for assessing and monitoring temporal and spatial variability of risks, enabling projection scenarios of how the current situation may evolve. Monitoring of human disease surveillance data has the potential to act as a warning system for ecosystem disruption and may be used to identify interventions for the preservation of ecologic and human health. Such an approach means that interventions can be applied higher up the causal chain than would have been possible based on environmental monitoring or health surveillance alone. Implementation of such interventions can improve ecological well-being which in turn will reduce the resultant burden of disease in humans (Cook et al. 2004).

Using the Driving force – Pressure – State – Exposure – Effect – Action (DPSEEA) framework, a set of New Zealand CCEHs is being developed and its utility as a tool to measure and monitor human health vulnerability, and the effectiveness of interventions for climate variability and change, is being explored. The DPSEEA framework was designed to support decision making on actions to reduce the burden of disease by describing environmental health problems from their root causes through to their health effects, and by identifying areas for intervention (Corvalán et al. 1999; Füssel & Klein 2004; WHO 1997). It is a hierarchical approach that links measurable indicators to environmentally caused diseases, and displays the various levels of action that can be undertaken to reduce environmental health impacts. Analytical EHs that quantify the impact at each step along the causal chain are particularly useful as they highlight where the most effective interventions can be aimed to protecting human health (Kjellström 1995).

## National climate policy and local adaptation planning: Comparisons across two continents

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Many of the earliest climate change responses were driven by local governments, under the guidance of international networks such as the ICLEI – Local Governments for Sustainability, which has been particularly influential in Australia. These responses typically began with local climate mitigation (greenhouse gas reduction) strategies, with some communities then progressing towards more specific adaptation plans (plans designed to reduce the negative impacts of already-entrained climate change). In the absence of State or National level policy requirements for climate change planning, the relationship between these early local action plans and the formal rules governing urban settlement planning and development has been loose.

For the most part, climate change planning remains a voluntary activity at the local level. For instance, in the relatively slow-adopting but high-emitting United States (U.S.) and Australia, formal obligations for considering climate change impacts during plan making and development assessment remain weak. Given this context, to what extent do differences in national or State climate policy frameworks influence local plans – for instance, in relation to the delicate balance between mitigation and adaptation goals? Given the voluntary nature of climate planning, do endogenous municipal factors – for instance exposure to risk, or socio-economic variables – seem to matter more than national or State policy settings?

This paper examines these questions by comparing national and State climate policy frameworks in the U.S. and Australia, focusing on the interface between central climate policy frameworks and local planning responses. Following a comparison of national policy frameworks, we select five case study matched-pairs of cities from Australia and the United States which have developed plans for both mitigation and adaptation, chosen to have similar size of municipality, socio-economics, and primary climate change challenges (for instance, coastal sea rise, drought, fire risk). We use content analysis of the plans to test the levels of similarity and difference between the choices the municipalities make in their plans. This research then is able to suggest whether situation (climate variables, size of municipality, socio-economic variables) matters more than national policy, at least as demonstrated through the selected case studies. We also examine whether there is a clear pattern of a preference for mitigation or adaptation actions by country, or other variable. In conclusion we reflect on the ways in which national policy for climate change affects local planning in the U.S and Australia.

## Climate change and extreme weather events: Adaptation to protect the health of our protection workforce

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Recognition that climate change poses a significant human health issue is widening throughout the health and policy sectors, as events unfold and modeling of the effects of predicted global warming emerges. Australia is regarded more vulnerable than most OECD countries to the effects of climate change and the potential health consequences are far reaching. Emerging by stealth or via catastrophic events, climate change will undoubtedly affect human health, either directly, or indirectly. We anticipate that a new climate will not necessarily bring new health risks, but rather more of the same, merely more widespread, more frequent, and in areas not previously exposed to such problems.

Australia is noted for its highly variable ‘natural’ climate, its heat, droughts and bushfires. Yet greater intensity

of extreme heatwaves, bushfires, storm events, coastal inundation and prolonged drying are heralded. Indeed, health consequences arising from the amplification of drought and drying, heatwaves and bushfires of recent years suggest that existing population health protection paradigm may be inadequate to meet tomorrow's needs.

Fires are familiar to Victoria, and have given rise to a vast network of responses, and post-fire inquiries designed to improve response functionality. The 2009 Victorian Royal Bushfire Commission unveiled substantial shortfalls in capacity to prepare the community, manage and respond, and these shortfalls contributed directly to significant loss of life, and livelihood. This salient lesson suggests that adaptation to climate change must therefore include thorough investigation of response systems to other of Australia's potential weather related emergencies. Complacency is misplaced under these new and intense climatic conditions, where existing systems can be so significantly overwhelmed, and where population health is so dependent.

The unprecedented cascade of events of early 2009 (heatwaves, fires, and then an influenza outbreak) stretched Emergency and Essential Services (EES) to their upper limit, and yet climate change scientists predict further exacerbation of climate extremes. The critical role of EES in protecting public health necessitates efforts to enhance and augment capability to ensure performance of their intended function at the required level.

A key element of these services is their staff, the people who provide emergency services (such as firefighters, energy providers, ambulance officers), and essential services (for example district nurses and community carers). Without their physical performance under duress, these services cannot operate. Extreme events, such as heatwaves delivers exceptional challenges, as the nature of their work means that they cannot absent themselves to tend their own or their family's needs. They cannot self-pace or reduce their output. Instead, their workload intensifies both volumetrically and in complexity, thereby amplifying their own exposures, and placing their own health at risk. Due the dependence on EES functionality during extreme events, population health risks escalate if these services falter.

Exercise or work in the heat, water loss or dehydration can reach proportions that impede heat dissipation and lead to heat stress with transient impaired performance of skilled sensorimotor, mental or vigilance tasks, or can severely compromise cardiovascular function and work capacity. Heat stroke is essentially failure of the regulatory mechanisms to withstand continued heat exposure, and has throughout history caused the death of thousands of soldiers, prisoners and workers.

With rising temperatures, the risk re-emerges for unprecedented heat exposure for EES workers. Exposures may be frequent. An additional challenge for these groups is that their work does not diminish, but rather intensifies during extreme events. Clouded judgment, as a consequence of heat stress, may result in poor decisions at critical moments and jeopardize the operation, or health of others. Motivation to continue in the service may place these workers at significant personal health risk, cognizant that self-pacing and reducing output may elevate risks to the populations they serve.

McMichael (2003) estimated that population mortality in Adelaide, Perth, Melbourne, Sydney and Brisbane could reach 2500 per year by 2020. Functional EESs are key to reducing this number, and preventing further morbidity.

This presentation will outline the specific risks facing Australian emergency and essential services and outline the process towards adaptation required to maintain functionality, protect the health of the workers, and the populations they serve during future extreme heat events predicted to increase under a warming climate.

## Mainstreaming Climate Change Issue in Bangladesh

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The vulnerability of Bangladesh due to climate change has been documented in IPCC reports. Researchers, scientific community and media have highlighted the impact of climate change in Bangladesh very clearly. As a positive response to the threat the country has signed of different climate protocols. The issue of upcoming climate change and its impact in Bangladesh and how to deal with it are very burning challenges for government as well as other development partners, NGOs and other stakeholders. Objective: The objective of the paper is to study how, within the year 2008-2009, the issue of climate change has been placed at the top priority by Government, UN Organizations, donors, development partners and NGOs of Bangladesh. Methodology: The paper has been developed on the basis of the published documents, reports, and different activities on climate change and vulnerability of Bangladesh by Government, UN Organizations, donors, development partners and NGOs of Bangladesh within 2008-2009. Results: Bangladesh Government has formed a Climate Change Cell (CCC) in 2006 and conducted a study on climate change and its impact on health in 2009. Government is attending all international conferences and presented the vulnerability of Bangladesh clearly and claimed effective cooperation from international community. Government has formed parliamentary committee for climate change and now ministers and Parliamentarians started talking in their meeting about climate change. In 2008, in a sudden, UNFPA Bangladesh has organized a policy dialogue on Climate change in collaboration with Department of Population Sciences, University of Dhaka. Recently UNFPA has released the State of World Population 2009 with a theme "Population, Gender, Climate". The Human Development Report 2007-2008 published by UNDP Bangladesh with a title -- Fighting climate change: Human solidarity in a divided world- Risks, Vulnerability and Adaptation in Bangladesh. FAO, along with DFID, UNDP, EC, and Government of Bangladesh has also published its report in 2008 on Community Based Adaptation in Action: A case study from Bangladesh (Improved Adaptive Capacity to Climate Change for Sustainable Livelihoods in the Agriculture

Sector). UNHCR is dealing with climate refugees in Bangladesh. USAID, Bangladesh has furnished its webpage with a title “Bangladesh - the Most Vulnerable Country to Global Climate Change”. The European Commission, Dhaka office has set a video clip in its web page with a title: Climate Change- a call to action. Under the new long-term strategic framework Strategy 2020, ADB focuses on responding to climate change as part of the broader agenda of environmentally sustainable growth in Asia and the Pacific. ActionAid Bangladesh, with the funding of Embassy of Denmark, implementing project on “Assistance to Local Communities on Climate Change Adaptation & Disaster Risk Reduction in Bangladesh” and organized a conference in November 2009. One of its prime objectives is to generate, document and disseminate critical knowledge on community based climate change adaptation for COP15. ICDDR,B is going to organize its 13th Annual Scientific Conference on Facing the Challenge of Climate Change. Bangladesh Center for Advanced Studies (BCAC) is doing huge research and has organized two conferences on Community Based Adaption. Bangladesh University of Engineering & Technology (BUET) has organized an International Conference on Climate Change Impact and Adaptation Strategies for Bangladesh in February 2009. University of Dhaka has also organized an international conference on Climate Change in 2009. So within the year 2008-2009 programs, projects, activities, reports, strategies of the Government of Bangladesh, different development partners, International/NGOs have replaced with the issue of climate change impact on Bangladesh.

## **Print Media and Climate Change in Bangladesh: The Missing Health Issue**

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In the context of recent climate change scenarios, Bangladesh is vulnerable to tropical cyclone, flooding, sea level rise, heat wave, cold wave, saltwater intrusion, water and vector borne diseases. Government and other stakeholders are concerned about the upcoming danger to the country posed by climate change. Print media can be an important agent of change in Bangladesh regarding climate change issues. In this article we analyzed the role of print media in highlighting climate change and health issues in the country.

To describe how media has covered climate change issues and its impact in Bangladesh.

Published online daily news reports, editorials, independent analysis, letters were collected from 14 Bangoli and 7 English newspapers for approximately two months from 20 September to 20 November 2009.

Content analysis was completed to evaluate the themes in relation to climate change coverage.

A total 117 reports on various issues of climate change and Bangladesh were found. On average, two reports were printed every day by the daily newspapers. Seventy seven percent of the reports concerned meetings in general of the Prime Minister or Ministers at home and abroad. The other 23 percent of the reports covered UN organizations' activities, NGO activities, Civil Society organized processions, roundtables, seminars and articles from climate experts in the country. The covered included climate change, CO2 emissions, ozone layer depletion, global warming, sea level rise, inundation of southern Bangladesh, , emergence of climate refugees, salt water intrusion and reductions in food production. Health-related issues such as the burden of diseases—what proportion people are exposed to climate change and incidence of waterborne, vector borne diseases, have not been covered within the reports and was likewise missing in the speech of the Head of the State and other stakeholders such as development partners, NGOs. Climatic variability can have a strong impact on health and needs to be highlighted in print media. Heat, contamination of water, shortage of water, increased salinity, shortage of food and tidal surges may have important impacts on health.

Coverage of reports on climate change is deficient. None of the daily newspapers has done any independent research on climate change and its impact on health in Bangladesh. Special issues on climate change, editorials and round table discussions with experts are insufficient within the context of the problem. As a result, there are no strategic plans regarding the management of or adaptation to climate change issues in Bangladesh. Print media has the potential to influence climate change policies through independent research, roundtable meeting with development partners, UN bodies, and can highlight the damages up to the need.

## **Strengthening the Link Between Climate Change Adaptation and National Development Plans: Lessons from the Case of Population in NAPAs**

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Adaptation Programmes of Action (NAPAs) were established in 2001 to help Least Developed Countries (LDCs) and Small Island States with immediate and pressing adaptation needs. As climate change adaptation planning moves to longer-term approaches it is instructive to review the NAPA process and examine how well it was linked to national development planning. This paper reviews 41 NAPAs submitted to the UNFCCC, to assess the process in terms of integration with countries' national development planning. We use the example of population as an issue related to both climate change and national development to assess how it is addressed as part of LDCs' adaptation and national development agendas.

Population growth in the developing world is increasing the scale of vulnerability to the projected impacts of climate change. Twenty-seven of the 49 LDCs are projected to at least double their current population by 2050. Slower population growth has been identified as a factor that can contribute to development and achievement of the MDG, the world's agreed-on targets

to reduce poverty. Although though all the NAPAs contain a section on linkages with national development plans, the two are generally not well aligned. Countries recognize population pressure as an issue related to the ability to cope with climate change and as a factor hindering progress in meeting development goals, yet it is not well incorporated into either adaptation planning or in national development strategies. Thirty-seven of the 41 link high and rapid population growth to climate change. Moreover, six NAPAs clearly state that slowing population growth or investments in reproductive health/family planning (RH/FP) should be considered among the country's priority adaptation actions. Furthermore, two NAPAs actually propose a project with components of RH/FP among their priority adaptation interventions, although none of them has yet been funded.

Structural factors hamper better alignment between climate change adaptation and national development planning. The current structure of ministries of meteorology and environment being in charge of adaptation programming and ministries of planning in charge of national development planning does not facilitate coordination. Countries need alternate structures that link the two, perhaps through national commissions located in offices of presidents or prime ministers. Guidance and funding from global sources must reinforce the need to address adaptation in the context of national development and the need to ensure that development plans incorporate climate change. As countries develop longer-term adaptation strategies, a mix of short- and longer-term projects that involve participation across development sectors—including social sectors that are currently lacking in the global architecture for climate change—is important to ensure that the range of people's needs related to adaptation are met. Adaptation strategies should strengthen both social (community) and human (individual) capital. Finally, attention to population, including through rights-based, voluntary FP/RH and other actions to reduce unintended pregnancy such as girl's education, promoting gender equity and a focus on youth, should be included in the harmonized longer-term adaptation strategies and national development plans.

## Linking Population, Fertility and Family Planning with Adaptation to Climate Change: Views from Ethiopia

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The unfolding effects of global climate change are being felt disproportionately in the world's poorest countries. Many of the hardest hit countries also face rapid population growth, with their populations on track to double by 2050. This rapid increase in the population is likely to exacerbate the effects of climate change. Scant research exists to link these issues together. Within the "Impacts, Adaptation and Vulnerability" literature, few, if any, studies relate population and fertility with vulnerability, resilience and adaptation to climate change. Furthermore, the role of women in adaptation and coping strategies has also been underrepresented in existing literature. This study presents findings from research to investigate how people in Ethiopia, hard hit by the effects of climate change, relate their experiences with changes in climate to various factors affecting their ability to adapt. Ethiopia is extremely vulnerable to the impacts of climate change due to social, economic and environmental factors. In particular, high levels of poverty, rapid population growth, a high level of reliance on rain-fed agriculture, high levels of environmental degradation, chronic food insecurity and frequent natural drought cycles increase climate change vulnerability in this country. Ethiopia's 2007 census measured the population as 74 million, growing at a rate of 2.6 percent annually, and expected to more than double by 2050.

The 2008-2009 study included in-depth interviews (IDIs) with national-level and local policymakers and government representatives, community leaders, and civil society groups as well as IDIs and focus group discussions (FGDs) with men and women living in the Oromia and the Southern Nations, Nationalities and People's regions. The study was conducted in peri-urban and rural pastoralist and agricultural areas. The study included 12 FGD conducted separately with 48 men and 48 women, 24 IDI with community members and leaders and 14 IDI with policymakers, government representatives and other key leaders.

Women and men from the two areas described the increasing challenges they face in adapting to climate change. They, along with the community leaders and government representatives, recounted how rising temperatures, more frequent draughts and, paradoxically, increased flooding, receding agricultural grazing land and diminishing forests are making it more difficult for their families and communities to cope. These reflections on increasing hardship are coming from people who are accustomed to enduring struggle to survive. They link population pressure to the effects of climate change and report that families should consider having less children to avoid as much hardship in making a living and in utilizing natural resources for survival. They highlighted the particular vulnerabilities of women and children. They spoke of communities coming together to promote coping strategies and the need for government assistance in the face of increasing frequency of adverse events caused by the effects of climate change.

This research leads to the following recommendations for Ethiopia, donors, the UN Framework Convention on Climate Change (UNFCCC, Germany) and researchers. 1) Support longer-term integrated approaches to climate change adaptation that build on people's expressed needs, and strengthen community-based adaptation strategies to include expanding access to reproductive health and family planning services. 2) Give more high-level policy support to Ethiopia's reproductive health and family planning programs to reduce the high unmet need for contraception and to improve maternal and child health. The government of Ethiopia should review its commitment to reproductive health and family planning. High-level policy support is critical to ensuring that these services are available to women and men who want to use them. Currently one-third



of women in Ethiopia say they want to postpone or stop childbearing but are not using contraception, leading to millions of unintended pregnancies. Moreover, the prevailing perception that women and children are currently and will continue to be the populations most affected by climate changes necessitates an increased focus on comprehensive maternal and child health programs. 3) Include population, fertility and access to family planning in future IAV studies. This study has paved the way in showing that many Ethiopians do think of population pressure and family size when they conceptualize their ability and the ability of their communities to adapt to climate change. Future studies to assess resilience and adaptive capacity should include components on population, fertility, reproductive health and access to family planning services.

## How can we engage with people about climate change adaptation?

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Humans are adaptable. As a race, we have adapted to many changes including the invention of the motor vehicle, modern sanitation and using the internet to search for information. However, the concept of adapting to climate change is arguably not getting as much traction as it could be in regards to engagement with the science.

According to Google Trends, terms such as 'climate change adaption' registered as significant in worldwide online search traffic in 2007. Although this only acknowledges Google search traffic and there are many other channels of communication, it is valuable to explore this statistic as roughly 1.7 billion people were using the internet by 2001.

Add to this the fact that the term 'global warming' gets almost three times the number of searches for 'climate change' in countries like India, United States and Canada.

If dialogue around the topic of 'adapting to climate change' is still in its infancy, how should scientists, policy makers and communicators talk about the work they are doing? If adaptation decisions need to be made, how can scientists engage with audiences in a meaningful way to highlight adaptation options?

This poster will examine the framing of adaptation science to be relevant to general audiences.

Applying a lens of adaptation science to climate-related events and consequences that all people can relate to provides a fruitful way to progress the discussion from impacts to adaptation research and adaptation options. However, taking this approach can arguably be a tricky path as society can judge harshly an organisation or expert who is seen to be taking advantage of a traumatic situation, like a disease outbreak or a cyclone.

In February 2009, devastating bushfires occurred in Victoria. The extreme fire weather conditions that occurred during January and February were partly due to very high temperatures following a 50 year warming trend, and very dry conditions following 12 years of below-average rainfall. Research done by CSIRO shows that by 2020, it is expected that Australia will see a greater number of extreme fire weather days, longer fire seasons and a greater potential for multiple fire events like those seen in the Victorian fires.

CSIRO's work in the area of climate projections, bushfire behaviour and bushfire effects on urban areas featured in the media. Information was sought by a range of audiences including the general public and policy agencies. This communication activity will be examined to draw out how climate change and adaptation concepts featured in the discourse.

How can science organisations encourage engagement with adaptation information? Can acute events, like the Victorian bushfires, help to encourage attention to the science and implementation of climate change adaptation options?

## Masdar City's integrated approach to sustainability and world's first zero carbon city

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The Masdar Initiative is Abu Dhabi's multi-faceted, multi-billion dollar investment designed to establish a centre which will be the global focus of innovative technologies in renewable and alternative energies as well as sustainable design. The city will rely entirely on solar and renewable energy sources, with a zero-carbon, zero-waste ecology, which will set the global blueprint for sustainable development.

Once constructed, Masdar City's water system will use total water management principles to treat all parts of the water cycle as potential resources. This approach includes aggressive use of a variety of water sources, including groundwater, seawater, surface runoff, rainwater harvesting, greywater reuse, blackwater reuse, and resource recovery for treatment and management of byproducts.

Future cities will need to be envisioned, planned, and developed based on a systems approach. This moves past sub-optimization of different aspects of the city; which have lead to inefficiencies and non-sustainable infrastructure. Scenario development and technology innovation can be tested and selections made based on current and future needs. Using systems modeling and other tools Masdar is able to optimise sources of supply and level of treatment required for each use, recoverable resources, energy demands, construction timing, and the carbon footprint.

Masdar envisions a technology roadmap to attract and develop innovative renewable water technologies. Several of the technologies to be used are experimental and require pilot testing to establish technical and economic feasibility. As many as 9 separate water conveyance systems will be employed at Masdar City to serve 12 defined uses over at least 3 distinct treatment levels. Planning for such intensive management requires infrastructure and technology development to meet ultimate goals.

Masdar presents a unique opportunity in its ability to demonstrate innovative water technologies and concepts. The vision, tools and practical lessons learnt from the Masdar experience can be readily translated to the Australian situation. The successful integration of water, energy and waste was achieved at Masdar through innovative planning, design and procurement. The models and tools can be readily adapted for new water infrastructure or rejuvenation of existing infrastructure in Australia.

## **Vulnerability of coastal island and adaptation measures for cyclonic storm surge and climate change in the coastal area of Bangladesh**

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Bangladesh is the most vulnerable country to the impacts of global warming induced accelerated sea level rise due to its geographical location. It has about 710 km long coastline where 28% of total people live (PDO-ICZMP 2004). Due to its geophysical setting Bangladesh coast is frequently visited by the cyclone-induced storm surge. As islands are exposed to the sea these are the most vulnerable to sea level rise and cyclonic storm surge both. During the last 48 years nineteen (19) major cyclones devastated the coastal area, where SIDR, a severe cyclone that hit the coast of Bangladesh in 2007, had highest wind speed. The assessment of impact of climate change induced cyclonic storm surge and evaluation of potential adaptation measures requires use of scientifically based and tested state-of-the-art mathematical modelling tools. This paper presents the potential impacts of climate change induced cyclonic storm surge on inundation depth and current speed which is essential for assessing the vulnerability of coastal embankment. Two selected islands namely Sandwip and Hatiya have been considered for detailed investigation. Adaptation measures such as mangrove afforestation, cyclone shelter and raising of embankment crest level have also been analyzed.

In this study severe cyclone like SIDR has been selected to assess the vulnerability of selected islands as it has highest wind speed compared to other cyclones. The study also shows that the wind speed of cyclonic storm surge is increasing gradually from the analysis of historical wind speed data. Two different local models were developed for two selected islands and three different tracks were taken for each island one is to the north, one is to the middle and one is to the south of the island. It was found that if the cyclone makes landfall to the north of the island it creates the most surge height. According to the 4th IPCC report maximum Sea Level Rise (SLR) will be 59 cm by 2100 whereas according to the Synthesis Report of Copenhagen Summit on March 2009 maximum SLR will be 1±0.5m by 2100. Model result shows that if SIDR type cyclone comes with SLR 0.59m and 1.0m during high tide maximum surge height will be 6.5 m and 6.82 m in Sandwip island and 9.2 m and 9.5 m in Hatiya island respectively. According to 4th IPCC report, if temperature is increased by 2oC wind speed will be increased by 10%. If the same cyclone comes with 10% increased wind speed during high tide with 59 cm SLR then surge height may increase by 0.9 m for both the islands.

Mangrove afforestation was assessed as an adaptation measure in the study since its roots and trunks system can dissipate energy of cyclonic storm surge. The roots and trunks system of Mangrove creates resistance to the flow and it has been incorporated in the model as an equivalent Manning number. It has been found that 400m and 600 m width of Mangrove can reduce surge height by 15 cm and 20 cm respectively whereas it reduces current speed to one-third. As it reduces the current speed to a larger extent reduces the risk of erosion and failure of embankment. Both Sandwip and Hatiya have coastal embankment but it is not sufficient to prevent overtopping. If similar cyclone like SIDR comes during high tide with 1m SLR, embankment crest level needs to be raised by 7.02m for Sandwip and 9.7m for Hatiya. There are numbers of cyclone shelters in both the islands but it needs redesigning considering SLR and increase of wind speed of cyclonic storm surge.

## **Adjusting risk management for a changing climate: Experiences with policy makers, dryland farmers and the wine grape industry in South Australia**

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Predictions are not instructions that people simply follow to make better decisions. They are pieces of an intricate puzzle that may sometimes contribute to improved decisions. Daniel Sarewitz. Nature 463: 2010

This paper describes lessons from projects with policy makers, dryland farmers and wine grape growers in South Australia from 2004 to the present. Each project started with requests for detailed downscaled climate change projections and developed into more complex conversations about risk management. The framework for risk management from the Australian New Zealand Standard and recommended by the Australian Department of Climate Change has a number of logical steps: Establish the context, identify, analyse, and evaluate the risks before treating the risk. Early in this process is the recommendation to get climate change projections. This is a reasonable request whereby decision makers say "if you can't tell me what the climate will be like in the future, how can you expect us to plan adaptation strategies?"

There is an inevitable mismatch between the level of spatial and temporal precision that decision makers want and that delivered by climate science. This is especially the case for precipitation and stream flow where the envelope of future projections is wide, as is the envelope of past experience due to annual and decadal variability. For the duration of the projects described in this paper, southern Australia was in an extended drought which was consistent with climate change projections. However in 2009 grain growers in one of the study regions had one of their wettest seasons on record. Appropriate practice changes for a constant drought may be depressing but relatively straightforward – shift from cropping to low input, low output extensive grazing. It is much more challenging to consider the appropriate practices that are resilient to the poor seasons (which are expected more often) but still able to respond to the rarer good season. However, we found smart thinking about flexibility, delaying key decisions and keeping options open.

While it is possible to produce high resolution climate maps of South Australian regions in 2030, 2050 and 2070, these bring to mind Monmonier's text "How to Lie with Maps" where he reminds us that any map is single representation of a number of possible maps that could have been produced for the same situation. If this is true of maps of current climate, it is even truer of maps of future climate. The probabilistic approach in the Climate Change in Australia report (CSIRO and BoM 2007) usefully conveys that there are 9 maps of the future depending on three levels of emission and model uncertainty

Many (but not all) of the participants concluded that detailed climate change projections were "nice to have, but not essential to the process of planning for a warmer and water constrained future". Some participants noted that detailed projections of the future could be a liability, a form of mal-adaptation where rather than planning for a range of futures attention was focussed on a single outcome.

The paper concludes that risk management is a sensible basis to discuss behaviour change required for adapting to climate change. Rural industries and policy makers are highly aware of risks associated with climate variability (droughts, floods and associated natural causes such as El Nino). Unlike most in urban communities there is rapid feedback from the climate to their livelihoods. This lived experience and knowledge of climate variability can be a barrier to discussion of climate change where people dismiss the reality or the threat of climate change with an argument that as they can cope with variability, climate change will be less of a problem. There is a paradox whereby climate change starts to erode the value of local knowledge about climate, yet this local knowledge is perhaps the greatest asset for the coming decades. The paper shows an approach that acknowledges and respects the way people are practicing risk management in the current climate and how they might adjust it in a changing climate.

## **Circling from Virtuous to Vicious: How the IPCC stopped helping and began hindering adaptive behaviour**

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In the unfolding global tragedy of our planetary commons, painfully depicted in Copenhagen in December 2009, national and international leaders are risking the future of the Earth by policy failure; the mass media highlights ethically bankrupt behaviours but fails to demand alternatives; and the assessment instrument of the UNFCCC (United Nations Framework Convention on Climate Change), the Intergovernmental Panel on Climate Change (IPCC), has metamorphosed from a useful policy tool into one that, at best, encourages no action and, at worst, justifies bad responses. Climate change entered a different regime in 2007 with the publication of the IPCC Fourth Assessment Report and the joint award of the Nobel Peace Prize to Al Gore and the IPCC. Policy no longer asked "whether" human activities are changing the climate but the more urgent questions of: "how fast?" "with what impacts?" and "demanding what responses?" Climate change became a risk management problem in which the approach, structure and character of the IPCC, horribly transformed by positive media feedback, is now a hindrance. In December 2007 the Director of the WCRP advised the heads of the two UN agencies that jointly sponsor the IPCC to close it because it had "completed its task of assessing the unique challenge that faces humanity". Climate change is: real and accelerating; derived from use of 'free' goods; generationally-postponed (affects grandchildren); managed by a convention (UNFCCC) uniquely initiated by scientists and NGOs rather than nations; wealth creating; and media titillating. In this paper I identify factors that have changed the IPCC from a well-intentioned peer-reviewed research assessment into a system that is impeding urgent climate action. The top ten challenges for the IPCC are: its linear structure (first 'science', then 'impacts' and, finally, 'mitigation'); peer review (poorly defined and facing an information avalanche: 1,200 exabytes in 2010); protracted gestation (fifth assessment due in 2014 even though the fourth was out-of-date in January 2007); mandated incapacity to make policy statements; no-preference display of results (failure to "out" bad models); model intercomparison project paradox (gradual community-wide performance improvement masks fundamental failures such as non-conservation); cost of participation vying with national and laboratory kudos; consensus requirement manifested as fear of highlighting shortcomings and failures (in models and observations); unknown(able) fatness of the probability distribution function tail; and poor handling of published errors and a few "awful emails". Climate prediction has languished near the top of local 'highs' in predictive skill for years and, while there are possible routes to improving the current models, few if any groups seem poised to pursue these (Green, 2006). IPCC's failings are well known among participants (Doherty et al., 2009): "adding complexity to models, when some basic elements are not working right (e.g. the hydrological cycle), is not sound science;" "until and unless major (climate) oscillations can be predicted to the extent that they are predictable, regional climate is not a well defined problem. It may never be. If that is the case, then climate science must say so" (Henderson-Sellers, 2008). Positive feedback in the media pushed public perception past a tipping point around January 2010, such that future assessments might be argued to be delivering

a deceptive view of what we know and even, perhaps, what we can know (Nature V464, no.7288, 11 March 2010). Forty years ago, Albert Crewe said: "It is up to the scientific community to point out where they can help....government cannot be expected to seek our advice and help, because they are much more accustomed to solving problems by new legislation...." and, "Perhaps better solutions exist... (but) until we can make ourselves heard.... problems are in danger of being grossly underestimated". Climate policy is now a choice between a bad or a very bad future (Stern, 2006; Garnaut, 2008). The debacle of COP-15 was not caused by serious challenges to the fact of global warming nor to the need for action but rather by the inability to reach politically acceptable agreements. I argue that faced by an almost universal preference for obfuscation and denial (Hamilton, 2010), prioritising climate change responses to try to constrain the potential for really dangerous outcomes, that cannot currently be ruled out with less than a 10% chance, is not aided by further research assessments.

## **Criteria and Indicators for Assessing Vulnerability to Climate Change and Developing Participatory Adaptation Measures: Javan Rhino Conservation, Ujung Kulon National Park, Indonesia**

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Indonesia, which hosts some of the richest biodiversity in the world, has been called a mega-biodiversity region. To conserve this biodiversity, the government has designated forested biodiversity-rich areas as national parks. One example is the 122,956-hectare Ujung Kulon National Park, which comprises lowland rainforests and mangrove ecosystems. The park is also the habitat of 40–60 critically endangered Javan rhinos (*Rhinoceros sondaicus*). The park, a UNESCO World Heritage Site, is in Pandeglang District, West Java Province, Indonesia.

The Javan rhino and its forest habitat are among the natural systems being affected by climate change. An analysis of temperatures from 1980 to 2008 shows that the temperature at Ujung Kulon ranges between 25.6 °C and 26.8 °C. According to IPCC scenarios of A2, B1 and A1B, the temperature may increase by approximately 1.950 °C, 2.675 °C and 4.265 °C, respectively, by 2100 compared with 2000. Scenario A1B predicts that January precipitation will increase by 139 mm but scenarios A2 and B1 predict a precipitation decrease of 92 mm and 78 mm, respectively. These may result in floods or droughts in the area, respectively. Higher temperatures will increase the evaporation and transpiration rate of the forest area. At the same time, the temperature rise will increase the rhino's need to wallow. The predicted future climate is likely to threaten the Javan rhino conservation program.

A system's vulnerability to climate change is influenced by its exposure, sensitivity and adaptive capacity. Assessing these variables in any system can help stakeholders identify and prioritise adaptation options. As the concepts of vulnerability to climate change and adaptation measures are new for stakeholders at the local level, tools for facilitating participatory knowledge sharing on climate change, especially on vulnerability and adaptation measures, are needed.

This paper reviews the application of criteria and indicators (C&I) for assessing the vulnerability of the Javan rhino and its forest habitat to climate change, informing local stakeholders about vulnerability to climate change and identifying adaptation options.

We first developed hypothetical socio-ecological principles and criteria (P&C) for the vulnerability assessment. Working with WWF-Indonesia, we organised a focus group discussion at the local level (Pandeglang District, West Java Province) for participants from the national park authority, local government, NGOs, local communities and universities. Experts from different disciplines, including meteorology, ecology, forestry, veterinary science, tourism and community empowerment also joined the discussion. The focus group was designed to discuss the P&C, adapt them based on group input and develop specific indicators for the climate change vulnerability of the Javan rhino and its forest habitat.

The exercise showed that local people around the park had not been adequately exposed to information on issues related to climate change, climate change impact and climate change adaptation. The P&C is a useful tool for communicating and discussing climate change vulnerability at the local level. The tool also enabled local stakeholders to identify climate change vulnerability indicators and potential adaptation options using participatory and better data evaluation methods.

## **An ocean acidification overview: effects on marine organisms and implications for the future**

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Almost one-third of anthropogenic carbon dioxide (CO<sub>2</sub>) that has entered the atmosphere has been absorbed by the ocean. Dissolution of CO<sub>2</sub> in seawater affects the seawater chemistry, increasing concentrations of hydrogen ions (reducing pH) and bicarbonate ions, and decreasing carbonate ion concentrations (potentially affecting calcification).

Increased atmospheric CO<sub>2</sub> has already resulted in changes in ocean chemistry, with global surface ocean pH already 0.1 unit lower than pre-industrial values and a 10% reduction in surface carbonate concentrations in the tropics. Global surface ocean pH is projected to decrease a further 0.3–0.4 units by 2100, with a 25% reduction in the saturation states of calcite and aragonite, the key mineral forms of calcium carbonate used by organisms such as shellfish and corals to form their shells and skeletons. These predicted changes could have a major impact on marine organisms, potentially affecting many fundamental biological processes including calcification, physiology, growth, reproduction and early development. However, laboratory studies to date show a variety of responses including a negative, positive, or no effect.

This presentation provides an overview of ocean acidification and its impacts on marine organisms, including a brief explanation of the chemical and biological processes involved, the range of responses obtained in laboratory and mesocosm studies, the potential impacts at the community scale, and future research needs.

## Measuring and monitoring climate change adaptation: developing a system for long-term biodiversity and ecosystem research.

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To date climate change adaptation research has focussed on projects that use existing national datasets on the distribution of species to predict range shifts and changes in the frequency of occurrence of these species. While these provide an indication of the likely consequences of climate change few are able to assess the consequences on ecosystem functioning. Indeed many of these modelling studies call for more detailed monitoring and the establishment of biodiversity monitoring networks. There is therefore an urgent need to establish long-term ecological research (LTER) programs that will provide baseline information necessary to measure biodiversity and ecosystem response to both short-term management activities and long-term impacts such as climate change. In Australia the commonwealth government is currently establishing a Terrestrial Ecosystem Research Network to provide infrastructure for measuring and monitoring ecosystem condition and climate change adaptation. Here we present a system for LTER research we have initiated in Australia (<http://www.griffith.edu.au/ppbio>) following the successful application of the PPBio Program by the Ministry of Science in Brazil (<http://ppbio.inpa.gov.br/Eng/public/>). The PPBio system provides a platform for standardised biodiversity and ecosystem research at the mesoscale that facilitates international comparisons of ecosystem condition and global response to climate change. The PPBio system provides a platform for tackling current challenges enabling managers to implement effective adaptation strategies, and also acts as a sound basis for future research needs.

## Adaptation and Development: Whose Goals and Priorities Count?

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It has been argued that adaptation to climate change should be integrated with development activities, and that it is time to pursue its 'mainstreaming' within such programmes (Burton 2009). Though, in principle, this would seem to be a crucially important step to take, in order to ensure that adaptation is not a mere afterthought, left for a time at which all other goals have been achieved, the proposal should be considered with some caution. One potential problem that has been noted is that decision-makers may welcome the combination of adaptation and development as a way to avoid assigning substantial new resources to adaptation (Huq and Reid 2009). Moreover, current developmental frameworks might become unsustainable given the magnitude and the dynamics of climatic changes, which could impede sustainable development efforts (Heyd and Brooks 2009).

There are also more fundamental problems to consider, however, since the impact of development on the poor often has been and is problematic because, all too often, development has favoured those who are already relatively better off. This is because the latter have greater capacity to absorb aid, be it technological innovation, financial incentives or educational opportunities. This pattern, unfortunately, reappears when the focus is on development with a focus on adaptation (see e.g., Kates 2009). It has been pointed out, for example, that the development of infrastructures, such as water reservoirs for electricity generation or irrigation, promoted in the name of adaptation to climate change, may bring about a net decrease in well-being to local rural populations, who bear the brunt of flooded valleys and interference in traditional livelihoods, while benefitting relatively distant (generally urban) populations.

In the past it has been assumed that these types of unfortunate mishaps in the delivery of development can, and should, be corrected by more closely targeting the least well-off for the kinds of changes from which they can authentically benefit. It will be argued here from the perspective of human security, with support from Amartya Sen's capability approach, that these impacts on the poor may be understood, at least partially, as a result of neglect for the fundamental capability of self-determination and agency (Sen 1985, 1993; Clark 2006). From this perspective, even if development succeeds in the delivery of a certain goods (such as satisfaction of basic needs, improved incomes, health, security, and so on) it remains problematic if it is carried out without consideration of capabilities for self-determination of those affected.

Hence, even development that claims to take a 'participatory' approach may be subject to critique if participation is mere tokenism and decisions are made without, at least, the informed, voluntary endorsement of those affected. From this vantage point, couplings of adaptation to development should seek to preserve and enhance capabilities for self-determination. Ideally action on adaptation should not only be agreeable to those affected, but guided by endogenously arrived at goals and priorities insofar as possible, which is why local preferences for adaptation need to be considered (Mustelin et al. 2009).

We propose, therefore, that endogenous-led adaptation is superior to its alternatives in at least two ways. First, endogenous-led, adaptation as such already constitutes an achievement in human security since it exemplifies the crucially important capability for self-determination. Second, endogenous-led adaptation is more successful in increasing resilience than other approaches. This paper will illustrate this by reference to a case of adaptation to

landslide hazards based on endogenously generated social capital (Aldunce et al. forthcoming). We conclude that the goals and priorities of those who are affected the most should especially be taken into account, and that a focus on the capability for self-determination is fundamental in the pursuit of human security in the context of adaptation.

## Assessments of Impacts and Adaptations to Climate Change in Japan using an integrated assessment model, AIM/Impact Policy

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The authors have been developing an integrated assessment model (AIM/Impact[Policy]), the purpose of which is to perform integrated assessments of the greenhouse gas (GHG) emission paths, GHG concentrations, temperature increases, and sectoral impacts at future points in time that are anticipated when setting and attaining climate stabilization targets such as the upper bounds of atmospheric GHG concentrations and the upper bound of global mean temperature increase.

AIM/Impact[Policy] can be roughly divided into the GHG emission projection model group, and the impact assessment and adaptation model. Using an energy-economic model incorporated into the GHG emission projection part, the paths of global GHG emissions under various restrictions (global mean GHG concentration, etc.) are estimated by optimization calculations. Here, optimization means that the total obtained by converting the level of utility (consumption) per person at each point of time in the future to the present value using a discount rate, and weighted by population, is optimized in the targeted period. Moreover, using a simplified climate model implemented in the energy-economic model, changes in global mean temperature under the various restrictions mentioned above are calculated and serve as the input data for the impact assessment and adaptation model.

In the AIM/Impact[Policy], detailed impact assessments which place a large calculation burden on computer are not carried out. Rather, numerous simulations are performed outside this model beforehand with different combinations of prescribed changes in climate/non-climate factors (i.e. intensive sensitivity analysis) and the results of the simulations are averaged for each nation/prefecture and stored as look-up tables to be implemented in this model (we call them "impact response functions").

The impact assessment procedure using AIM/Impact[Policy] is as follows. When a global mean temperature change scenario is transferred from the energy-economic model of AIM/Impact[Policy], first a climate scenario by country or by prefecture is created with pattern scaling. For the pattern scaling, AIM/Impact[Policy] is equipped with the climate change database, in which country/prefecture-mean of change in climate variables projected by GCM is archived as look-up tables. GCM outputs evaluated in IPCC-AR4 as well as older GCM outputs have been included in the database so far. Then, by inputting the climate scenario by country or by prefecture into the impact functions by field prepared for each country/region, the impacts by field for each country or region are calculated.

In this study, impacts and adaptations of global warming by field under the Business as Usual (BaU) scenario and two scenarios which GHG concentrations are stabilized at 450 ppm and 550 ppm in terms of carbon dioxide (CO<sub>2</sub>) equivalent concentration (stabilization scenarios) were carried out focusing on flood damage and rice yield in Japan.

With regard to flooded area, the maximum daily precipitation during a year was adopted as a climatic variable. In the flood calculations, it is assumed that Japan's average level of protection corresponds to that for rainfall with a return period of 50 years, and that no damage occurs in the case of rainfall with a lower intensity than that. An increase in flooded area and flood damage cost are expected due to increases in rainfall intensity and the frequency of rainfall with strong intensity. In order to assess the adaptation strategies, changes of protection level are investigated.

With regard to rice yields, changes in accumulated insolation in the warm season (May-October), mean temperature change in summer (July, August), and mean temperature change and CO<sub>2</sub> concentration in the warm season excluding summer (May, June, September, October) were adopted as climatic variables. The rice yield shows a different trend from food damage. Productivity is found to improve as the temperature increases up to around 2°C, after which it turns to a decreasing trend. Up to around 3°C there is no decline in productivity compared with the present condition, but as the temperature increases further, productivity falls to below the present level. Hence, an increase in rice yield can be initially expected due to global warming. With further rises in temperature, however, the trend is expected to reverse to a decrease in yield together with a projected increase in interannual variations in yield due to the relationship between temperature and sterility rate. In order to assess the adaptation strategies, changes of planting date are investigated.

## Assessing stress to ecosystems caused by future climate change to inform broad adaptation policy and planning at a continental scale

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Conservation policy and planning for climate change adaptation at a national level requires broad analyses of future impact that are not limited by a small number of species centric models nor by restricted spatial extent. Our robust approach focuses less on detailed future biodiversity patterns, such as habitat models of many species, and more on ecologically significant

environmental change in a broad sense. We do this by transforming spatial climate change projections into ecologically relevant environmental change projections that use ecological data with a continental scope. This approach assesses how climatic change may translate into ecological change or stress at very large scales and applied these to Australia as a whole.

One approach uses continental maps of vegetation or biomes, defined by ecosystem structure and broad plant species dominance, to classify environments - including but not restricted to climate – according to these broad ecological categories. We then assessed, using a variety of metrics, how environments defined by these classes change in extent and spatial distribution in future climates and how this change may translate into ecological stress and/or change.

## Networking across global marine 'hotspots'

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Marine natural resources, such as fisheries, provide significant social and economic benefits globally, and early warning of changes in resource availability is required to minimise social tensions (e.g. increased poverty and changes in resource allocation) and societal costs (e.g. income redistribution and government restructuring). Additionally, prior knowledge of how and when resources may alter will also facilitate the development, application and evaluation of adaptation options for fisheries. Based on identification of the world's marine climate change hotspots we are coordinating a global network of researchers, managers and policy makers. By sharing information currently emerging on climate change impacts in regional global warming 'hotspots', typified by predicted above average ocean temperature increases, we will provide the potential for early warning and evidence of the biological response by natural resources to climate change. Examination of hotspots provides us with the first opportunities to detect the nature and pace of climate change induced impacts on our marine ecosystems, separate the impacts of synergistic stressors like climate and fishing, and also offers the strongest prospect for validating species or ecosystem model projections against reality. With sufficient interdisciplinary research and information, these hotspots will also provide the first opportunity for evaluation of adaptation options in fishery systems. A network of scientists working in global marine hotspots, where information is integrated and synthesized, contrasted and compared across locations, can best address the challenges of climate change. Collaboration at a global scale is necessary to develop knowledge for managers to make decisions and for increased community understanding of the need for these decisions, including increased confidence in the models and adaptation options being proposed.

## Adaptation by the Australian mining industry in response to climate change

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As with other primary industries, mining is affected by climate variability and extreme events. Therefore, climate change, which typically equates to altered conditions or more extreme events in Australia, will impact on the mining industry. Potential impacts, along with adaptation options are being reviewed as part of a broader study within CSIRO that is also investigating impact and adaptation by climate change and climate extremes by associated mining communities. This paper outlines the need for such a study and presents findings from publically available reviews previously performed, in addition to results from an expert workshop that explored the operational risks of climate change on mining. The research aims to develop a knowledge platform from which climate adaptation options for the mining industry can be identified and assessed for future adoption.

As some aspects of mine operation and design decisions are already affected by climate related events, the industry successfully reacts to changes of conditions, whether climatic or geologically related; it is therefore well accustomed to reactive adaptation strategies. As climate change increases or modifies climate-related risks to mines, effective climate risk-management strategies will need to be adopted at an early stage of the mining process to reduce unwanted impacts. Information about future climate changes and their impacts is therefore essential to assist mines tailor specific risk management and adaption strategies.

At present, very little work has been conducted to ascertain the level of risk the Australian mining industry faces from climate change and changes to patterns in extreme events. One such study in Australia on the ASX100 companies (2006) identified that coal exporters, and those who rely on water and port facilities are most at risk from climate change impacts. A study of climate change adaptations in the Canadian mining industry (2009) indicated that although some companies view the affects of climate extremes as a threat, few are acting on this; additionally, a poor understanding of climate risks and their implications may reduce future adaptation activity within the industry.

The workshop conducted by CSIRO identified vulnerabilities across the whole of the mining life-cycle, particularly related to water and energy security, infrastructure tolerances, climate education and in particular the production stage of the mining life-cycle. These will be investigated further throughout this project, together with the increased geohazards (e.g. landslides) and the impact on local communities. Given the limited prior analyses there is a need to explore this issue more fully. Hence, we are performing a systematic assessment of mining processes and related activities to develop a balanced risk management approach to adaptation.

As a four phase project, the next phase will identify case studies through workshops and industry surveys followed by industry supported case studies in and around the mines. In the final phase, a synthesis of results will be developed to provide adaptation options and advice to mines and communities wishing to assess their own vulnerabilities and adapt to climate change.

## Victorian Adaptation Responses to Climate Change and Human Health

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Human health is dependent on the built and natural environment and many of the predicted climate and environmental changes that will occur as a result of human-induced climate change will impact directly (heat-related deaths, death due to extreme weather events) or through indirect pathways (changes to crop yields, vector-borne diseases, food-borne illness) on human health. Social and economic changes will also result in adverse health effects.

Recent and current events in Australia have provided a glimpse into the future with lengthy and extreme drought, impacts on water supplies, unprecedented heatwaves, devastating bushfires and dengue fever outbreaks.

There is an unavoidable level of climate change predicted regardless of mitigation action. Individuals, communities and governments will be required to implement adaptation actions to reduce the impacts of adverse health impacts. The impacts of climate change will occur differentially and some individuals, communities or sectors of the population will be more vulnerable and require greater attention.

Heatwaves can affect anybody including the young and healthy, however, there are certain individuals and communities that are more 'at risk' than others particularly people over 65 years and older. When you add in other risk factors such as people with a chronic medical condition or disability, people who are living alone and socially isolated, people on specific medications, people with mental illness and those in sub-standard housing, those in the population who are aged 65 years and above are most at risk of adverse health impacts.

International and experiences demonstrate the significant impacts of extreme heat, and the January 2009 Heatwave in Victoria: an assessment of health impacts was a stark confirmation that Australia has similar patterns to those seen overseas of mortality when extreme and record temperatures are reached. The report showed that all of the impacts studied the group mostly affected were those aged 65 years and above.

This paper will present details of the actions being undertaken by the Victorian Government to assist the Victorian community, particularly those aged 65 years and above to adapt in the face of increasing temperatures, particularly periods of extreme heat such as those experienced in January 2009. The responses include a statewide heatwave plan, extensive support for Local Government heatwave plans and responses, Community registers, a Heat Health Alert System and a Heat Health Monitoring System.

For the community and individuals in general and those sectors that have the task of caring for those in this age group, it will be important that they recognise the health impacts of both the natural and built environment in supporting adaptation, and to be well informed and supported to take action that will assist those most vulnerable to not only survive periods of extreme heat, but to maintain a quality of life that they currently have.

## Assessment of constraints and barriers to public health adaptation to climate change

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Public health adaptation to climate change is an important issue and is inevitably required to cope with the adverse health impacts of climate change over the next few decades. To date, however, few studies have systematically assessed the constraints and barriers to public health adaptation. This paper endeavours to review the studies on public health adaptation to climate change, identify the current constraints and barriers to adaptation, and finally explore the future research directions in this emerging field.

An extensive literature review was conducted using electronic databases, including PubMed, ScienceDirect, ProQuest, Web of Science, as well as the Google Scholar search engine. Additionally, relevant websites, such as World Health Organisation, Intergovernmental Panel on Climate Change and United Nations Development Programme, were also searched.

It was understood that the public health adaptation to climate change can essentially operate at two levels, including adaptive capacity building and adaptation actions implementation. However, there are both constraints and barriers arising from uncertainties of future climate and socio-economic conditions, and others relating to financial, technological, institutional, social capital and individual cognitive limits. The opportunities for planning and implementing public health adaptation are reliant on effective strategies to overcome these constraints and barriers. We propose that high research priority should be given to well-designed and coordinated multidisciplinary research on the assessment of potential health impact of climate change, evaluation of cost-effective public health adaptation strategies, identification of health co-benefits of greenhouse gas mitigation policies, and particularly the projections of potential health impacts under different climate change and socio-economic scenarios.



## Planning for climate change: a case study of mainstreaming and integrating adaptation within the Department of Sustainability and Environment

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This case study examines methodological complexities inherent in using climate change science and adaptation frameworks to inform government decision making. Difficulties are created by the need to bridge long term climate science projections with one to five year government business planning cycles. Adaptation mainstreaming efforts present challenges, including understanding context specific impacts, governance arrangements for delivery agencies, effective use of risk and vulnerability frameworks and finding a common language between science, policy and business management approaches. A number of research directions are suggested by the case study.

The Victorian Government recognises its roles in helping the natural environment to prepare for and adapt to climate change and improving the management of Victoria's ecosystems and biodiversity in the face of climate change. In recognition of this, the Department of Sustainability and Environment's (DSE) Environmental Policy and Climate Change division commenced a pilot project with the Forests and Parks division to assess climate change impacts to the division. An adaptation report was prepared for the division. From this pilot a number of preliminary findings can be made.

There are a number of benefits and opportunities that can be generated by undertaking adaptation assessments. By taking action now to prevent future damage to assets there can be financial cost savings compared with projected costs to repair or replace damaged assets. Adaptation can also lock in lasting benefits by preventing long term damage to ecosystems (OECD, 2009). The Forests and Parks division pilot demonstrated adaptation planning can also improve policy linkages across and between different divisions within an organisation. Victoria's recent Biodiversity White Paper establishes biolinks as a policy response which will: reconnect habitat between existing isolated parks providing climate refugia; facilitate species adaptation; and enhance the value of parks. This policy response addresses and strengthens both biodiversity and climate change adaptation agendas.

Integrating adaptation considerations into existing decision making frameworks is preferable to developing new business compliance mechanisms. All DSE divisions are required to prepare business plans and complete strategic risk assessments as part of attestation requirements on an annual basis. With varying degrees of success, the project encouraged the division to consider physical climate changes over specified time frames in these existing assessment processes. It is envisaged that this approach can be duplicated with delivery agencies by modifying their existing governance arrangements to ensure they consider climate change impacts in their decision making frameworks.

The pilot has enabled the engagement of staff across the department, building their knowledge and providing updated information on climate change projections. The process has identified different understandings of adaptation, vulnerability and adaptive capacity. There is a need for further discussion, research and development of a common language and understanding on these concepts and a need to bring together climate change impact assessment methodologies, risk management, models and business planning approaches to assist government with effective adaptation planning.

## Implementing information on the costs and benefits of adaptation in a portfolio –based decision framework

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This paper poses the research question: how can information relating to the costs and benefits of adaptation be used in making decisions about adaptation in the face of existing uncertainties in climate change impact estimation? We utilise Portfolio Theory, (PT), to explore the extent to which it can frame cost-benefit analysis within a more explicit treatment of uncertainty. In doing so, PT allows the adaptation decision-maker the means with which to trade off economic efficiency, measured here by Net Present Value (NPV), directly against uncertainty, measured as variance of NPV.

This paper demonstrates these methodological issues in the specific context of the riverine flood risk posed by climate change to Shrewsbury, Shropshire – a town in the UK that has historically been subject to frequent flooding. The benefits of implementing three alternative adaptation options – engineering-based defences, property resistance measures and flood warning mechanisms – are estimated. The benefit estimation includes damages avoided to property and economic output, as well as the injury and mental health impact costs avoided, measured by use of benefit transfer of non-market values. Flood adaptation benefits are estimated over a period of 50 years and compared with their costs in formal cost-benefit analyses. Uncertainty resulting from climate change and socio-economic change is introduced by the application of multipliers that serve to represent the potential effects of alternative climate and socio-economic scenarios on the benefits and costs of the adaptation measures. The outputs of the cost-benefit analyses are then incorporated into portfolio analysis of these options that estimate the Expected NPV and variance of 60 individual portfolios constructed using combinations of 2- or 3-options, implemented to varying degrees, depending on the budget constraint assumed.

The cost-benefit analyses of the three alternative adaptation measures, implemented to varying degrees, show that whilst the hard defence option has the highest expected NPV, its variance is also significantly greater than the other two options considered. Conversely, whilst the warning system option generates the lowest NPVs, the variances associated with it are

also the lowest. When the measures are combined into 2- or 3-option portfolios, a positive, relationship between return and variance, is identified reflecting the fact that whilst the expected net present value will be higher with the inclusion of some options there is a trade-off to be made with the attendant higher uncertainty of return. The effect of adding a third option to the analysis is that the range of variance over which the portfolios are spread is significantly reduced.

The results of the portfolio analysis show that it is possible to construct a locus of portfolios that represent trade-offs between efficiency and uncertainty. Sub-optimal portfolios that have both lower NPV and higher variance than an alternative can be identified and removed from the portfolio possibilities presented to the decision-maker. The composition of the portfolio selected for implementation will then be determined by the preferences of the decision-maker relating to economic efficiency and uncertainty.

The illustrative application of portfolio analysis in this chapter serves to demonstrate that it may be used in conjunction with currently utilised decision-support tools such as CBA in order to incorporate climate change impact uncertainty more explicitly in project and policy decision-making. However, whilst the example presented here demonstrated the potential efficiency-uncertainty trade-off to be made, future testing should include the following research priorities: a) to increase the realism, expand the application of the portfolio approach, both in terms of the number of options included in individual portfolios and the consideration of wider range of options; b) test method effectiveness in other sectoral or cross-sectoral contexts where, for example, the climate impact data is less readily modelled and available; c) compare method findings with other emerging approaches to the same problem such as robust decision making (RDM) that evaluates adaptation from the stand-point of whether a given adaptation option is sufficiently flexible to be effective under alternative climate scenarios (Lempert et. al. 2006). Whilst these approaches appear likely to be complementary, it is unclear how this complementarity will be operational in the absence of a systematic comparison in a given decision context.

### Three Things to Consider When Estimating Allowances for Sea-Level Rise

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Currently, planning guidelines which include an allowance for future sea-level rise have been, or are being, developed within Australia. Such allowances should be supported by statistical evidence indicating their “fitness for purpose”, should be consistent with standard design practice and should ensure that there is no overall under- or over-design. All indications are that the State’s allowances will lie in the range 0.8 to 1.0 metre for assets which will last until 2100. The Department of Climate Change recently released a report “Climate Change Risks to Australia’s Coast”, which suggested an allowance of 1.1 metres for the 21st century. It will be shown that, if design levels were to be based solely on such allowances, there would a very small likelihood of these levels being exceeded by the ocean during this century. Therefore, for many purposes, the allowances would be too large. There are three main reasons for this tendency:

1. the allowances are inconsistent with the probability of flooding which we presently find acceptable,
2. the allowances are based on sea-level rise at 2100, rather than over some finite period within the 21st century, and
3. the allowances are based on a worst-case emission scenario.

These arguments will be discussed with Australian examples. A statistical tool will be introduced for assessing the likelihood of coastal flooding during the course of this century. Over-adaption, such as a requirement for excessive allowances for sea-level rise, will lead to the diversion of significant resources away from more appropriate adaptation or mitigation.

### Modeling interannual variation of crop productivity: Towards global crop forecasting

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One of the most concerning issues related to food security under changing climate is to know the changes in interannual variation of crop production induced by the change in intensity and frequency of climate extremes and climate variability. To minimize their negative impacts on crop production, it is essential to develop a tool that can predict the interannual variation of crop yield on a large scale with seasonal forecasts and/or climate projections. However, when developing a process-based crop model for a large scale, researchers encounter the difficulties in spatial heterogeneity of crop production aspect (ex., cultivar, planting, fertilizer, and irrigation). Typical grid interval of atmosphere-ocean coupled general circulation models (GCMs) that applied to seasonal forecasts and climate projections is hundreds kilometers. In a grid scale of GCMs, various types of crop management are assumable depending on the local environmental and socioeconomic conditions, although such detailed information over the globe is hard to access. Alternatively, it is needed that methodologies that can account the spatial heterogeneity in the crop production aspect on a grid scale of GCMs on the basis of the limited global datasets.

The presented study developed the process-based crop model by applying a Bayesian inversion analysis to the crop component of the Soil and Water Assessment Tool (SWAT) to improve the model capability of simulating the interannual variation of maize yield over U.S., China, and Brazil. For each state (or province), the Markov Chain Monte Carlo (MCMC) technique was applied to the 10 parameters of the model related to crop growth and yield to estimate their parameter values under the given data in the manner of probabilistic distribution. The posterior distributions of

the parameter values were estimated on the basis of the data during the 20-year calibration period (1981-2000), while the verification of the model was conducted for the 27-year period (1981-2007). These calibration and verification procedures are used for all study areas. After iterating 10,000 times with three Markov chains, we discarded the first 8,000 samples as burn-in period and then calculated the posterior distributions of the parameter values on the basis of the remaining 6,000 samples. The Gelman-Rubin's statistics indicates whether posterior distributions converged to the stationary distributions. The ensemble simulation results by perturbing the parameter values (referred to as perturbed-parameter ensemble approach) showed that the ensemble mean of the simulated maize yield agrees well with the observations for most study areas in terms of interannual variation, even though the modeling and calibration procedures were common for all study areas.

The obtained posterior distributions of the parameter values indicate the possible uncertainty of the parameter values under the given data. The perturbed-parameter ensemble approach gives better simulation results than the case based on only posterior means, suggesting the adequacy of ensemble approach to express the spatial heterogeneity in the crop production aspect. The higher capability of the model to simulate the interannual variation of crop yield would be beneficial to predict the impacts of climate extremes and variability on food security more realistically.

## Development, Dissemination, and Application of Drought Indices for Monitoring and Forecasting Drought in the Southeast USA

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Definitions of drought depend on the perspective of the user. Thus, it is essential to engage potential users of drought indices from the beginning of the process of developing drought indices to assure that they will be relevant and valuable to decision makers. The Southeast Climate Consortium (SECC) has followed a participatory approach to the development and dissemination of drought indices and other climate information for agricultural, forest, and water managers in the southeast USA.

The SECC first developed a forecast of the Keetch Byram Drought Index (KBDI), which forecasts threat of wildfire based on El Niño/Southern Oscillation (ENSO) phase. The KBDI forecast is produced beginning in January of each year for Florida, Georgia, and Alabama, with monthly forecast by county for the probability of reaching different KBDI levels. Levels of KBDI and spatial scales were both based on stakeholder feedback. Forecasts are updated monthly through July, which is the end of the wildfire season.

The Lawn and Garden Moisture Index (LGMI) uses daily Doppler radar measurements of precipitation to estimate drought at a 4 km × 4 km grid. While users request a minimum spatial scale at the county level, they much prefer an index that shows higher resolution, such as the LGMI. Results are presented as a GIS map and maps can be stored and converted into a movie that shows the dynamic nature of drought in the southeast USA. The SECC has also developed an ENSO-based forecast of LGMI at a weather station basis, which presents measured values of LGMI for the previous 30 days and forecasts LGMI for 30 days.

A new Agricultural Reference Index for Drought (ARID) is currently being developed by the SECC. The objective of ARID is to give a more robust estimate of drought impact on agricultural crops than the LGMI, while retaining the features of daily updates and high spatial resolution. As was done for the KBDI and LGMI, ARID is being evaluated by potential users throughout the development process. ARID is based on FAO56 estimates of potential evapo-transpiration and a soil water balance that assumes a 40 cm rooted depth and full ground cover. Comparisons of ARID with other drought indices show indicate that it provides excellent estimates of crop stress. ARID also correlates strongly with soil moisture and corn yield.

Both KBDI and LGMI forecasts are presented on AgroClimate, a web-based decision support system developed by the SECC [<http://agroclimate.org>]. If users approve, products that show monitored and forecast values of ARID will also be presented on AgroClimate.

## Assessing Vulnerability to Climate Change for Adaptation

M C M Iqbal<sup>1</sup>

<sup>1</sup> Plant Biology, Institute of Fundamental Studies

Introduction and scope: Climate change impacts on critical sectors of a nation such as agriculture, health and water resources, which affects food security, human well-being and livelihoods of the people in tropical countries. It is necessary to objectively assess the impacts of climate change in the context of climate trends and scenarios on socio-economic consequences, with the available human and technical resources. This paper looks at the process of vulnerability assessment for the major sectors in Sri Lanka and the limitations of the assessment process and suggest changes for an optimum assessment. These are based on the preparation of the second national communication for climate change for the UNFCCC. The framework for assessment of vulnerability was a mixed approach dependent on the sub-sectors and availability of human resources. Questions addressed were (a) What are the major consequences of climate change on the sectors? (Food security, malnutrition, water supply, disasters etc.). (b) Which geographical areas in the country are vulnerable to climate change? (Based on rainfall: arid and wet zones). (c) Which communities are most affected? (Coastal communities, subsistence farmers, urban poor etc.). (d) How should the risks be assessed? (Expert judgment, modeling studies, socio-economic analysis). Methodology: A simple generic approach to the different sectors was: review the vulnerability of the sectors and identify vulnerable areas, describe links between climate and socio-economic conditions, evaluate and prioritize feasibility of available adaptation measures, identify barriers and risks to implementation of suggested measures. From this a more specific set of conditions were developed to identify information and data relevant to assess the sectors. The

methodology adopted was to ensure broad participation of the public sector and relevant organizations through workshops. This generated existing knowledge on vulnerability and adaptation, created and re-enforced awareness of climate change, suggested new directions for research, identified barriers to change and drew attention to outdated policies and the necessity for possible policy changes. Assessment: The tools of assessment used were: expert judgment, modeling studies and impact matrix analysis. Expert judgments were provided by officers from public sector institutions and academia based on their ground experience, research and access to past data and records. These experts had much experience in their area of expertise and were best able to synthesize adaptation measures taking into account traditional methods. Biophysical modeling studies were done by scientists in the plantation agriculture sector, to assess the economics impacts on GDP, loss of revenue, marginal costs, and energy inputs from climate change. Some of the issues of climate change are met under a different context. In agriculture, the breeding of crops for short-age, drought and salinity tolerance are on-going programs. New challenges are to develop varieties for heat tolerance. Drawbacks: A major drawback was the lack of trained human resources to conduct the assessment process and address the challenges from climate change. Capacity building is necessary for down-scaling information from General Circulation Models to regional levels, which is a costly exercise for smaller countries. The sectors affected are divergent not only between and but also within. Some sectors have many agencies with over lapping interests and authority, resulting in difficulties in decision making. Past legislation and policy needs to be examined for conflict of interest with the new challenges from climate change. Possible solutions: The solutions to the above are technical as well as organizational. Technical solutions require improving the network of automated weather stations linked to the central department of meteorology, and alternatives to downscaling such as trend analysis from past weather data. A coordinating authority for each major sector responsible for all issues on climate change is necessary to undertake the vulnerability assessment process, identify and implement adaptation measures. The creation of centres for climate change in the sub-sectors would facilitate the coordination process. Capacity building for the assessment of socio-economic impacts on human well-being and their livelihoods is imperative for decision making. Strengthening the institutional capacity from the top-down is necessary with a concurrent implementation of adaptation measures from the bottom. A positive outcome was that adaptation measures are being practiced at the farmer and institutional level, since the challenges are not new. However, a shift in the overall approach is necessary since the scale and magnitude of the

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Drawbacks: A major drawback was the lack of trained human resources to conduct the assessment process and address the challenges from climate change. Capacity building is necessary for down-scaling information from General Circulation Models to regional levels, which is a costly exercise for smaller countries. The sectors affected are divergent not only between and but also within. Some sectors have many agencies with over lapping interests and authority, resulting in difficulties in decision making. Past legislation and policy needs to be examined for conflict of interest with the new challenges from climate change.

Possible solutions: The solutions to the above are technical as well as organizational. Technical solutions require improving the network of automated weather stations linked to the central department of meteorology, and alternatives to downscaling such as trend analysis from past weather data. A coordinating authority for each major sector responsible for all issues on climate change is necessary to undertake the vulnerability assessment process, identify and implement adaptation measures. The creation of centres for climate change in the sub-sectors would facilitate the coordination process. Capacity building for the assessment of socio-economic impacts on human well-being and their livelihoods is imperative for decision making. Strengthening the institutional capacity from the top-down is necessary with a concurrent implementation of adaptation measures from the bottom.

A positive outcome was that adaptation measures are being practiced at the farmer and institutional level, since the challenges are not new. However, a shift in the overall approach is necessary since the scale and magnitude of the consequences of climate change are much larger and unpredictable.

## **“Climate change, an issue of the elites?”: Rethinking adaptation through the eyes of the most vulnerable in Nepal**

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In the wake of almost two decades of climate negotiations that have failed to precipitate adequate mitigation and adaptation commitments, it is clear that vulnerable communities around the globe require assistance to adapt to current and future climate variability. However, as international development actors scramble to identify and commence ‘adaptation’ projects, we risk overlooking the multifarious nature of vulnerability and adaptive capacity and may subsequently employ methods that might be ineffective or lead to maladaptation in the long term. In this paper I use the lens of women’s collectives and community development committees in Nepalgunj, a town on the Himalayan plains in Nepal, to explore adaptive capacity and perceptions of environmental change at the community level. In this paper I assert that, in addition to a continued critical engagement with the adaptation discourse, which plays a key role in shaping implementation frameworks, grassroots capacity building should be one of the first steps we take towards building more adaptive societies.

Data for this paper was collected during two months of field research that included time in rural Nepal and with Nepali delegates at the Copenhagen climate conference. The research involved a range of actors including government officials, NGO employees and local community members in semi-structured interviews, focus groups and participant observation. The organisations that were engaged for this research did not specifically address climate change, however, they all address social vulnerability to environmental risks through a range of different empowerment methods. For example, a group of women’s collectives in Nepalgunj empower women through savings and loans schemes, the lobbying of local government for better services, and strengthening social networks. Here, I also consider the perceptions of the communities around climate change in order to further understand their motivations for action and to explore how this may impact the long-term efficacy of projects related to environmental vulnerability. In almost all cases, community members were unfamiliar with the concept of climate change or it was disconnected from their realities. For example, a few participants discounted climate change as an issue of the elites. This paper inserts itself into the climate change adaptation debate by listening to the perspectives of local NGO staff and participants in rural Nepal and reflects this onto contemporary adaptation frameworks. Their voices challenge our assumptions, and speak in a unique way to our theoretical conceptualisations of their world.

I contend that amidst the plethora of challenges facing vulnerable communities there needs to be renewed consideration of local level capacity building, through actions such as the development of collectives and enhancement of social networks, as a key component of adaptation at the community level. Many of the activities explored in this paper provide a necessary foundation for the enhancement of adaptive capacity in a future that will likely be punctuated by uncertainty. This needs to be accompanied by continued critical engagement with the dominant adaptation discourse which often assumes adaptation will be relatively simple with the appropriate financing. The challenges posed by climate change and adaptation must be faced with vigilant listening to those who are most vulnerable.

## **Learning from case studies of Australian agriculture adapting to climate change: understanding transformation and transition dynamics**

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The challenge of adapting agriculture to climate change will require primary industries to make transformative changes as well as incremental adaptations. Most of the adaptation strategies that are being developed for primary industries to respond to climate change are aimed at informing tactical, short term decisions and producing incremental change. However, it is unlikely that this suite of adaptation actions alone will completely cover the adaptations needed for sustainable farming, fisheries, forestry and mining in the long-term. To address this gap in knowledge and practice, we propose a conceptual framework for understanding the process of transformation in the context of agriculture adapting to climate change, using knowledge from the transition, adaptation and transformation science literature. Our framework draws on the theory of transitions and transition management, which conceptualises transitions as a process of societal change that occurs through

a cycle of four clusters of transition activities. We combine this transition management cycle with four key questions for understanding the process of adaptation (who or what adapts; what do they adapt to and why; what impacts result; and how well do they adapt?), to provide a better understanding of the dynamics of transformative adaptation and offer insights into the opportunities and limitations for transforming agriculture in the face of climate change.

This conceptual framework is being validated and refined through a five-year longitudinal study, using multiple case studies from a range of Australian primary industries and communities that are transforming in response to climate change. These case studies include examples of transformation from the following industries: peanuts, rice, wine, grazing, fisheries and mining; as well as three community level case studies across Victoria, New South Wales and Queensland. Case studies are designed to focus on the conditions and processes that drive these primary industries and communities to make significant, transformative shifts in their practices in order to adapt to climate change. This longitudinal study draws on a mix of qualitative and quantitative research methods, stakeholder participation and a range of relevant theoretical approaches, to identify and synthesise key lessons from our multiple case studies. We present preliminary findings from the first case study of our series, namely the Peanut Company of Australia's (PCA) decision to expand its peanut production systems beyond its traditional farming areas, through the development of a new supply option in the Northern Territory. We focus on the key characteristics of the planning and reorganisation phases of this transformation, as identified by the conceptual framework. In doing so, we determine the social features of, and influences on, the PCA's transformation process: the conditions needed to successfully plan, reorganise and manage the impacts of this transition. The lessons learned from our case studies will help inform policy developers and decision-makers at a range of levels who are faced with adapting agricultural industries to climate change.

### **Managing bushfire risk using an integrated assessment of the sustainability of a planned neighbourhood**

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Climate change is likely to lead to more bushfires. Our built environment needs to adapt to better cope with this increased risk. What fire risk factors need to be considered when building or rebuilding our neighbourhoods? How can we build neighbourhoods in ways that reduce these risks? Does adapting our neighbourhoods to better cope with bushfire risk have consequences for the sustainability of our neighbourhoods in other areas?

This paper introduces CSIRO's Neighbourhood Integrated Sustainability Assessment Platform (NiSAP), a software tool that answers these questions. NiSAP enables urban planners and developers to assess the bushfire risks of a particular neighbourhood scenario and make changes in order to reduce these risks. NiSAP can also assess a neighbourhood's performance in other areas including energy use, water use, transport, health, waste, ecological function, and materials use. By creating alternative scenarios for neighbourhood development and using NiSAP to assess each option, the impacts on bushfire risk and other sustainability issues can be determined and compared. Synergies can be discovered and conflicts identified. Planners and developers are assisted to make decisions to optimise bushfire risk and sustainability outcomes. NiSAP uses spatial (GIS) data in its analyses and makes use of GIS maps to display the outputs of the analyses, making interpretation of the analyses easy.

### **Learning from experience: deriving lessons from the local level climate adaptation actions in three urban areas of Asia and Africa**

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The building and execution of climate adaptation frameworks (strategies, plans) for local urban areas (local governments, municipalities, cities) are still at beginning stage in most parts of Asia and Africa. Even though a few of the Asian and African urban local areas seem to be at the forefront, these have only started analysing climate impacts and identifying adaptation options for not many years. However, some common lessons could be taken out from the know-how and practices of these early urban local areas working on climate adaptation learning and action. Utilising the experiences of three urban local areas (Albay, Cape Town and Durban), this paper exhibits a comparative analysis of the up to date efforts for climate adaptation planning in these urban local areas in connection with some of the inter-linked questions that we considered vital to be answered for taking out common themes that could be advantageous for any local level adaptation planning in Asia and Africa. With the aim of evaluating the climate adaptation actions of Albay, Cape Town and Durban through a questionnaire survey, three criteria were selected by which to weigh the similarities and dissimilarities in planning processes and structures of these three urban local areas, including: (1) background; (2) drivers of adaptation planning (focusing on six elements of the proposed change model for climate adaptation: leadership for adaptation, vision for adaptation, organizational culture for adaptation, good governance for adaptation, innovation and creativity for adaptation, and resources for adaptation); and (3) adaptation strategies (steps involved and mechanisms used). By examining these three urban local case examples, the paper helps test the elements of the change model for climate adaptation, and suggests some key transferable lessons supporting the processes and structures for designing any local level climate adaptation frameworks in Asia and Africa.

## Opportunities for Climate Adaptation Learning & Action at the Urban Local Level: The Case of Lahore, Pakistan

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The overall purpose of this paper is to examine the opportunities for climate adaptation learning and action in urban Pakistani local governments. Opportunities have been identified by making a comparison with some of the core learning organization characteristics identified during the review of literature, spotlighting predominantly on those characteristics that are believed to be the most significant and pertinent to the Pakistani context. Initially, the paper makes a broad review of literature related to the learning, and identifies some of the key characteristics that could bring change in the context of climate adaptation learning and action within Pakistani urban local governments. One representative Pakistani urban local public organization (City District Government, Lahore) was selected for this research. The primary data was collected through two research methods: initial interviews and case study interviews to explore as well as explain such characteristics in the Pakistani context. A total of 21 Pakistani professionals, related to the urban local governments, participated in the in-depth interviewing. Thematic analysis of the data collected helped developing a model comprising six different key characteristics that could bring change in the context of climate adaptation learning and action within Pakistani urban local governments, including: leadership for adaptation, vision for adaptation, organizational culture for adaptation, good governance for adaptation, innovation and creativity for adaptation, and resources for adaptation. The paper provides valuable information by identifying some of the characteristics that could bring change for climate adaptation learning and action within the urban Pakistani local governments.

## Coral Arks: a triage model for marine resource management based on coral resilience to climate change

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There is now little doubt that climate change is already and will continue to impact coral reefs globally. One of the most potent weapons that marine managers have to ensure that reefs have the best chance of regenerating following extreme climatic disturbance is the creation and protection of marine 'refugia'. Historically, marine reserves have been chosen to protect fish populations rather than corals. This management model may be flawed because it is the hermatypic coral species that provide the reef's structural integrity and habitat and food for marine organisms. Evidence already exists that suggests that many of the world's marine reserves may not survive future temperature increases. While the protection of vulnerable reefs has merit when resources are abundant and the threat is mild, this model of management may not be appropriate for catastrophic climate changes. In this study we present a new model for coral reef management based on the identification and augmented protection of small pockets of reef that have historically demonstrated resilience and are well placed to survive catastrophic disturbance to seed regeneration on surrounding reefs. To this end, we set about identifying a set of coral 'refugia' in one of the most vulnerable and highly valued marine systems, the inshore reefs of the southern Great Barrier Reef. The Keppel region lies at the mouth of the Fitzroy River Catchment which makes it vulnerable to changes in water quality as a result of land use along the catchment. The Keppels has a history of disturbances in the past including coral bleaching and flood but its strong recovery indicates that coral refuges do exist as these have probably seeded past reef recovery. Eighteen sites were assessed for coral species abundance and richness, temperature, light, the presence of thermally tolerant algae within the main reef-builders, benthic cover and habitat variety. Four coral 'refugia' were chosen based on a combination of these characteristics. Although relatively small in area, these 'refugia' may be the key to the resilience of the Keppel reefs. By enhancing their protection, it may be possible to improve the capacity of the entire system to survive and regenerate following future disturbance. This study could serve as a model for other ecosystem types in other regions both nationally and globally, particularly in developing countries with limited resources, whereby a triage assessment of sites is conducted in order to focus resources to those sites which are more likely to survive catastrophic disturbance to seed regeneration at surrounding sites: veritable Noah's arks against climate change.

## Adaption strategies for changing fish production as a result of global warming

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The majority of the world's 200 million fisherfolk and their dependents live in areas vulnerable to climate change according to Allison et al (2005). Many of these people represent the poorest people in society, the people with the least capacity to adapt. Some 20% of the protein consumed by poor humans comes from the sea. Away from a narrow coastal fringe, the productivity of the photic zone of the ocean is limited by the supply of nutrients from deeper in the ocean. The thermohaline circulation provides the large scale recirculation of these nutrients within the ocean basins while localised upwelling, driven by the surface marine winds, supports regional fisheries. Changing ocean temperature in the polar regions where dense water sinks to drive the thermohaline circulation and changing wind patterns as a result of global warming are likely to bring about changes. While the vertical circulation may slow, the concentration of nutrients may rise with time as the deep water is subjected to the rain of marine snow for longer. As the overturning time of the ocean is many centuries, the period of reduced productivity could be significant.

An adaptation strategy that maintains the protein supply from weakening upwelling centres during the above transition is to provide by other means the nutrients that are no longer supplied by upwelling. The Ocean Nourishment technology discussed by Jones and Young (1997) is the marine equivalent of agricultural fertiliser application. Here the primary production is enhanced by providing the limiting nutrients. The extra nutrients can be manufactured or mined and provided to the ocean by broadcasting from ships. Many studies show the result is enhanced primary production. Investigations such as Ware and Thompson (2005) show a good correlation between phytoplankton standing stock as a result of primary productivity and yearly fish catch.

The cost of such adaptation has been estimated and is found to be less than the current value of small pelagics. The increased fishing efficiency expected from a nourishment scheme contributes to the feasibility of the poor artisan fisherman being supported through a period of rapid climate change by such a concept.

## Recent rapid climate change in south-eastern Australia and its impacts: important lessons for adaptation

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The bio-geophysical and social impacts of climate change have been deliberated upon at length in various scientific studies. One of the major geophysical impacts – is sea-level rise which will have social as well as ecological consequences. The aim of this study is to develop a systems understanding of differential vulnerabilities of selected occupational groups to sea level rise. The study areas are the Demak and Semarang regencies of the Central Java province of Indonesia. These regions are affected by hazards such as land subsidence, tidal floods and coastal erosion which make them particularly vulnerable to any rise in sea level

The theoretical basis of the study is the Sustainable Livelihoods Framework and so it follows a capital-based approach towards estimation of the vulnerability. Vulnerability indices for different livelihood capitals, or assets, (social, economic, human, physical and natural) of groups such as fishermen, brackish pond farmers and mixed labour group (skilled and unskilled) were created as a quantitative estimate of vulnerability. Indexing is a well-established and efficient tool to derive such estimates. To expand this estimate, a detailed understanding of livelihoods using Participatory Rural Appraisal techniques such as historical time line analysis, resource mapping, brain storming exercises and focus group discussions was developed. In addition, community adaptation mechanisms which were already in place in response to coastal erosion and tidal floods were obtained using participatory approaches. They were placed in the context of being indicative of their adaptive practices to the hazard-Sea level rise. These responses were attributed to the livelihood capitals they possess and were assessed as a robust indication of the capitals upon which they rely on to help them in the face of hazard like Sea Level Rise.

The Participatory Rural Appraisal techniques and other qualitative exercises aided in providing a richer, qualitative, background to the quantitative information collected on livelihood assets/capitals. A mental model depicting the feedback loops between different component factors identified using these exercises was built. Components of this model include different livelihood capitals of the groups, along with their individual livelihood system factors depicted in multiple geographical scales of operation. For instance, in the case of fishermen, this included the web of factors causing degradation of the fishing system. This integration of the qualitative and quantitative approaches helps build an understanding of the livelihood systems, their background and their contribution to the vulnerability of respective occupational groups to the hazard in terms of a mental model depicted using Causal Loop Diagrams. This will enable the simulation of the differential vulnerability behaviour/pattern of the groups in the future. The analysis will deliver policy planners with a holistic perspective of human vulnerability to a natural hazard like sea level rise.

## Vulnerability assessment to Sea Level Rise- Arriving at a systems perspective through the integration of quantitative and qualitative approaches

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The Participatory Rural Appraisal techniques and other qualitative exercises aided in providing a richer, qualitative, background to the quantitative information collected on livelihood assets/capitals; especially on respective occupational systems. A mental model depicting the feedback loops between different component factors identified using these exercises was built. Components of this model include different livelihood capitals of the groups and individual occupational system factors depicted in multiple geographical scales of operation. This integration of the qualitative and quantitative approaches helps build an understanding of the livelihood systems, their background and their contribution to the vulnerability of respective occupational groups to the hazard in terms of a mental model depicted using Causal Loop Diagrams. As a key outcome, this study seeks to deliver policy planners with a holistic perspective of human vulnerability to a natural hazard like sea level rise.

## **Adaptation and Limiting Factors: Issues and Perspectives from Grass root Level in Tungabhadra Basin**

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It is common that phenomenon of long delay in execution of large irrigation projects and this promotes either violation of cropping pattern or illegal irrigation. As a result, when the project is completed, head-reach farmers consuming more than water allocated to them at the cost of tail-enders allocation. Tail-enders by virtue of their limited voice both in policy making as well in decision making remains on receiving end. To come out of this vicious cycle, tail-enders has to adopt innovations at community level. Most of times, even if they find sustainable innovation, lack of assistance and marketing channels, often, fail them. Here is a case study about how tail enders are trying to find a solution for themselves. Tungabhadra Reservoir was constructed in 1950s but, distributary canal net work took two more decades to be completed. As a result head-reach farmers, though allowed only semi-arid crops, have shifted to rice and sugarcane cultivation and Tail-enders, from day one, were forced to scarcity of water and thus, low farm yields. Majority of tail-enders remained as mute recipients of things. But, one community, which was rehabilitated from those of Bangladesh implemented small scale innovation of construction of fish ponds in fields and moved away to vegetable cultivation thus ensuring higher household income. But construction of ponds requires financial resources and hence, only some can implement this innovation. This innovation has potential to improve household income levels, but factors such as a) lack of credits for construction of farm ponds and b) developing market for fish produce are remaining major bottlenecks. This kind of innovations in the face of resource hardship is common everywhere and given a opportunity, we would like to present our findings.

## **Optimising information use in adaptation planning: Examples from Kiribati**

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A critical issue for effective adaptation planning is the provision of robust scientific information, provided in appropriate formats. However, decision makers in developing countries such as Kiribati often have limited access to climate information and limited technical capacity to apply such information for adaptation decision-making. Consequently, a priority of the Kiribati Adaptation Project (KAPII) was to provide specific climate change information to fill existing gaps, whilst also providing Government of Kiribati staff with skills in applying this information within a risk assessment framework to underpin and guide adaptation planning.

The case study presented here focuses on the capacity building activities undertaken to support application of coastal information in risk assessment and adaptation planning.

Place-specific probabilistic information on coastal hazard drivers, and how climate change will impact these drivers, was compiled in an interactive database through the development of an Excel based “Coastal Calculator”. The tool enabled site-specific calculations to be made, and comparison between, present day and potential future (based on defined climate change scenarios and timeframes) values of tide levels, storm tide levels, wave heights, run-up and overtopping volumes at the shoreline. The tool also enabled the information to be easily accessed and utilised in decision-making for risk assessment and adaptation planning. In addition, a range of spatial information sources were collected and converted to Google Earth files. These files were shared and accessed readily with Government stakeholders who would not normally have access to such data or have knowledge of GIS.

The combined effect of the Coastal Calculator tool and Google Earth files provided an information rich baseline, accessible to a wider range of decision-makers, upon which to undertake risk assessment. In addition, a range of other capacity building support materials were developed, including handbooks, visual tools and templates to support the process of embedding climate change risk assessment and adaptation planning in the Republic of Kiribati.

The study found:

- Flexibility is important. Application of the Coastal Calculator and associated information broadened in scope as stakeholders recognised the value of the tool in supporting decision making, and

requested the tool to be modified to be fit for their purpose. Application to real problems or issues, rather than potential issues or scenarios, is vital to achieving this recognition.

- Visual tools are vital in providing an inclusive decision making environment.
- Uncertainties in climate information and analysis tools must be clearly communicated.
- The case study demonstrates an approach to develop local capacity in applying detailed and specific climate information in risk management and adaptation planning. The process has enabled the Republic of Kiribati to:
- Assess the potential impact of climate change at a range of scales: from island to village level.
- Develop inter-ministerial interaction and decision-making, which is an integral part of ensuring sustainable coastal management.
- Show case its potential vulnerability on the world stage, by presenting scientifically robust information on how climate change will impact existing coastal hazards and resulting problems at a side event at COP 15 in Copenhagen.

## **Economic predictions of flood damages with respect to the extreme rainfall in Japan**

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Given the increasing certainty that climate change is accelerating, the fourth report of the Intergovernmental Panel on Climate Change (IPCC AR4) presented adequate evidences to confirm that rainfall intensity is increasing and cause more frequent and serious flood damages. Japan is particularly vulnerable to flooding because of its steep geography and humid climate characterized by typhoons. Many researchers have used hydraulic models and cost-benefit analysis for appropriate countermeasures in small catchments throughout Japan. However, no studies have done to estimate the flood damage for the entire country in order to compare the costs of regional countermeasures. Therefore, in this study, we evaluated the occurrence of flood hazards and associate damages with respect to extreme rainfall events in the past and future across Japan.

Precipitations in 1, 024 stations throughout Japan from 1980 to 2000 time periods were used for frequency analysis of annual maximum 24-h rainfall data. The generalized extreme value (GEV) probability function was fit to estimate the return period of extreme rainfall. The regression relationships between extreme precipitation and maximum precipitation, which was selected as maximum value of 24-h averaged rainfall over a month, were developed for each different season. The numerical maps, prepared by the Japan Meteorology Agency (JMA) to show the spatial distribution of average 24-h rainfall in every month, were used with the developed regression relationships to estimate the spatial distribution extreme rainfall events. A two-dimensional non-uniform inundation model was run with the estimated extreme rainfall events to obtain the maximum water depth and inundation period. Moreover, resulting flood damage cost was estimated for 11 land use types based on the flood control economy investigation manual published by the Ministry of Land, Infrastructure, Transportation, and Tourism (MLIT).

From our analysis, it is noted that the rate of increase in extreme rainfall varies linearly with the rate of increase in damage cost. When it is assumed that flood protection is completed for a 50-years return period of extreme rainfall, the benefit of flood protection for a 100-year return period of extreme rainfall is estimated to be 210 billion USD. Under the same assumption, the extreme rainfall shifting from 50 to 100 year return period results in damages of approximately 10 billion USD per year. The completion of flood protection measures largely benefits in urban contexts due to the possibility of large costs of flood damage in dense areas. Such detail estimation is proved to be helpful for prioritizing the vulnerability regions for making appropriate countermeasures as needed under the adverse effects of climate change in future.

## **Resilience, Vulnerability and Adaptive Capacity of an Inland Rural Town Prone to Flooding: A Climate Change Adaptation Case Study of Charleville, Queensland, Australia**

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Climate change is currently considered a major and urgent issue of global significance. In Australia its effects are already being experienced in the form of higher temperatures and more frequent extreme events. A warmer climate will increase the risk of floods, potentially leading to more severe damage to people, property, and the environment. In Australia flooding is the costliest form of natural disaster, with losses estimated at over \$300 million a year.

Adaptation strategies need to be community and location-specific. A sound understanding is vital about the vulnerability, resilience and adaptive capacity of communities that are regularly flooded, in terms of how they prepare, respond to and cope with flood events, and the effectiveness of mitigation measures and plans enacted.

This study is an historical case study of the 2008 flood in Charleville, an inland rural town in Queensland, Australia. Charleville experiences frequent flooding and lies on an extremely vulnerable and extensive flood plain, with no significant elevated areas available for relocation.

Structured questionnaires were administered in personal interviews in February 2010 to householders, businesses and representatives from government, disaster committees and community service organisations (n=91). Household and business participants were restricted to those affected by the flood. Data were analysed using appropriate quantitative and qualitative techniques and SPSS statistical software.

The main vulnerability found in households and businesses was the low level of flood insurance cover (only 32% of residents and 43% of businesses had cover), making them more vulnerable to economic losses. This was compounded by the fact that this cover is difficult to obtain and costly.

Residents displayed high levels of resilience and strong personal networks (evidenced by 77% evacuating to family or friends during the flood), high levels of sense of community and participation in community activities. They believe they have a personal responsibility for preparing for floods. Low formal volunteer rates were found, however this study suggests a high level of community spirit and the likelihood of strong informal volunteer networks.

Few participants would move to another town if affected by another flood. Residents heeded practical advice given on floods, eg., checking electrical appliances. Boiling tap water, however, is less of an issue as bore water quality is less affected in flood events. Many intend moving irreplaceable items above ground level in the future and almost 90% will continue to keep ditches and drains around their properties clear and free of debris. Residents rated the preparedness of State Government, utility providers and their Local Hospital highly (78%, 59% and 49%, respectively).

Better flood modelling and additional river height gauging stations are needed to enable more targeted evacuations. Bradley's Gully requires further mitigation works. More affordable insurance products are necessary and regular information on how residents can prepare and the roles different organisations play, including in other languages. Further research on the psychological impacts of flood events is recommended.

A key highlight was the importance of residents taking personal responsibility for preparation and personal mitigation activities, and its sizeable contribution to the community's ability to respond and cope with flood events.

## Rapid Resilience: A systems based approach to addressing Urban Climate Change Resilience

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It is no headline that there is inadequate information, data, and awareness in many cities – particularly those in developing countries - on the projected local impacts from climate change, and strategies for adapting to those impacts. In part this reflects the high degree of uncertainty around urban scale climate scenarios, but equally uncertain future city growth patterns may create new and unforeseen urban risks.

Considering the urban environment as a complex system, and identifying the elements that build resilience to the shocks and stresses that cities will increasingly face, Arup has developed a systems based approach for city governments which provides a rapid assessment of emerging vulnerabilities, and identifies pathways to respond.

Cities have the potential to be hotspots for risk associated with climate change impacts. Lack of protective infrastructure, limited access to services and weak social networks compound the shocks and stresses inherent to urban locations. Stresses from climate change are expected to happen over weeks and years and include higher temperatures that lead to lower productivity for city food suppliers, sea level rise that erodes low-lying cities or gradually disappearing glaciers and snowfields that sustain city water supplies. Shocks are expected to include an increase in the frequency and intensity of hydro-meteorological hazard events, triggering secondary impacts such as the failure of critical infrastructure (electricity substations due to flooding, transport systems due to urban heat waves).

Urban systems are combinations of resources, institutions, individuals and processes that combine to accomplish a set of specific functions. A resilient urban system is able to tolerate significant changes and alteration before reorganizing around a new set of structures and processes. To combat the climate change challenge, cities will need to create, enable and sustain both the systems required for survival and the characteristics that create opportunity for their residents, during slow changes (stresses) and after unexpected shocks.

Recognizing the complexity of urban environments, and the uncertain shocks and stresses that climate change is expected to bring, Arup's approach seeks to: "improve the capacity of the urban system to deal with uncertainty". This involves 3 key principles:

- a. Understand the boundaries and 'components' of the urban system (Ecosystems, Institutions, Infrastructure and Knowledge Networks)
- b. Analyse these components against the 'characteristics' of urban resilience – including the capacity to visualise problems and act accordingly (resourcefulness), the capacity to respond, and the capacity to learn and internalize past experience and failures.
- c. Use a rapid approach to analysis and response - Arup's approach focuses on the first steps Cities can take towards urban climate change resilience, responding to boundaries of institutional influence and control, planning horizons across land use and infrastructure portfolios, and the risks of action and inaction in an uncertain climate.

Arup's experience in cities across Asia, Australia, Europe and the US has reinforced the currency of this approach. While standard engineering approaches calculate the probability of climate impacts and design or adapt the physical infrastructure to cope, imprecise science creates the risk of under or over-engineering. Arup's focus more on a resilience based approach entails living with nature rather than keeping nature out, and requires a combination of both soft (capacity) and hard responses.

## Adaptive strategies to mitigate the impacts of climate change on European freshwater ecosystems

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Understanding how freshwater ecosystems will respond to future climate change is essential for the development of policies and implementation strategies needed to protect aquatic and riparian ecosystems. The future status of freshwater ecosystems is, however, also dependent on changes in land-use, pollution loading and water demand. In addition the measures that need to be taken to restore freshwater ecosystems or to sustain priority species need to be designed to adapt to future climate change. This is the rationale behind a new project recently started in Europe, REFRESH (Adaptive strategies to Mitigate the Impacts of Climate Change on European Freshwater Ecosystems), which is concerned with generating the scientific understanding that enables such measures to be implemented successfully.

The key objective of the REFRESH project is to develop a system that will enable water managers to design cost-effective restoration programmes for freshwater ecosystems at the local and catchment scales. This will account for the expected future impacts of climate change and land-use change. At its centre is a process-based evaluation of the specific adaptive measures that might be taken at these different scales to minimise the expected adverse consequences of climate change on freshwater quantity, quality and biodiversity. The focus is on three principal climate-related and interacting pressures; i) increasing temperature; ii) changes in water levels and flow regimes; and iii) excess nutrients.

The Project considers how freshwater ecosystems (rivers, lakes, reservoirs, and riparian wetlands) in Europe will change over the next fifty years. It will use a series of field experiments in which river, lake and wetland sites have been selected to represent a gradient of climate conditions across Europe. These will be supported by laboratory and mesocosm experiments, analysis of major databases that enable time-space modelling, further analysis of long-term time-series and by evidence from palaeoecological studies. All these approaches will be combined to help develop the process-based models needed to run scenarios for adaptive strategies and which are required for up-scaling from local to river basin.

REFRESH will provide an improved prediction capacity of the hydrological and hydrochemical response of surface waters to land-use/management and climate change. It is anticipated that the results will support restoration planning by showing how scenarios for changes in future climate, land-use, nitrogen deposition and water resources can be combined and down-scaled to the catchment level. Key outputs will include the development of a set of principles and guidelines that will allow managers to assess vulnerability to climate change. A catchment modelling framework will be developed that will allow decision makers and managers to generate forecasts under different scenarios that incorporate alternative adaptive measures and enable optimum choices to be made that also acknowledge uncertainty and risk. A methodology will be provided that will allow the cost-effectiveness of alternative adaptive strategies to be modelled and evaluated. Ultimately REFRESH will provide a comprehensive overview of adaptive management principles and measures required to modify key directives and advise national governments and environment agencies.

## Local and large scale approaches to adaptation in Canada

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Adaptation is an ongoing process that involves a wide range of players, including community groups, civil society, the private sector and all orders of government. In Canada, responsibilities for policy making are spread among four different orders of government – federal, provincial / territorial, municipal and aboriginal – with some areas of shared responsibility. This paper reviews case studies of adaptation in Canada and new initiatives there were designed to create better linkages between local scale activities and large scale strategic approaches.

A review of Canadian case studies of local adaptation actions reveals that these actions are diverse in nature, reflecting local concerns, and occur in response to a range of drivers such as extreme events, research projects, awareness building campaigns, local champions and peer leadership. Most are geographically discreet in area and have only rarely been part of regional or broader strategies. Most actions required minimal new investments and some are the first of several steps that will be required to address climate change in the longer term.

While not all actions need to be part of a larger strategy, risks associated with “one-off”, local actions are recognized. For instance, coastal protection in one area could lead to erosion risks to adjacent areas that are deprived of sediment. There is a risk of developing complacency when actions are not part of an on-going strategy. It can be perceived that once an action has been taken and an immediate risk addressed, that adaptation is complete. Local actions may also be dependent on investments or policy changes at higher orders of government, and cannot be undertaken until an enabling environment is provided.

Natural Resources Canada, a federal government department, leads two initiatives to facilitate action on adaptation with an emphasis on mainstreaming adaptation into existing decision-making and sharing lessons learned.

The first initiative is the creation of six Regional Adaptation Collaboratives which bring together several orders of government and civil society to analyze adaptations, develop tools, undertake policy-relevant analysis and implement pilot projects. The second initiative works with professional organizations – planners and engineers – to increase the capacity of these professions to address adaptation in their day to day work. It is hoped that the presence of such implementing mechanisms will create a more cohesive approach to adaptation.

These initiatives aim to facilitate the sharing of insights from early actions – costs, stakeholder feedback, implementation challenges and solutions, and products such as model by-laws are shared broadly, reducing barriers for others. Since these early adaptations may also provide insights into “mal-adaptive” practices, helping people communicate openly about less successful initiatives will be important as well.

## **Linking up with opinion leaders and adaptive capacity to climate change in the Sunshine Coast Region \***

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Social change occurs at all scales and a better understanding of the factors involved in different contexts is crucial for responding collectively to complex problems such as climate change. Attention to the interplay of determinants at the collective national or sub-national levels has been the focus of most adaptive capacity research. However, recognition of the scale and context specific nature of adaptive capacity has led to recent interest in local, community, household and even individual pre-conditions for responding effectively to socio-ecological stressors such as climate change. In particular, processes of change operating through social networks, social learning and leadership have been identified, but there remain gaps in knowledge about how individual actions relate to collective response capacity and how complex global issues are translated into action at the local level. In other fields of research, such as community health, influential individuals occupying central positions in their social networks and key intersections between networks are targeted to increase the rate of attitude and behaviour change in a community. In such interventions the diffusion of innovations model (Rogers, 2003) provides a theoretical framework for connecting individual behaviour to broader social scales through networks and interpersonal influence. Similarly, the support or opposition to new ways of thinking and responding by influential individuals across the range of social sectors could be critical to developing effective collective response to climate change.

This paper describes the development of a framework used to identify influential individuals with demonstrated competencies and skills consistent with factors important to collective response capacity, across sectors within the Sunshine Coast Region. The results of an online survey used to consult over 1300 community organisations are discussed along with the methods applied to select a sample of opinion leaders with whom to explore their strategies for influencing social change. Finally, the significance of the research is discussed in relation to achieving a better understanding of latent response capacity in regional contexts.

\* This project is part of the South East Queensland Climate Adaptation Research Initiative.

## **The effects of climatic extremes on different phenological stages of navel oranges**

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Phenology can be defined as the initiation or termination of programmed developmental stages responding to cues from day length, light and temperature. The length of phenological stages may vary from season to season because of season to season differences in weather conditions, particularly temperature. The impact of temperature is encapsulated in the heat unit concept. Most variability in phenology is accounted for by variability in the time taken to accumulate a certain number of heat units using upper and lower temperate thresholds. Therefore, different phenological stage during the growth cycle of citrus tree is affected by the extreme temperatures if the range is out of the optimum limits. In the last few years certain phenological stages such as flowering, fruit colour, fruit sunburn and fruit maturity has been affected due the unexpected rise in temperatures. The data on the effect of climatic conditions on different phenological stages is presented with special reference to climatic extremes in recent years.

## **Networked resilience – a role for Health Promotion in regional responses to climate change**

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There is increasing focus on climate change as the major preventable threat to the future health of humanity. Health Promotion teams generally have links with educational, social, administrative and business sectors of the community, and are therefore well placed to catalyse the formation of ‘soft infrastructure’ for community resilience to the impacts of climate change.

The Health Promotion team of North Coast Area Health Service embraced this challenge with an initiative based on Complex Adaptive Systems Theory and Action Learning. It collaborated with key regional stakeholders concerned about climate change to develop broad agreements for strategies to increase active transport; improve food security; and to increase energy and resource sustainability.

The initiative was termed Resilience as this is central to human, social, ecological and global complex systems. Brian Walker has defined Resilience as ‘the capacity of a system to absorb disturbance, undergo change and still retain essentially the same function, structure, identity, and feedbacks’.

The project objectives were to:

- Collaborate with other organisations to develop a Northern Rivers Climate Change Collaboration Agreement;
- Use the Agreement to accelerate community action for climate change mitigation, adaptation and transition strategies;
- Engage stakeholders in collaborative food and transport projects that synergistically address climate change and obesity.

A Northern Rivers Climate Change Collaboration Agreement was quickly developed. Disparate organisations signed on, and developed a way of working together. While a shared vision continued to grow, some differences emerged. At the same time, a paradox was navigated: most of the organisations were hierarchical bureaucracies, yet they were seeking a way of collaborating to facilitate rapid emergence of responses to climate change. Eventually, the Collaboration adopted a minimum set of governance guidelines to enable Sustain Northern Rivers, its action program.

This inter-organisational network achieved a number of outcomes. Transport initiatives included a novel approach to mapping regional commuter flows, modes and motivations by triangulating data from partner organisations, a model which could be used in other regions that lack transport data. Food initiatives included food value chain analysis, a Food Resilience Roundtable which scoped projects to increase local food production for local consumption; and the Eden at Home resource for growing backyard food.

A focus of the project was to maximise learning. A reflective Action Learning component was developed to understand how Complex Adaptive Systems theory could inform adaptive responses to climate change and creative action in organisations. These concepts were integrated with social network analysis to evaluate the way the Collaboration contributed to the development of soft infrastructure based on networks.

Social Network Analysis revealed the rapid development between 2006-2009 of a highly interconnected network of organisations addressing climate issues. The emergence of associated projects is also shown.

Health promotion can play a vital role in addressing the potential impact of climate change on rural communities. Social Network Analysis can add value to such efforts by providing a map of soft infrastructure development, a basis for advocacy, and a means for identifying new networking opportunities.

## Drought and the future of small inland towns

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Australia's vulnerability to climate variability and change has been highlighted by the recent (and current) drought situation. For example, a persistent rainfall deficiency over the last seven to ten years has resulted in low inflows into the Murray-Darling system, with some active storages currently at less than 20% of capacity. Droughts are, and always will be, part of the Australian climate and it is impossible to prevent these natural disasters from occurring. There is also the possibility that the frequency, intensity and duration of droughts may increase due to anthropogenic climate change, stressing the need for robust drought adaptation strategies. However, answers to the following questions remain highly uncertain:

- a. what are the effects of long-term drought on small rural towns?
- b. what are the critical water security issues?
- c. what options do small rural towns have in terms of drought adaptation?
- d. do small rural towns actually have the capacity to implement adaptive strategies that are required to mitigate drought related impacts and remain viable into the future?

Two case study sites (Mildura and Donald) have been investigated. Both towns are located in Victoria but each has differing water sources, rainfall/climatic patterns, economic bases, population sizes, and water resource management practices, and importantly both have been strongly impacted by the current drought. For each case study site, a whole-of-government (Federal, state and local), business and community perspective will be provided on the:

- context and impact of drought on water supply and availability
- context and impact of drought on society, economy, and mental health;
- adaptation measures being put in place as a result of the knowledge gained from previous drought experiences (e.g. use of alternate water supplies, water reuse, water savings projects, drought awareness programs, change in town focus from agricultural to tourism or mining etc); and
- areas where future adaptation measures need to be developed following subsequent reflection on ways of better preparing for such events (e.g. additional/alternative water supplies, changes in agricultural practice, changes in industrial water use).

## The association between meteorological factors and hospital visits of allergic patients with sensitization to tree pollen

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Allergic disease is one of the diseases affected by climate change that is rapidly progressing globally. Pollen is the main cause of allergies and it is affected by meteorological factors. As higher temperature in spring, the start of the tree pollen season is earlier and the total pollen counts increase. The increased pollen counts cause worse

symptoms for allergic patients and increase the frequency of severe symptoms. However, there are few studies about the relationship between meteorological factors and allergic patients sensitized to pollen. We aim to investigate the association between meteorological factors and the hospital visits of patients with sensitization to tree pollen.

The study subjects were adult patients who had medical records of allergy skin prick tests at Ajou University Hospital between April and July from 1999 to 2008 except 2001. We reviewed the results of the tests and defined a patient sensitized to tree pollen as anyone with one or more allergens that was equal to or larger than a positive control solution and non-response to negative control solution. The meteorological factors were the monthly means of the daily maximum temperature, the average temperature, the minimum temperature, the relative humidity, the wind speed and, the precipitation in Suwon between February and April from 1999 to 2008 except 2001. We analyzed the association between annual meteorological factors and the total number of patients sensitized to tree pollen for four months and the trends of the annual numbers of allergy skin prick tests and patients sensitized to tree pollen.

The total number of subjects was 4,715. The mean age of the subjects was 38.4 years (SD, 13.41 years), and there were 2,206 men (46.8%). The number of patients sensitized to tree pollen was 965 (20.5%). The minimum temperature in March significantly correlated with the number of patients sensitized to tree pollen ( $R=0.754$ ,  $p=0.019$ ). There was a significant association between the minimum temperature in March and the sensitization to tree pollen of patients (OR, 1.116; 95% CI, 1.029-1.211). The annual numbers of allergy skin prick tests and patients sensitized to tree pollen had increasing trends. Using each regression equation, the predictive value of the number of allergy skin prick tests in 2008 was 2.6 times higher than in 1999 and that of patients sensitized to tree pollen was 3.5 times.

There was an association between the minimum temperature in March and the number of hospital visits of adult patients with sensitization to tree pollen in this study. This suggests that a higher minimum temperature in March increases the tree pollen counts, and the symptoms of allergic patients worsen, so they visit hospital more frequently.

## Designer Guidance: climate change information for New Zealand users

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Understanding of the local impacts of climate change enables decision makers to consider the consequences of climate change, manage their risks and take advantage of any opportunities. Information and guidance on preparing for climate change that is both useful and used is essential to ensure better decisions are made about planning for the future.

Different audiences require information in different forms of media and even within one audience people have different ways of taking on board information and making use of it. This is why it is important that information is provided in many forms including oral presentations, workshops, printed publications, technical manuals, maps, fact sheets and web pages. Celebrating examples where community and local government have taken steps to prepare for climate change through published case studies is also a powerful way of showing that adaptation does not have to be hard and we have the information and ability to take action now.

The NZ Ministry for the Environment has developed a range of information material and guidance to help New Zealanders become informed about what climate change means for us and what we can do to increase our resilience. Many different types of New Zealanders have an interest in learning about climate change and so the Ministry has developed material for the general public, libraries, schools, planners, hazard analysts, local government staff and engineers. This paper will present examples of the different information available and discuss the purpose and audience of the material, as well as the rationale behind it. For example:

- New guidance on incorporating climate change in to flow estimation, to be published later in 2010
- New web-based, decision-support tool (a “toolbox”) for local government and land managers to help users understand how climate change could affect them and what they can do to adapt
- Maps showing projected changes in regional rainfall and temperature
- Technical guidance on the impacts of climate change on drought, coastal hazards, flooding and fire risk
- Local government guidance manuals and summary publications detailing expected changes to the NZ climate, the relevant legislation and how to incorporate climate change into a risk management approach to decision-making
- Web based ‘Quality Planning’ guidance notes for planners
- Case studies highlighting examples of climate change being incorporated into local government planning
- A stylised climate change impacts map indicating the potential regional impacts of climate change in New Zealand

For informed decision making to succeed, the information needs to get out to the people who will use it. Stakeholders can play a vital role in encouraging the use of guidance and disseminating information throughout their own networks to reach an even larger audience. They can also advocate within their own sector to raise awareness, give weight to government guidance and encourage adaptation and better decision-making. The use of stakeholder networks to lend support to government guidelines on planning for sea level rise will be discussed as an example of the power of stakeholders as part of your communication and dissemination plan.

## Hop, skip and...: Moving beyond the analytical drivers of public health related climate change adaptation to explore the impact of knowledge, culture and risk perception

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Interest in the public health aspects of climate change adaptation has accelerated in recent years. However, the focus has largely remained within mainstream definitions of health, which tend to emphasise the biophysical and associated policy-based responses. This has resulted in public health related adaptation efforts concentrating on those already widely accepted in the climate change literature, that is, the opportunities and constraints offered by the interaction of three key factors: biology, technology, and economics. Viewing adaptation in this way only focuses on exogenous or analytical drivers. What about the impact of endogenous drivers of adaptation such as knowledge, culture and values, and perceptions of risk? How do these inform public health needs? This paper seeks to explore the important relationship between these exogenous and endogenous drivers by drawing on lessons derived from social determinants, human ecology and health promotion experiences. It is argued that a broader view based on a commitment to socio-cultural engagement, inter and intra-sector capacity building and interdisciplinary practice is required if the climate change impacts on public health are to be effectively and sustainably addressed.

## Boonah 2 and Gold Coast 2 – Ecologies of Climate Change

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Adaptation to climate change in cities is typically addressed at the physical and technological level and the adaptation of existing social, economic, political and cultural systems. This presentation questions the assumption that our core values and systems - products of the Enlightenment and the industrial revolution - and their manifestations in cities, will remain suited to a changed environment. It looks at how social, economic, political and cultural relationships might themselves be adapted for the viable future of our cities.

This leads to some proposed revised underlying principles for the design of cities and for the design process itself. It is argued that these principles and the process by which they are applied to the design, building and maintenance of cities must be ecological (non-linear, requiring relational thinking processes) rather than linear, definitive and prescriptive.

The strategy of Metrofitting is presented – a conceptual and organisational approach which puts the city in a position to adapt to climate change. As an extension of retrofitting, metrofitting has a transformative agenda to identify major areas of threat, and develop a framework of strategies to prefigure a viable city future. It engages with the city's cultural and social fabric, opening the doors for changes in ideas related to food production, qualitative economies, shelter, learning and transport.

Two speculative case studies are presented, based on successful submissions for design and ideas competitions. The first examines the parameters of a city for 50,000 people in the Boonah Shire: based on a retreat from much of coastal Brisbane and the arrival of large numbers of environmental refugees. The second examines the economic, social, and physical options for the Gold Coast in the face of significant sea level rise and increased frequency and strength of extreme weather events.

Both case studies present concepts for the re-imagining of these cities, where a pre-emptive engagement with the community assist in the re-direction of the psychological, the forming of new economies, and re-defining cultural and social transactions and objects. This involves designing from the future to the present: imagining detailed viable and desirable scenarios for the future and designing the core strategies and actions to reach them.

## Climate change risk responses through common interests and collective action behaviour: The case of Sydney Bushcare volunteers

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Building adaptive capacity has been established as a central climate change response. Adaptive capacity can be facilitated by government, but increasingly it also requires working in partnership with other stakeholders like private organizations, non-government organizations and individuals. This paper presents a case study of the collective actions of volunteer environmental groups in Sydney as a means of exploring how the actions and interests of individuals may build adaptive capacity. Using the example of bushcare groups of the City of Ryde in suburban Sydney, the paper examines the socio-economic and cultural qualities that strengthen or create obstacles for collective action among the Bushcare volunteers. The paper finds significant common interests in ecosystems restoration and management, shared values and reciprocal relationships amongst bushcare volunteers and across different local groups. These relationships and motivations, the paper argues, can be leveraged to generate material interventions necessary for climate change response.



## Modeling rice cropping schedules in the Vietnam Mekong Delta for adapting to changes in flooding, salinity intrusion and monsoon rains

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A cropping schedule that determine the dates of sowing, planting and harvesting with adequate cultivation management can influence crop productivity, water demand and resources allocation on arable land. Cropping schedules are usually planned to maximize economic crop yield and land use efficiency with minimizing risks of crop damage under the environment. Conversely, environmental change will bring about changes in cropping schedules especially in terms of the duration of crop cultivation and the number of harvests.

The Vietnam Mekong Delta (VMD) located in southwestern Vietnam produced 20.7 million tons of rice in 2008, which is one of major exporting countries of rice in the world. The rice production system being conducted in the VMD has been highly adapted to variable adverse water environment such as seasonal flood, salinity intrusion and onset of monsoon rains. Such adaptation means that the rice cropping schedule in the VMD varies with different regional environment, resulting in variable rice productivity across the delta. Actually, unusual climatic variations such as early flooding, early salinity intrusion and rainfall shortage often cause crop failure. To keep stable rice production in the VMD, the interplay of environmental conditions and cropping schedule should be quantitatively evaluated.

We developed a model for determining the cropping schedule of rice cultivation in the VMD, with adaptation to various water resources constraints to evaluate the effects of environmental change on rice cultivation. For the validation, we compared the model estimates on the heading date and time changes in leaf area index of rice crop with those estimated from the MODIS satellite imagery data at nine selected sites in the VMD. The route mean squared difference between model estimation and satellite with respect to the heading date of rice plant were 17.6, 11.2, and 13.0 days in the upper, middle, and coastal region of the VMD, respectively.

Coupling the cropping schedule model with hydraulic dynamic model of water resources and quality in the VMD, we evaluated changes in cropping schedules and crop failures caused by abnormal flood occurred in 2000 and salinity intrusion in 2004 as the extreme cases. There, we found a simple index defined as the difference between available period and required period for rice cultivation, i.e. safe margin for cultivation (SMC), is very useful for indicating the vulnerability for a cropping schedule adopted in the delta. We also projected climate change impacts on cropping schedule and rice production in the VMD. Several climate change scenarios and the resulting changes in river discharge of the Mekong river were applied to the model. As a result, total rice production in 2030 would decrease by about 11% relative to the present under the A1B SRES with the MIROC hires AOGCM scenario. This is mainly due to reduction in yield, while harvest area do not significantly change. Against these failures, adaptation measures can be considered based on the cropping schedule model.

## Dealing with uncertainty in forest management under climate change

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Adapting forest management to future climate is a difficult task because of the complexities and uncertainties involved. Uncertainty about climate change is compounded by the impacts that climate change has on forest ecosystems, the forest sector and forest-based communities. Much has been written about managing uncertainty, but there is little to guide us in choosing appropriate methods for actually managing uncertainty.

This paper is tailored to the adaptation needs of a selected community in British Columbia, Canada. A recent climate study indicates a range of possible future climatic conditions in terms of temperature and precipitation. Projected temperatures are consistent about a direction of change (i.e. temperature will increase), while there is significant uncertainty in projecting the precipitation change. The impacts of climate change on forest productivity and tree species composition (either as a result of ecosystem adaptation or a consequence of proactive forest management) will affect rotation age, wood quality and volume, size of logs, and, consequently, the distribution of forest products and jobs. The magnitude of socio-economic impacts will depend on the nature and rate of climate change, the response of forest ecosystems, forest sector and communities, and also on the adaptation policies for addressing climate change.

In this paper, we systematically examine uncertainty in adaptation decisions to find parameters related to climate change to which forest resources, the forest industry and local communities are most sensitive. We specifically investigate changes in forest productivity over mid- and long-term planning horizons. A changing climate means that productivity of the local tree species will be affected.

The two approaches to decision-making under uncertainty address different questions. The traditional prediction-based decision-making aims at finding the best strategies under the most likely future climate change conditions. Given that the future climate change conditions cannot be predicted, another approach is to search for the robust forest management strategies.

The decision framework we propose combines the robust planning approach for making decisions under uncertainty with a method for generating strategies under multiple criteria. The proposed framework is illustrated using an example of forest management that aims at maintaining harvest volume over time. Changes in climate variables are linked to the impacts on forest productivity. Opportunities and challenges of the proposed framework are discussed using the preliminary results of a case study.

## **The Adaptation Atlas: A Case Study in Managing Complex Information Needs for Adaptation**

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The debate around adaptation financing, design and practice has highlighted the complex nature of addressing the impacts of climate change. Responses have to be tailored to location specific characteristics, and have to be designed in such a way as to coordinate across diverse sectors and cohesively address the intricate problems that have arisen with anthropogenic climate change. The Adaptation Atlas is one such endeavor that brings together the results behind publications that study the impacts of climate and detailed information on adaptation activities in an attempt to address the various information needs of policymakers, researchers and practitioners in the adaptation field. It aims to serve as a networking agent in the future, eliciting commonalities in technologies and adaptive practices, resulting in the establishment of a 'community of practice'. The paper will outline the framework used to create the Atlas, the data collection efforts and an approach to continue with innovation based on demonstrated user needs, the advances in scientific literature and adaptation practices. It will also highlight the lessons learned from the initial application development and from users' experiences of the tool.

## **Interviewing sceptical farmers about climate change adaptations**

**G Kuehne<sup>1</sup>**

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This paper reports on research undertaken as part of a project aimed at helping irrigators to explore the options for adaptation to climate-related changes.

Semi-structured in-depth personal interviews were conducted during November/December 2009 with eleven irrigation farmers from the Loxton area of the South Australian Riverland. A graphic-elicitation method using five A4 mini-posters was incorporated into the interviews to further draw out farmers' beliefs about climate change. Similar to photographs used with the photo-elicitation research method, the mini-posters were found to be useful for uncovering deeper veins of meaning, as farmers sought to explain what the images, charts and tables presented in the mini-posters meant to them.

For successful adaptation to climate change to occur, farmers first need to understand what climate-related risks exist through effective communication from scientists and others. Farmers then need to be aware of what their adaptation response options are.

This leads to the research aim which was, 1) to better understand the beliefs that farmers held about climate change, 2) jointly uncover and identify what adaptation options farmers have, 3) identify the influences on the decision-making of farmers when they considered adapting to climate change, and 4) establish how their adaptation responses varied according to their beliefs about climate change.

The interviews aimed to explore which adaptation measures such as: altered farming practices; improved risk management; and increased water use efficiency had been adopted (or considered for adoption) as a result of concerns about climate change.

The interview participants live in a semi-arid climate which, when irrigated, is able to achieve high levels of productivity. Prior to 2006-07 these irrigators always expected to receive 100% of their annual water allocation. The research was undertaken at a time when many of these farmers were fighting for financial survival. They were in their fourth year of low water allocations, and were also experiencing declining commodity prices which had exhausted the financial reserves of many. The responses that they have made to the severe reductions in water allocation, of the past four irrigation seasons have shown that they are capable of making changes to counter threats which are outside of their experience, when there is a return on investment to be made, and when they have the resources available to do so.

The interviews showed that farmers found it hard to even consider adaptation to climate change when the effects of the drought, and low commodity prices, meant that the survival of their businesses were at stake. Irrigators perceive that, in the short-term at least, the combined effects of drought and low commodity prices were of a much greater direct impact on them than the effects of all but the most pessimistic of climate change projections.

The interview results were also found to be influenced by the beliefs which farmers held about climate change. Most farmers expressed some uncertainty about the cause of climate change—preferring to explain any observed changes to the climate as natural variability, rather than supporting the idea of anthropomorphic causes.

This research finds that having farmers understand climate-change risks, and having them understand their available adaptation options, may not be enough to cause the desired changes in behaviour. To encourage the uptake of various adaptation options it may also require the use of economic incentives as well as a greater understanding of how, social and other factors interact to influence the decision.

## Farmers' Perceptions and Adaptation Measures towards Climate Change in South India

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Agriculture's vulnerability to climate change will put millions of people in developing countries at greater risk of poverty, hunger, and malnutrition. A new report from the International Food Policy Research Institute, quantifying the costs of agricultural adaptation to climate change, provides projections for decreased crop yields, higher food prices, and increased child malnutrition by 2050, as compared to a scenario without climate change. It estimates that an additional US \$7-8 billion per year must be invested to increase agricultural productivity to prevent these adverse effects. Adaptation is widely recognized as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced. The objective of the present study was to identify farmers' perceptions towards climate change along with their farm-level adaptation measures with a view to suggest appropriate research/policy issues which help in facilitating farmers' adaptation to climate change. A sample of 60 farmers from Pampanur village, Atmakur mandal of Ananthapur district (Andhra Pradesh state of India) was selected randomly. Data was collected using a pre-tested interview schedule from the farmers. Frequency and percent analysis were used for analyzing data. Farmers' recognize the climatic changes by the rise in temperatures, prolonged dry spells, changes in monsoon patterns, delayed and shorter rains, and traditional knowledge on weather forecasts failing. Insurance on crop loans is the major adjustment of farmers' to climate change. Planting contingent crops like sorghum, horsegram, korra and vegetables; change in planting dates of groundnut; increase water availability through increasing storage capacity of reservoirs; construct water-harvesting structures; improved drought forecasting and working as labour under National Rural Employment Guarantee Act programme is the major adaptation measures followed by farmers' in case of drought. Important criteria for farmers' in choosing the adaptation measures are that they should be simple, easy and reliable. Capacity building at local, national and regional levels is vital to enable developing countries like India to adapt to climate change. Education and training of stakeholders, including policy-level decision makers, are important catalysts for the success of assessing vulnerabilities and planning adaptation activities, as well as implementing adaptation plans. Enhanced funding is required for adaptation projects in developing countries and needs to be increased in national budgets as well as in multilateral funds. Govt. policies designed to promote adaptation at the farm level will lead to greater food and livelihood security in the face of climate change.

## Flood risk and climate change: Main challenges to reduce vulnerability in Tunisia

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The study of Tunisian climate during the last century concluded on the detection of a statistically significant trend in the annual average temperature since 1975. We show too, an increase of the rainfall variability since 1980 represented by more frequency of wet and dry years. Climate change projections over the Mediterranean region indicate changes in mean climate conditions (temperature, rainfall). However, climate change is likely to bring changes in climate variability and extreme events as well, which include increase in the frequency and magnitude of hydrological disasters.

All this seems to be confirmed during the last years. So, we have observed a very dry period (1999/2002) followed by three relatively wet years with a very disastrous food over the region of "le grand Tunis" during September 2003. These floods are characterized by a loss of men as well as a very important material damages, due to:

- The intensity and severity of the rainfall, (reach 130 mm / hour)
- The no respect of the building constraint related to the liable to flooding areas.

Regarding the statistical laws such a climate surprise is possible but unlikely. This unexpected climate development may represent a strong signal of Tunisian climate disturbing and constitutes a first sign of climate change.

A better coordination and arrangements between the National Meteorological Institute and The Technical Services can largely improve the flood risk management. About that, we must take arrangements concerning:

- role of networks observations of each institution and integration data information system,
- operating and best use of a reliable meteorological forecasts,
- use of the prevision outputs of meteorological models to initialize hydrological models.

The real challenge is to find mechanism to perform exchange information between the main partners.

Adaptation to climate change is not an option, it is a priority. We need to build a national adaptation plan with emphasis on adaptation to extreme events like flood and drought. It is opportune to reduce our vulnerability to flood through the improvement of the preparedness steep and adaptive actions at long range.

The urban development plans of the city of Tunis and the other urban areas are viable. Nevertheless, regarding the urbanization grow as well as some social constraints, a number of habitable areas are sensitive to hydrological disaster. The struggle against anarchic building is probably the main challenge. We don't need really a new legal provisions managing urban area, we need only to introduce new innovations in the implementation of this legal provisions.

## Facilitated social learning experiences are important for sustainable land-use practice change

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Governments, communities and industries are urgently recommending rural landholders to adopt sustainable land-use practices to protect biodiversity, reduce the environmental impact of farming and become better prepared for the impacts of climate change. For the most part, however, they have been unsuccessful. Understanding what learning processes are important in driving rural landholders to conserve and protect natural resources is essential if we are to design policies that will be effective in accelerating sustainable land-use changes and averting ecological and social decline. This poster describes the results of a study that aims to increase our understanding of individual learning in a social learning process that leads to sustainable change in an industrialised rural agricultural context. I use the case study of the north-eastern Australian beef grazing rangelands where badly managed land is contributing to poor water quality entering the Great Barrier Reef, increased atmospheric dust loads and a loss of biodiversity. Sequential qualitative and quantitative methods were used. Through qualitative interviews with beef producers it was discovered that perceived personal and operational changes that showed signs of increased sustainability involved five main aspects (1) adoption of a more sophisticated management plan to include increased monitoring of stock, rainfall and pasture condition, strategies to reduce grazing pressure and increased business skills; (2) increased environmental awareness, particularly of pasture condition; (3) personal development (4) becoming less risk adverse; and, (5) becoming more proactive and adaptable. Learning experiences that were linked with increased sustainability tended to be interactions with respected peers in courses, workshops and project groups and the networks that resulted from these forums. This social learning process involved producers coming into contact with different life experiences and ideas, collective problem solving, knowledge sharing, a redefining of goals, acquiring skills, developing trust relations, critical reflection of decisions, learning to learn, broadening horizons and becoming more open and aware. Adversity or difficult times associated with drought, labour shortages and/or financial difficulties were seen by producers as strong catalysts for changing practices. Results of the quantitative survey showed that producers who said they were mainly learning from extension activities were significantly more likely than producers who said they were mainly learning from family, neighbours and self practice to report undergoing personal and operational changes that increased sustainability. In conclusion, social learning processes that appear to be developing identities more likely to change to sustainable land-use practices are happening through facilitated extension settings. These processes are providing opportunities for collective problem solving and changing perspectives of land management and beef production. On the other hand, the absence of discussion by producers of undergoing conflict management and negotiation processes as part of a need to overcome shared social-ecological problems, as well as a heavy emphasis on improving pasture rather than non-productive landscape features, indicates that different kinds of extension experiences are also likely to be necessary to transform the underlying assumptions of productivism. Increasing the opportunities for rural landholders to engage in these extension opportunities during drought and other difficult times could accelerate the 'change process'.

## Understanding Perceptions of Future Climate Change to Inform Adaptation Needs: A Case Study of the Rewa Delta, Viti Levu Island, Fiji

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At the forefront of threats emanating from changing climates are the people of the developing world, where the effectiveness of environmental policy and top-down decision-making to bring about appropriate and sustained adaptation is being increasingly doubted. Having their own set of shorter-term socio-economic challenges, people of the developing world often fail to perceive the risks associated with future climate change. The wealth of literature, mainly from the developed world, concerning public perception of climate change demonstrates the importance of risk perception in responding and adapting to climate change. Adaptive strategies in developing countries can be implemented successfully only through community empowerment, to which an understanding of the perceptions of climate risk is essential.

Pacific Island Countries are a particularly vulnerable region of the developing world owing to their comparative smallness, remoteness, fragility of ecosystems, limited resources, and heavy dependence on marine and coastal resources. In most parts of the Pacific, coastal ecosystems and communities are already experiencing changes in the natural environment as sea-level rise erodes coastlines and king tides inundate agricultural and freshwater lands. Using data from a survey of households and stakeholders, this paper discusses research on climate change risk perception undertaken in the Fiji Islands. The case study area is the Rewa Delta, in south-east Viti Levu, the largest island of the Fiji group. The Rewa delta is a low-lying area and is naturally exposed to sea-surges and river flooding. It has a population of >100,000, mostly indigenous Fijians occupying their traditional land along river banks. Livelihoods involve a heavy reliance on the river and the sea for subsistence.

The results obtained show that climate change is not perceived as an issue of high concern by the people of the Rewa Delta. Although many of the respondents have heard of the term, most commonly from the media, most are not aware of the nature of changes and the risks associated with climate change. Even though changes are evident in the natural environment in the form of increased erosion, king tides and inundation, people commonly see these as something normal

and natural - something they cannot do much about – which they feel it is happening because god is punishing them. The communities do not plan to re-locate even if threats intensify due to their strong cultural links with the land they occupy. Risk perception is centered more on short- term climate variability and is thus a barrier for longer-term climate-change adaptation in the Rewa Delta. The results imply that appropriate methods of risk communication, using vernacular languages and indigenous concepts, are important for promoting adaptation among such communities. An understanding of risk perception among vulnerable human communities is essential before developing specific climate-change adaptation solutions.

## **Sustainability Assessment of a Climate Change Adaptive Urban Development: Ridges at Peregrin Springs, Sunshine Coast, Australia**

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A sustainability assessment was conducted by the University of the Sunshine Coast of an integrated water supply system proposed at the Ridges at Peregrin Springs estate on the Sunshine Coast, Australia. The need for innovative water supply strategies was demonstrated by the recent water shortages experienced in South East Queensland. An evaluation of the three pronged strategy indicated that the estate could become a net exporter of water and that the approach had potential for broader applications in other developments. A key outcome of the study was a methodology that could be used to assess water supply strategies in future developments.

The Ridges project incorporated Holbrook's principles for Climate Change Adaptive Urban Developments (CCAUD). Operationally, the project advances the strategies for Total Water Cycle Management and Water Sensitive Urban Design. Additionally, CCAUD aligns well with government regulation for urban water management and policy direction in Australia for climate change adaptation. CCAUD provides an integrated approach taken to enhance the climate adaptive capacity of new communities.

Non-potable water for Ridges will be produced from a sewer mining operation on the estate. The extracted water will be treated to an A+ quality and distributed via a purple pipe system for non-potable outdoor uses and toilet flushing.

Potable water demand will be met through a hybridised approach involving an innovative community roof water harvesting system which is backed up during the dry weather by traditional mains water supply. Water collected from roof tops will be treated to a potable level and distributed within the estate and exported to nearby communities through the existing mains water network.

It has been demonstrated that overall, the amount of water produced from the two decentralised approaches may exceed the total annual demand of the estate. This means that the estate could effectively provide a net surplus to the water grid, despite its continued reliance on mains water supplies during dry weather. Further benefits to centralised water infrastructure are provided from the reduced need to treat effluent flow from the estate.

Commissioned by the Sunshine Coast Council, the University of the Sunshine Coast conducted the review of the Ridges CCAUD proposal. A Triple Bottom Line approach was adopted to identify and assess the biophysical, social and economic costs and benefits of the CCAUD project compared to BAU approaches.

It was found the CCAUD approach could supply a more reliable source of water (even under drier climate change conditions), required less energy, produced less greenhouse gas emissions and could be produced in a cost competitive manner. Of particular interest are the latent possibilities for a broader application of CCAUD practices to Greenfield developments and the potential to supply potable water from non-traditional sources to established housing without the need for expensive retrofitting.

As a product of the assessment process, a model has been proposed that provides a step-by-step methodology that could be used to assess future consideration of CCAUD projects. This methodology is highly applicable in regions that are expected to experience the dual pressures of high population growth and changing climatic conditions.

## **From coping to managed retreat- a transition approach for adapting to sea level rise and increased flood frequency**

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This paper discusses a transition approach to assessing options and feasibility of managed retreat; and the tools needed for its implementation.

Projections for New Zealand's two most significant direct climate change impacts by 2100 indicate an up to fourfold increase in flood frequency, and sea level rise of 18-59cm or more, depending upon the emissions scenario and response of the polar ice sheets to warming (IPCC 2007; MfE 2009). Adaptation to climate-related impacts in New Zealand has to date focused primarily on coping strategies (such as emergency management, stop banks and sea walls, raising minimum floor levels, accepting more frequent localised flooding, and soft vegetative buffers), rather than a more strategic approach to reduction or

avoidance of harm from such events (PSConsulting and David Hamilton and Associates, 2007; Lawrence and Allan, 2009).

Sea level rise will continue for centuries even with stringent mitigation (IPCC 2007). Flood frequency is likely to increase at least in the medium term. It is therefore likely that physical protection and adaptation measures aimed at coping with increased physical hazards will eventually become insufficient or ineffective. The high costs associated with community and infrastructure impacts near the coast and on flood plains will mean a range of response options are likely to be required in the coming decades, but ultimately, retreat from the most exposed coastal and flood-prone areas will be unavoidable. Costs are potentially reducible if managed response strategies to reduce exposure to flooding and inundation are adopted early.

Managed retreat has been suggested as an important long-term response to climate change but has not been researched thoroughly in the New Zealand context (Environment Waikato 2006). Examples from communities that are already exposed to hazards that have proven difficult to manage, can offer some analogues for developing a general transition approach to managed retreat, and indicate the extent to which this could actually reduce the vulnerability of different population groups and communities at risk from sea level rise and river flooding. The response options discussed include consideration of 'worst case' sea level rise scenarios based on observations and projections since the last IPCC assessment (e.g. Pfeffer et al., 2008; Vermeer and Rahmstorf, 2009; Velicogna, 2009), including projections beyond 2100 (e.g. Delta Commission 2008).

Transitioning to and implementing a managed retreat policy will need to deal with several interlinked time horizons as well as physical and socio-economic inertia. Challenges include (a) developing a clearer framework for understanding the limits of current adaptive coping strategies, (b) formulating and gaining community acceptance of managed retreat as a policy option, (c) identifying the decision points for introducing managed retreat policies, (d) the time required for managed retreat policies to deliver effective changes, (e) the time needed for any required institutional changes such as legislation, plans, rules and their effective practice, (f) the lifetime of infrastructure and existing-use rights that could determine the economic and environmental costs and benefits as well as social and cultural implications of managed retreat.

It is unclear at this stage how a range of cost-effective, equitable and acceptable responses to increased flood and sea level risk might unfold temporally and how a transition to managed retreat might be implemented. This paper explores the available regulatory and non-regulatory tools for managing a transition, from coping strategies and first-round physical protection to managed retreat, and discusses their adequacy and necessary policy and regulatory framework, guidance and potential best practice information. The likely barriers to managed retreat and possible thresholds that could trigger decision-makers to move from coping to managed retreat are also explored. We are currently in the process of further developing and testing this approach in a specific context, the results of which will be presented in a subsequent paper.

## Using climate change scenarios to direct habitat restoration

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Habitat restoration can increase landscape resilience through buffering fragile habitat, protecting ecosystem services or increasing landscape linkage. Large amounts of time and money are invested in restoration projects targeted at attaining some or all of these goals. However, restoration implies an attempt to bring back a former habitat, and as rainfall intensity, duration and seasonality changes, so too will the distribution of vegetation for which hydrology has a key influence.

We aimed to quantify the impacts of climate change by applying a realistic climate change scenario to riparian systems in a lowland floodplain in Queensland's Wet Tropics Bioregion. The Tully and Murray catchments were cleared over the course of a century from the 1880s, with accelerated clearing and draining of swamps in the 1960s. These rivers rise in the uplands and foothills of the Wet Tropics, and drain areas which experience up to 7000 mm rain per annum, though with a pronounced dry season of several months duration each year. Consequently the pre-clearance vegetation is a complex of lowland rainforest, eucalypt woodland and swamp communities. Approximately 26% of the riparian vegetation is cleared today, and we assess the differences in target communities if restoration were aimed at pre-clearance vegetation (c. 1880) or at the most-likely community in 2080 based on models of current climatic correlates with extant vegetation.

Climate change scenarios were developed using a feed-forward artificial neural network. This model uses climate, soil parent material and terrain variables to characterise future potential vegetation. There are 15 vegetation types relating to the model. GIS analysis was used to determine the difference in vegetation types under different climate change scenarios in the Tully-Murray catchments. Buffers based on stream order defined the riparian area. Areas of no riparian vegetation were found using the regional ecosystem data combined with the riparian buffer. Vegetation types existing at three times (pre-European settlement, current and 2080 under a warmer, drier scenario) were assessed and compared.

Lowland rainforest contribution to riparian vegetation increases from 37% of the pre-clearance community to over 77% in the 2080 scenario. This increase is achieved by significant declines in almost all other vegetation types, including from 24% to 0% by semi notophyll and semi microphyll (cool, wet) forest and from 4% to 0.5% in swamp forests. Targeting restoration activities at pre-clearance communities would result in planting schemes representing the major vegetation types present today, including swamp woodland communities. Climate change scenarios suggest that by 2080 the warmer, drier climate is likely to make swamp woodland unsupportable and lowland rainforest the dominant community type across the lowlands. Areas in rain shadows are likely to see a greater preponderance of woodlands dominated

by *Acacia* spp. and *Eucalyptus* spp. Consequently a restoration aimed at pre-clearance vegetation is likely to target a community unlikely to be favoured by prevailing climate in 53% of the catchment if all currently cleared riparian strips were planted. This would result in the waste of valuable resources, and fail to meet key restoration targets. We suggest that similar scenario planning is undertaken in other regions where extensive restoration plantings are planned.

## Developing an Integrated Regional Vulnerability Assessment - A Pilot Project in South Eastern NSW

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The impacts of climate change are likely to have significant implications for our environment, economy and communities. Many impacts of climate change are already underway, while many others may not be felt for decades. We need to start planning now for climate change to ensure our environmental, social and economic systems are able to cope. We need to adjust our policies and actions to help our ecosystems, infrastructure, communities and productive sectors adapt to the future impacts of climate change.

Current leading practice indicates that to effectively respond to climate change, a comprehensive and integrated process is required that

- a. begins with scoping and assessing the components of vulnerability within a region,
- b. assesses climate change risks and opportunities to identify priorities, and
- c. results in the development and implementation of a climate change preparedness plan or adaptation strategy to address priority risks and capitalise on opportunities.

Vulnerability assessment is an important first step towards developing a credible adaptation strategy. The essential quality of a vulnerability assessment is that it informs actions to reduce vulnerability or build adaptive capacity and resilience by decision makers in communities and industries. In many cases, adaptation will be largely managed by individuals and businesses, with only an indirect facilitating role for public policy.

An integrated vulnerability assessment is one which brings together assessments of different sectors and communities, and explores the dynamic relationships that exist between them. Exploring these relationships can provide a more holistic assessment of a region's vulnerability to climate change.

The NSW Department of Environment Climate Change and Water (DECCW) in conjunction with a regional network of NSW Government managers is conducting a regional vulnerability assessment to climate change in the South Eastern part of NSW which encompasses the South Coast, Alpine region and the Southern Tablelands. The SE region is a pilot project for the eventual roll-out of similar assessments across the state.

### Key objectives

4. A credible basis for adaptation planning: Vulnerability assessment is an important first step towards developing a credible adaptation strategy. The aim of the vulnerability assessment is to be able to judge possible actions against their potential to reduce vulnerability. The assessment will conduct a preliminary analysis of the key sector and community vulnerabilities to climate change in the medium term (to 2050).
5. Capacity Building: This pilot project will significantly enhance the capacity of the NSW Government to conduct future vulnerability assessments by refining best practice methodology. This can in turn be applied to the rest of the state. As a participatory process, the project will itself build the adaptive capacity of stakeholders by providing an opportunity to consider climate change impacts and constraints and enablers of adaptation on a sector and cross-sector basis.
6. Leading Practice Model: The project will provide a leading-practice operational model for developing effective regional climate change vulnerability assessments. An anticipated outcome is the development of an evaluation report and leading-practice guide which can be used to guide subsequent projects across the remaining State Plan regions of NSW.
7. Enhanced coordination of service delivery: As an integrated, 'whole of government' project, it will also strengthen inter-agency relations and collaboration. This will be important to the implementation of adaptation actions identified during this project.

## Waves of change: Community discourse on a local policy of 'planned retreat'

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Resilience to sea level rise depends on being able to adapt/transform from situations when they become untenable and this is determined by the ability of the community to take advantage of new opportunities. Local councils in coastal communities need to manage transition to new types of institutions that are flexible enough to manage a dynamic sea level. Yet there are few empirical examples of how this can happen. This case study looks at one local community in New South Wales, Byron Shire which has had a policy of 'planned retreat' since 1988. This policy has been mostly latent until 2009 when erosion from storm across the region directly threatened a number of private properties in the beachside suburb of Belongil Spit and triggered the implementation of the planned retreat policy.

To investigate the community response to the policy of planned retreat this study looks at community discourse in the two local newspapers. The power of news media in portraying public issues and being able to both inform and shape public opinion is well documented. Community discourse in the local media provides a window on local framing of issues and focuses on the actual impacts on people lives and can influence action. It can also reveal the local understanding of the phenomena, evidence/knowledge and associated issues, different expectations of authority and action, and normative judgements of values, concerns, risks and uncertainties. Major themes that emerge from this analysis of more than 100 news articles published over eight months include issues around: problem framing, risk perception, equity, parochialism, sense of place and identity.

The discourses that are examined in this case study will assist local governments that are considering the option of planned retreat as it can help them to better engage with their community over issues of risk and uncertainty with the goal of developing more robust and equitable planned retreat policies and so transition to more resilient coastal institutions. However the conclusions drawn also raise questions about the current capacity of local governments to manage issues of high levels of risk and uncertainty and heightened community conflict. Community discourses at this scale are likely to focus on the small scale spatial and temporal perspective and so limit the potential to transition to more robust and dynamic coastal institutional arrangements that will build resilience to sea level rise in the longer term.

## Local government as knowledge brokers for effective climate change adaptation

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Increasingly it is being advocated that the local scale is the most appropriate level at which climate change adaptation should occur. This is the scale at which impacts of climate change will be felt, at which local knowledge can be utilised and experimentation and learning can take place. Therefore local authorities, as the level of governance closest to the people, are considered to play an important role in supporting their community's resilience to climate change through facilitating and co-ordinating knowledge and action between the community, industry and higher tiers of government.

A lack of sufficient knowledge of climate change and specifically on local level impacts is frequently identified as a barrier to effective management of climate change adaptation by local authorities. This has resulted in the calls for 'more and better' science as well as for 'more and better' public understanding of the science. This is despite clear evidence from social science disciplines that 'more and better' scientific knowledge is only one aspect of individual or public decision making. Even as there is increasing debate and action on climate change, it remains unclear at the local scale what is the role of knowledge, whose knowledge needs to be included, and how it can be used in effective institutions for adaptation to climate change. Operating as a boundary organisation local government must span the divide between policy and science to function as an intermediary between both the producers and users of knowledge while recognising the cultural limitations and constraints of both (Gurlan 2001, McNie 2007). While there has been an expansion of the suite and breadth of 'boundary' concepts that emerged from social and political sciences the application and testing of this concept has been limited and has not been attempted in the context of local government.

To examine the realities of local governments managing knowledge for adaptation to climate change we look at two local authorities in the coastal area of the Great Barrier Reef region. The GBR region, as a social ecological system, is predicted to be one of the regions of Australia most affected by global environmental change due to altered average climatic conditions, elevated sea levels, and increased extreme weather events such as cyclones and associated storm surge. In the GBR region there are a total of 29 councils which comprise one city council, six shire councils, 12 regional councils and 10 Aboriginal councils. Through document analysis and semi-structured interviews with both council staff and elected representatives, our case studies investigated one rural coastal shire council and one coastal regional council. Through these two case studies we explore the capacity of these local authorities to effectively broker knowledge between the research community, the local community and the state government.

The findings from these case studies illustrate the complexities of knowledge brokering within these two local authorities. The 'thick descriptions' provided by the case studies will assist knowledge producers and users, as well as decision makers across all tiers of government, to better understand the perspectives and needs of local authorities in the production and integration of knowledge for effective adaptation policy.

## Monitoring, evaluating and reporting climate change adaptation in local governments in Sydney, Australia

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The Sydney Coastal Councils Group (SCCG) together with CSIRO's Climate Adaptation Flagship and the University of the Sunshine Coast has recently completed a two-year research project on Climate Change Adaptation. Project outcomes have included assessing and mapping vulnerability of the Sydney coastal region (Preston et al. 2008), identifying key barriers and opportunities for climate change adaptation in local councils (Smith et al. 2008a) as well as recommending strategies to manage them (Smith et al. 2008b). The present research is extending this work by focusing on monitoring, evaluating and reporting actual climate change adaptation activities in local councils.

Climate change (CC) adaptation needs to be monitored to direct, control and evaluate resources invested in



different climate change adaptation measures. Consistent monitoring, evaluation and reporting would not only aid decision making in local councils but also enable other levels of government to track local adaptation progress and subsequently provide more effective incentives and policy guidance to foster adaptation.

Thus, although monitoring adaptation is vital for a coordinated response to CC and for improving resilience, currently there is “no evidence of systematic monitoring and evaluation” of adaptation in SCCG member councils (Smith et al. 2008b: p.86). It is hypothesized that, if monitoring of CC adaptation takes place at all, this is done implicitly as part of general reporting, done inconsistently between councils, and receives only unsystematic attention by decision makers.

The present research aims to set the path for a consistent CC adaptation monitoring and reporting in local councils. In reviewing councils’ current monitoring and reporting requirements, existing metrics relevant for CC adaptation will be identified. Additional metrics will be proposed where appropriate together with ways to incorporate them into existing reporting requirements of local governments.

Workshops with councillors and council staff will analyse existing monitoring efforts and discuss relevant indicators. In a second step, in-depth case studies with selected councils will address challenges such as defining the boundaries of adaptation. In addition, an international literature and practice review will be undertaken to identify best practices in adaptation monitoring and evaluation.

Overall the research aims to develop a model for monitoring, evaluating and reporting adaptation activities at local level, thereby promoting councils’ role in CC adaptation.

The poster will present initial findings open for discussion at the NCCARF conference.

## **Decision Making in a Changing Climate: Responding to Uncertainty, Surprise and the Lag of Impacts**

**K Levin<sup>1</sup>**

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As a result of the unprecedented rate of human-induced climate change, there is now widespread consensus that unless proactive adaptation efforts are embraced, significant and sustained climate impacts will be borne by human populations and ecosystems. While mitigation activities will direct efforts to curb greenhouse gas emissions, adaptation efforts will be needed to bolster the resilience of human-built and natural environments.

Yet the problem of climate change is riddled with surprises, lag time before impacts are felt, and uncertainty – characteristics that pose challenges to decision makers faced with integrating climate impacts into planning and policy processes. Unfortunately human society has always found anticipation challenging and our decision-making processes are often slow to react to, learn from, and foresee change. Those most vulnerable have little to no resources to wrestle with today’s climate impacts, let alone contend with future impacts, some of which are too uncertain to predict with a high degree of certainty at present. Also, decision makers tend to prioritize current risks, even if efforts are better spent towards mitigating future risks or goals cannot be achieved without planning for future risks.

How are legislators, planners, and regulators to respond to climate change’s surprises and prepare for short- and long-term impacts, especially if resources may be scant and regions and countries face other pressing needs? The World Resources 2010, a joint publication between the UN Development Programme, UN Environment Programme, the World Bank, and World Resources Institute, will explore the topic of “adaptation decision making in a changing climate.” It will take as its premise that existing decision-making paradigms cannot contend with the uncertainty, surprise, and long lead time of human-induced climate change. In doing so, it will make the case for adaptation decision making that puts a premium on both rapidly responding to and anticipating change, and thus incorporating climate risks and uncertainty. It will demonstrate how integration of climate impacts into decision making can be seen as an opportunity to enhance development and wellbeing in a changing climate.

Accordingly, the research objective of the 2010 World Resources Report is to determine which options are available to decision makers that will allow them to advance policies and plans that withstand and prepare for a changing climate. Specifically, we seek to shed light upon decision-making innovations that can:

1. react to change quickly to contend with surprises; and
2. anticipate change and deal proactively with uncertainties and the lag of climate impacts, advancing interventions in light of impacts that may only manifest themselves far into the future but which are of necessity demand early intervention.

The Report will focus on adaptation in developing countries, and will provide guidance for how decision-making processes can be made resilient themselves in order to provide the enabling environments necessary for communities and ecosystems to thrive in a changing climate.

The Report will draw upon case study research, ask experts and practitioners relevant policy questions and collect commentaries, host internet-based and in-person roundtables, and perform related independent research and analysis. The empirical findings from the research and case studies will pave the way for policy prescriptions. While the Report will

focus upon national and sub-national decision-making processes, recommendations will be designed for decision-making innovations that provide the enabling environments necessary for communities and ecosystems to thrive in a changing climate. The Report will conclude by proposing a roadmap for adaptation decision making in a changing climate.

In this presentation, we will discuss our findings thus far.

## **Assessing the impacts of climate variability and change on community agriculture projects; an approach for local adaptation strategies**

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Community agriculture projects in Tanzania rely on seasonal rainfall as the sole source of water for crop production. Identification of the risks and impacts on community agriculture projects is a key step towards sustainable adaptation in a changing world. Adaptation is a process with multiple components, such as awareness raising, capacity building, stakeholder participation, mainstreaming, and impact assessments. As far as impact assessment on community agriculture projects is concerned, an emphasis on the appropriate combination of both bottom-up and top-down approaches are needed. This can serve to identify the location of specific impacts which require local adaptation strategies to benefit a rain-fed agricultural system.

A combination of bottom-up and top-down approaches using the Participatory Rural Appraisal and SimCLIM tool respectively were used to assess the impacts of climate variability and change on the community agriculture project (DASIP), in Shinyanga region, Tanzania. Findings showed that the top-down approach tends to generalize the findings, and most identified impacts do not represent the reality of the observable impacts to the local farms. However, this approach has contributed to a solution of allocating areas suitable for a rain-fed agricultural system through spatial modelling of mean rainfall. The impacts were identified by using Participatory Rural Appraisal to assess community seasonal activities, observable impacts, and coping strategies. The findings indicate that seasonal shifts, dry spells, extreme events such as drought and flood, and rainfall distribution are the major impacts facing community agricultural systems. Farmers indicate that dry spells are the major impact on rain-fed agricultural systems. The modelling of the local extreme events and seasonal rain showed the greatest impacts on rain-fed agricultural area.

This study suggests that modelling the local climate impacts on the agricultural sector using the bottom-up approach is very important and should focus on the seasonal rains especially the duration (the length of the rainy season) and extreme events. This information informs the project manager and farmers on the likely changes to the lengths of the rainy seasons, the frequency and intensity of extreme events so that they can decide on which adaptation strategy to adopt regarding the seeds or type of crops to be planted in their local area. Also the top-down approach can provide valuable information to financial donors and the government to allocate community agricultural projects to the area which receives adequate precipitation. This study recommends that more research is needed on the modelling of dry spell which always occur during the crop seasons, so that information can be incorporated in a projects design to increase crop productivity in rain fed agricultural systems.

## **The role of decentralized community-based renewable energy systems for climate change adaptation**

**D Ley<sup>1</sup>**

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This paper examines the role that decentralized renewable energy (DRE) systems have in increasing rural populations' adaptive capacities towards extreme weather events. I argue that DRE is a viable solution to meet climate change adaptation goals by being useful to prepare for and during a disaster; in the aftermath of a disaster, such as for relief and reconstruction; and in the long term, by enabling development and thus increasing adaptive capacities and bridging the gap between adaptation and development. Rural communities throughout Latin America have increasingly suffered the impacts of climate change and few policies exist to help them adapt to these impacts. The basic infrastructure and services that they frequently lack can be provided by low carbon technologies, potentially funded by international carbon finance flows that could enable the Millennium Development Goals of economic growth and poverty alleviation to be met while minimizing carbon emissions. Therefore, DRE can contribute to the mainstreaming of development, climate change mitigation and climate change adaptation policies and practices. Political Ecology provides a useful framework for evaluating rural renewable energy projects, focusing on structures, markets, local response to development interventions and to the material effects of development on the physical environment. In addition to applying the theoretical framework of Political Ecology, I used the Pressure and Release (PAR) Model, which explains disasters as the 'intersection of the natural hazard and the processes that generate vulnerability'. These processes, examined under a political ecology framework as the relationships between political and economic structures and between the physical environment and communities, are categorized as root causes, dynamic pressures and unsafe conditions, and are based on physical, political, economic and social environments. I assessed fifteen community-owned renewable energy projects to analyze whether current renewable energy projects are achieving their goals. The case studies are located in Guatemala and Nicaragua, countries that have a generally low Human Development Index and are most likely on track to meet the Millennium Development Goals (MDG's) in the rural areas. Much of the urban population has access to electricity in contrast to a large rural population that doesn't have access to the national grid. Rural poverty, land degradation

and over-use of natural resources are common. These countries are affected annually by hurricanes and tropical storms, which exacerbates poverty and causes setbacks to development. The prospects for the increased use of rural renewable energy for sustainable development are considerable, as are the need for increased climate change adaptation and the potential for increased climate change mitigation efforts. The case study projects were established primarily as development, emissions reductions, climate change adaptation and disaster relief. The projects were evaluated on economic, development and climate change indicators that include sustainable development, poverty alleviation, emissions reductions, and climate vulnerability. I examined how the existence and type of common property governance, local historical and environmental background and project implementation process influence the project success in meeting multiple objectives of climate adaptation, mitigation and development. Research methods included participatory poverty assessment techniques, semi-structured interviews, stakeholder analysis, and a combination of rapid and participatory methods. Technical inspections of the renewable energy systems were carried out using approved standard inspection protocols. The main finding is that DRE systems can play an important role within climate change adaptation by decreasing vulnerability to extreme weather events. However, DRE can also increase vulnerability if there is the creation of real or perceived danger, creation or exacerbation of social tension and lack of safety and quality practices. DRE is an effective way of 'mainstreaming' climate change and development policies and practices. It was also proved that the existence and type of common property governance, the local historical and environmental background of the site and the project implementation process influence the project success in meeting its stated goals. I conclude that actions that enable adaptation also enable development, but not necessarily the reverse. Development projects must be designed with climate change adaptation in mind to ensure the robustness of the technology to withstand extreme weather events and the community organization and unity in the case of an emergency.

## **A differential vulnerability assessment of Darwin, Australia: towards a better understanding of adaptive needs in urban settlements**

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The impacts of climate change have been, and are predicted to be, significant and wide ranging. They occur across all spatial, social and biophysical scales and commonly include long time frames with lag effects originating in the past and spanning into the future. To date, assessments of the impacts of climate change have tended to focus on rural systems and natural resource management, at the global, regional, national and sub-regional scales. Rarely do they focus on local scale impacts and vulnerabilities of urban settlements. The past, present and future impacts of climate change on urban settlements are likely to exacerbate pre-existing vulnerabilities and may cause new ones. This paper assesses climate change impacts and vulnerabilities at the local urban scale, to complement more common and broader regional studies. In particular, a case study carried out for this purpose provides an assessment of differential vulnerability across Darwin, the dry tropical capital at the top end of the Northern Territory of Australia. The aim is to provide input into policy and community debates, to be used in conjunction with other information, as an aid to the discussion of the implications of, and possible adaptive responses to, climate change.

This paper presents the methodological approach used to conduct the differential vulnerability assessment of Darwin. It describes the challenges of the approach, which used both spatial and people-focussed qualitative methods. The assessment concentrated on four environmental stressors: increased cyclone wind damage risk, increased storm surge risk, sea level rise and increased discomfort, through temperature and humidity. Due to the availability of social data, the spatial unit of scale chosen for the study was the environmental management units (EMUs) provided by Darwin City Council. The social data available at the EMU scale enabled the differential vulnerability assessment to present findings in terms of the effects on people; places and infrastructure; economy; and the natural environment, from a people-centred view.

Findings include: 1) an assessment of cyclone shelter capacity in the case of increased cyclone wind intensity and increased shelter capacity needs as a result of climate change; 2) an assessment of the exposed population living in the storm surge zone using different published zone delineations, and the distance to nearest tropical cyclone shelter; and 3) an assessment of the impact of temperature and humidity on human discomfort and the flow on effects on water and energy consumption across Darwin. Vulnerability to the four stressors are also ranked and presented spatially as well as in a summary table that highlights areas of increased concern in relation to the stressor. Adaptive needs and policy responses are discussed; however, no specific recommendations are made. The study concludes with a call for further action, commitment and interaction from whole-of-government, non-government, private and community entities to fully assess the community's adaptive capacity and identify future adaptation needs.

## **Financing climate-adaptive urban infrastructure in developing cities**

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Cities are on the forefront of combating global warming. The prospects for the development trajectory of cities will play a determining rôle in addressing the climate change challenge. Although around two-third of world energy (7900 Mtoe in 2006) are consumed in cities contributing roughly 80% to global GHG emissions (OECD, 2009; WB, 2009). Meanwhile, cities are the most fragile places to climate change. The future of hundreds of millions of people in urban areas across the world will be affected by the different impacts of rapid urbanization and climate change. It is estimated that in addition to sea level rise, 3

to 4 of every 10 non-permanent houses in cities in developing countries are located in areas prone to floods, landslides and other natural disasters – further exacerbated by climate change. The adaptive capacity and the capability of systems to actively and adequately respond are largely influenced by wealth, availability of technology, appropriate decision-making capabilities, human capital, social capital, risk spreading (e.g. insurance), ability to manage information, and the perceived attribution of the source of stress (UN-Habitat 2008). Importantly, financing climate resilient infrastructure in cities are one of the key components out of these determining factors and allow for enhanced capacity building in cities confronting CC challenges.

The urbanisation is expected to continue throughout the world, global population will grow to 9 billion in 2050, of which more than 70% in urban area (UN Habitat, 2008). Increased urban population implies the rise in demand for urban infrastructure and services: housing, transport, energy, water supply and waste management. How to manage the quality of infrastructure in cities to make them resilient to climate change is crucial to improvement in social welfare in development countries for the decades to come. The question of capacity building of climate change adaptation should be addressed properly. Moreover, the efficient operation and expansion of infrastructure in developing countries is crucial for economic growth and poverty reduction (Estache and Wren Lewis 2009). However, if the current urban development patterns remain unchanged, greenhouse gases (GHG) emissions from fossil fuels combustion in cities will skyrocket in the next decades, making the +2°C target of IPCC (2007) unlikely to be achievable. Altering development trajectory in cities plays a vital role in future climate regime (Nature, 2009).

The COP-15 has included the 2°C target in the major terms of the Copenhagen Accord, however the clauses on finance of climate mitigation and adaptation, in particular in vulnerable cities still remain uncertainty. In this regard, one of the key issues in post-Kyoto negotiations is to reach consensus on how to finance actions needed in fast-growing developing countries (DCs) to enable altering the business as usual trends and to increase their climate resilience and adapt the induced climate change for the coming decades.

This study aims to establish a policy framework that allows reorientation of upfront investment in urban infrastructure for changing pathway to increase their CC adaptation capability by harnessing economic lever to facilitate sustainable and climate-friendly development trajectory in cities. It explores different climate finance mechanisms and their applicability for climate resilient infrastructure development in the context of fast urbanization in developing cities. CDM, programmatic CDM and sector crediting approach including Sectoral No-Lose Target (SNLT), SD-PAMs and NAMA are analysed with regard to their policy relevance, implementability and economic and environmental effectiveness as well as related challenges in light of scaling up financing actions in cities. Appropriate financing schemes including carbon finance are needed to be integrated in the post-Kyoto regime for shifting the BAU trajectories to adapt to climate change in cities in DCs.

## **Toward the synthesis of implications of climate change for regional food security: modelling approach and a case study**

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This paper presents a modelling approach to investigate the synthetic impact of climate change on regional food security. An integrated model system, Food and Water Security Integrated Model (FAWSIM) was developed to assess the climate change impact on food security in different scales from global to local. The system integrated a suite of tools, including, drought risk assessment index (DRI), Food Security Index (FSI), crop model DSSAT, and food balance models, etc. These tools were employed to assess the synthetic impact of climate change on food security of Jilin province, China.

Using the drought risk assessment tool, from the ensemble of 120 runs (6 SRES emission scenarios 20 GCM change patterns), the results showed, at global level, a consistent projection of higher drought disaster frequency (DDF) than that of baseline for most world cropland. It indicated an overall enhanced drought risk in future. Both drought affect area and drought intensity tended to increase with rising global temperature. The median value of ensemble for the drought disaster-affected area increased from 15% of baseline to 44% by 2100. The average cropland drought risk index (DRI) doubled from baseline 52.45 to 104.60 in 2050, and continue increased to 129.40 in 2100. Correspondingly, the drought affected rates of yield reduction of major crops increased significantly, more than 50% in 2050 and almost 90% in 2100.

Regionally, Food production risk was investigated DSSAT maize model. From DSSAT results, Jilin's maize yield was highly likely to decline in the western and central, the high productivity area at present, but to increase in the current marginal growing areas in the east. The major phenological reason for such decline was due to the reduced growing season in the west and central, leading to a shortened grain filling period. The average maize yield in the west and central was projected to decrease 15% or more by 2050 as predicted by 90% of the 120 samples.

The FSI focuses on regional and local scales food availability, accessibility, and utilization, which took 13 food security related local aspects as indicators. The model results showed relative high values of present and future climate conditions for most cities and counties in the central area of Jilin, indicating a high resilience of these areas' food security to climate change impact. Most counties in the west and a few in the east showed consistent low FSI values at baseline and future climate conditions, indicating relative high vulnerable situation of these areas .

Two potential adaptation strategies, increase irrigation and shift of maize cultivar, were identified from the

vulnerability assessment and tested for Jilin. Increase total irrigation helps to maintain the current production level but only if the warming trend is under certain threshold, while the improvement of maize cultivars provides a more resilient solution against the future warming climate for the region in the long term.

## **Rural livelihoods, vulnerability and adaptation to climate hazards: Reflections on a case study in Ningxia, Northwest China**

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This empirical study addresses the role of climate variability in the livelihoods of agricultural communities in Ningxia, Northwest China. The study explores exposure and vulnerability to climate and other stresses and capacity to cope with and adapt to changing climate risks. Data include meteorological observations and official reports to describe recent climate variability and its impacts and questionnaires and focus group discussions to understand vulnerability. Sample villages were located in three different agro-ecosystems; irrigated, mixed irrigated/grazing, and rainfed.

Ningxia's perennially dry climate is a significant limiting factor on agricultural production in the region and is exacerbated by drought. Climate observations show stable temperatures during 1950s through to the 1980s followed by a modest positive trend. Precipitation shows very minor trends with slight increase in June/July (3-5mm/decade) and slight decrease September to November (1mm/decade). A marked feature has been three very dry years from 2004-2006. Recent climate variability, particularly the drought, was perceived to have had a significant effect on livelihoods but it was not the only challenge respondents had faced. Susceptibility to drought was higher in the mixed irrigated and grazing and rainfed areas, due to farmers' greater exposure to climatic hazards and because a greater proportion of their income originated from farming activities. Respondents had used a wide range of measures to retain and enhance soil moisture and to maintain agricultural production. When questioned on the constraints they faced, lack of money, water shortage and agricultural inputs were cited most often.

The discussion examines challenges in disentangling the role of climate within complex and dynamic livelihood systems. These include methodological issues in quantifying the significance of climate and non-climate factors, the rapidity of socio-economic change in China and reconciling local perceptions with meteorological observations. The paper emphasises how climate risks need to be incorporated within a wider framing of rural livelihoods and development planning processes and priorities and argues that for the short term, good potential exists to incorporate adaptation within mainstream development plans and poverty alleviation programmes without requiring major changes in current policies.

## **Lessons learnt from Fiji rural climate change adaptation project**

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The University of the South Pacific has facilitated community-based adaptation projects in six Fijian villages from 2006 to early 2010, with financial support from AusAID. Three of these villages suffer from coastal erosion and three from low and poor water supply systems; with the problems exacerbated during the dry season. Our experience with these projects suggests many lessons for community-based adaptation projects more generally, which can be summarized as: (i) project management system and coordination set-up is essential (ii) proper community-based awareness, information and training programme is essential, (iii) community leadership or management system play an important role in project implementation and uptake (iv) community involvement is essential (v) support from outside groups, both in terms of policies and technology inputs, is important (vi) information about climate change and adaptation needs to be disseminated and shared to ensure uptake of best practices, (vii) long-term monitoring, maintenance and evaluation is needed (5-10 years). Several of these lessons confirm our earlier and ongoing experience with locally managed marine areas.

## **Using degradable polymer film to mitigate the impacts of climate variability and change on agricultural production**

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Degradable polymer film (DPF) is an emerging technology that can assist cropping farmers in the low rainfall cropping areas of Australia to manage and adapt to climate change and seasonal climate variability. The film is made from a thin layer of transparent, impervious and stretchable polyolefin that degrades when exposed to radiation into CO<sub>2</sub>, water and natural substances. The degradation time can be manipulated in the manufacturing process to suit the desired application. This paper reports on findings from recent field, controlled environment and farm system modelling studies on the environmental, crop growth and economic impacts of DPF applied to winter grain crops in Birchip, Victoria.

When laid over a newly sown crop with the edges buried, the film acts like a glasshouse to capture and concentrate soil and plant CO<sub>2</sub> emissions, recycle evapo-transpiration losses back to the soil, and trap radiation leading to increases in temperature. Incident rainfall is diverted away from the crop and concentrated in the uncovered space between film strips, thus altering the spatial (i.e. horizontal and vertical) distribution of crop available soil water and

associated solutes (e.g. nutrients) across a paddock. The combined effect of these environmental changes on crop growth, development and yield is complex and varies with seasonal climate, management and soil factors.

An alternative application involves laying the film prior to sowing in alternate (i.e. covered/uncovered 'skip-row') strips across a paddock. By concentrating rainfall into the uncovered strip, the film promotes an earlier 'break' with the crop subsequently sown into the uncovered strips. The film then persists for a period of time after sowing to provide additional rainfall to the developing crop. Using the film in this way generates higher and more consistent grain yields (albeit over a smaller area), and increases the viability of higher value alternative crops such as canola or field peas which are otherwise restricted by rainfall availability

## Stochastic downscaling climate change scenarios over NSW

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To run farming system simulation models for evaluating adaptation strategies to climate change, site specific daily climate data for future climate projections are needed. A spatial weather generation downscaling (SPWD) method was developed and applied to downscale climate projections of global climate models (GCM) to weather stations of New South Wales (NSW) for minimum & maximum temperatures, precipitation and radiation. SPWD is based on a modified version of WGEN that uses parameters calculated site-specifically from daily historical climate. Monthly GCM-projections are initially downscaled to sites using an inverse-distance interpolation method. Site based GCM-projections are then transformed by transfer functions which are derived from historical climate and GCM-projections for the same hind-casted period. Daily sequences were generated from those transformed monthly GCM-projection using WGEN. Verifications of downscaled GCM-projections and historical data showed good results for the period 1961-1999. The method was applied to downscale GCM-projections for 1602 sites across NSW. Downscaled GCM projections included 9 GCMs by three emission scenarios, B1, A1B and A2 for the period of 2011-2099.

Simulated change analyses are based on 7 GCMs under the A2 emission scenario for the period of 2040-2059 to represent the period around 2050 climate. All seven models projected a rising trend for temperature changes in NSW, but varied largely among GCMs. For example, CGCM3.1-T47, CGCM3.0-T63, and MIROC3.2 projected up to 5-8 °C increases in the central and northeast of the state. INMCM3.0 projected the lowest temperature increases of 1.0-2.0 °C across the state. The other three models, BCM2.0, CSIRO-Mk3.5, and CSIRO-Mk3.0 projected temperature increases of 2.0-3.5 °C.

Projected spatial precipitation changes do not have the same changing trend as temperatures. CSIRO-Mk3.5 projected a 10-20% annual precipitation decrease for most areas of NSW. Only small areas in the far north-western corner are projected to have 0-10% increases. CSIRO-Mk3.0 projected 10-20% increased precipitation on the eastern coast. INMCM 3.0 projected up to 10% decreases for the Great Dividing Range and southern boundary areas with Victoria. Higher increases are also projected by INMCM3.0 for the Northwest and Sydney valley. The other four models projected a large increase in precipitation for western NSW. BCM2.0 and CGCM3-T63 projected precipitation increases across the state. MIROC3.2 projected decreases in the southern boundary areas but increases in all other areas, especially over 30% in the northeast regions. CGCM3.1-T47 projected decrease in some southern boundary sites as well as the northeast corner.

Other variables such as extremes in precipitation or temperatures are also downscaled to achieve the results that are in consistent with GCM projections. The downscaling model and the downscaled data can be potentially used for various applications for developing adaptation strategies to climate change in agricultural, hydrological and other ecological systems.

## The role of parks and nature in human health during a time of climate change

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Climate change is the most pressing social, economic and environmental issue we face in the 21st century. Global climate change is occurring and the predicted climate change impacts on south-east Australia are increased temperature, reduced rainfall, more frequent extreme weather, increased fire frequency and rising sea level. The impact of climate change on parks will be significant and these changes will have consequences not only for what can be described as the traditional role of parks in protecting biodiversity and mitigating climate change by sequestering and storing carbon in natural ecosystems, but for the health and well being of the broader society.

The presentation and paper contend that climate change impacts will necessitate parks to be managed for the integration of environment, society, and health objectives by exploiting the inter-relationship between sympathetically managed parks and positive human health and wellbeing outcomes. The paper explores how park management is adapting to the contribution parks make to public health through the development of the "Healthy Parks, Healthy People" concept and program. The range of activities being delivered under "Healthy Parks, Healthy People" programs are explained and the important role and scope of parks to contribute to broad society objectives, especially in terms of public health are explored.

Parks and protected areas are uniquely positioned to support both environmental and social climate change mitigation and adaptation strategies as they protect ecosystem services and provide the setting for vital human

interaction with nature required for balanced physical and mental health. Parks and other natural environments are a fundamental health resource, particularly in terms of control of insect disease vectors, reservoirs of genetic material for medicines, environmental detoxification, buffering the impact of disease by providing potable & irrigation water and food, providing heat sinks, and, mitigation of extreme weather events and floods.

In addition to their contribution to public health and wellbeing through ecosystem services, it is becoming increasingly apparent that parks also contribute to societal health and wellbeing through the provision of settings for preventative medicine. Medical evidence has demonstrated that there is a positive link between a healthy environment and a healthy society. Being exposed to nature or participating in activity in a natural setting can reduce stress and blood pressure, boost immunity, enhance mental health and aid recovery from injury or disease. Based on this body of evidence, park agencies around the world are adapting their management of parks and ecosystems and developing nature-based health programs.

The health challenges the world will face during a time of climate change are becoming increasingly evident. These challenges are likely to include the exacerbation of some current health risk factors and health issues such as physical inactivity, unhealthy diets, stress related illnesses, and proliferation of disease. These will be compounded by growing urbanisation and an increasing difficulty in provision of potable water, nutritious food and clean air.

Climate change will inevitably lead to greater demand for health services which will become increasingly difficult and costly to provide. Other solutions to improve effectiveness and efficiency of health service provision will need to be determined. Some of these solutions may include preventative medicine methods and treatment that reduce the percentage of the population requiring medical services and/or accelerate patient recovery. Adapting our health sector to the challenges of the future may also include looking beyond the established health sector for the provision of health services.

As the steward of Victoria's parks system, Parks Victoria has a unique and challenging role in assessing and addressing the impacts of climate change. "Healthy Parks, Healthy People" signals a paradigm shift in park management which brings new insight to the relevance of parks, and their management, to society and reinforces connections between human and environmental health. There is an integral link between a healthy parks system and the value placed on it by the community. In the future it is conceivable that park management could be evaluated on broad societal health and wellbeing criteria and that park management plans will include directions and strategies to address health and wellbeing issues.

## **Linkages between Adaptation and Mitigation in Forests: Landscapes, Communities and Policies**

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Adaptation and mitigation are two dissimilar approaches to climate change but with potential synergies or conflicts. The linkages between adaptation and mitigation are particularly clear in the forest sector, as forests can contribute to both adaptation and mitigation. They play an important role in mitigation through the global ecosystem service of carbon sequestration and storage. Forest activities relevant to mitigation (afforestation, reforestation and deforestation avoidance) are increasingly included in existing or emerging policies (e.g., CDM (Clean Development Mechanism) and REDD (Reducing Emissions from Deforestation and forest Degradation)).

Forest ecosystems contribute to adaptation by providing local ecosystem services that reduce the vulnerability of societies to climate change. Examples are mangroves protecting coastal communities against natural hazards and forests protecting clean water supplies and controlling erosion in watersheds. Ecosystem-based adaptation is an emerging set of adaptation policies and measures that take into account the role of ecosystem services in reducing the vulnerability of society to climate change, in a multi-sectoral and multi-scale approach.

Empirical studies are lacking and more research is needed to explore the linkages between adaptation and mitigation in forests. In this communication, we present examples of conflicts or synergies between mitigation and adaptation at different scales. We show that the linkages can be observed at the scale of landscapes, projects or communities, and national or international policies. We also present approaches for exploring these linkages at different scales.

At the landscape scale, ecosystems that sequester carbon, provide relevant local ecosystem services to vulnerable people and are resilient to climate change would be beneficial to both mitigation and adaptation. However, ecosystem types or locations preferred for carbon sequestration projects may not be those that bring the best adaptation benefits. In a landscape, the linkages between mitigation and adaptation can be observed by analysing the trade-offs between ecosystem services, i.e., carbon and local ecosystem services relevant to adaptation.

At the project or local community scale, adaptation activities can benefit mitigation through the carbon sequestration associated with ecosystem-based adaptation. However, adaptation activities can also reduce ecosystem resilience or carbon sequestration; for instance, dams or dikes can affect coastal ecosystems negatively. Mitigation forest projects may affect the capacity of local communities to adapt to climate change, either positively (e.g., through diversified incomes or strengthened local institutions) or negatively (e.g., through land deprivation or dependence on external funding). The linkages between mitigation and adaptation at this scale can be observed through the effects on livelihoods and ecosystem management.

To date, mitigation and adaptation have rarely been linked in climate policies. On an international scale, the CDM is the only mechanism that indirectly links adaptation and mitigation, as a levy on this mitigation instrument finances an adaptation fund. On a national scale, it is thought climate change mitigation policies can benefit adaptation and vice versa, but this remains theoretical. The lack of linkages between adaptation and mitigation in the forest sector is clear in climate-related policy documents, such as the NAPAs (National Adaptation Programmes of Action).

## Vegetation Change and Migration in Protected Areas and Biological Corridors under Climate Change Scenarios in Mesoamerica

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Climate change will affect the spatial distribution of ecosystems. Even though the future distribution of ecosystems depends on the ability of plants to migrate, most biogeography studies related to climate change consider unlimited migration ability or no migration. As migration is reduced by the fragmentation of landscapes through which species could disperse, the establishment of corridors may facilitate the adaptation of ecosystems to climate change. This study aims to assess the contribution of biological corridors to facilitating plant migration between protected areas under different climate change scenarios in Mesoamerica.

We developed a model for representing the migration of plants in a fragmented landscape under scenarios of climate change. Vegetation changes under climate change are estimated using two approaches: a simple biogeographical model (Holdridge) and a soil-vegetation-atmosphere transfer model (MAPSS). Different assumptions are made on migration processes. This model is implemented with cellular automata and applied to the Mesoamerican landscape with different scenarios of fragmentation around protected areas or connectivity enhancement by the Mesoamerican Biological Corridor. A sensitivity analysis is performed with different climate change scenarios and assumptions on the processes of vegetation change and migration.

Results show that biological corridors play an important role in facilitating the migration of plants between protected areas in Mesoamerica. Some corridors are highly valuable, especially where they connect vulnerable protected areas along the gradients of future climate changes, e.g., altitudinal gradients. Results show that the role of corridors depends on their spatial configuration and the changes in the spatial climatic patterns. However, uncertainties in future climate require consideration of several climate scenarios for planning conservation under climate change. Conservation plans that enhance landscape connectivity can increase ecosystem resilience to climate change.

## Adaptation options for mining communities

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Changes in climatic conditions are expected to impact the mining industry in diverse ways across Australia. How mining operations respond to these changes will have major implications for the communities associated with them, in addition to the direct effects of climate change on these communities. Likewise, community responses to dealing with climate change may have implications for nearby mining operations. This project investigates ways that mining communities and mining companies can work together to assess the likely effects of climate change and the adaptation options open to them.

This project forms a component of a broader project within the CSIRO Climate Adaptation Flagship investigating adaptation to climate change and climate extremes by the Australian mining industry. Climate modelling in support of this project indicates changes in rainfall and temperature patterns could significantly affect mining regions. Hotter and dryer conditions and more extreme weather events such as flooding, including changes in the frequency, intensity and geographic distribution of cyclones (hurricanes), are expected to have significant implications for mining operations in different parts of Australia. Recent exploratory work in the Earth Sciences and Resource Engineering division of CSIRO investigated the likely effects across the various stages of the mining operation, and identified the main concerns as those related to water, energy, geohazards, infrastructure, transport, and site rehabilitation. These included: water scarcity and excesses; increased energy requirements (e.g. for cooling workspaces, residences and machines and for pumping water) as well as disruptions to energy supply and increased transmission losses; changes to the stability of rock faces and other aspects that pose health and safety concerns; damage to transport routes from extreme rainfall and temperature events; the need for increased tolerances of mining machinery and other infrastructure, such as tailings dam susceptible to flooding; and, threats to mine site rehabilitation efforts through erosion, drought and fire.

The types of responses that mining operations undertake in relation to the above specific challenges will have implications for surrounding communities. These communities will also be facing the more direct effects of climate change (e.g. heat stress). While there are many studies of adaptation to climate change, there are few that consider explicitly the effects that might occur in mining communities, and whilst there is a large literature on the links between the minerals sector and local communities, the impact of climate change is rarely addressed specifically.



In tandem with a more comprehensive survey of perceptions across the mining industry, this study will use a case-study approach to assess the likely effects of climate change on specific mining operations and communities. Participatory and action-oriented methods will be used to involve a range of different stakeholders to assess vulnerability to climate change and to develop consequent adaptation strategies. Relationships between local community adaptation and broader climate adaptation planning at different spatial scales and levels of government will also be investigated.

### **Just before Losee abstract, please insert the following abstract: Developing climate change adaptation strategies for urban infrastructure**

**D Lorenz<sup>1</sup>**

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Urban infrastructure is designed to perform in the expected climatic conditions of the region in which it is located. Climate change is projected to significantly alter climatic conditions around the globe, with variations across regions and planning horizons, and therefore infrastructure in many areas will be exposed to increasing vulnerabilities to failure as conditions exceed performance thresholds and design standards. These vulnerabilities will be amplified as changes in population profiles and expectations also occur. Climatic changes such as increased frequency of extreme heat and storm events will in many cases require changes to asset management practices, design standards, materials, placement and renewal strategies. Understanding these increasing vulnerabilities is key to developing appropriate responses to effectively and efficiently adapt to the changes. Whether the impacts of climate change occur from extreme events or gradual changes, damage to infrastructure and services is likely to be costly unless appropriate measures are taken to adapt. This presentation shares practical methodologies and learnings from a range of projects undertaken to assess climate change risks and adaptation measures across various types of urban infrastructure in Australia. It will discuss the use of appropriate global emission scenarios and related climate change projections upon which to base assessments. It will also share a systems-based assessment methodology that can assist asset managers to clarify the potential 'cascading consequences' of climatic changes or events, and identify key priorities for the stakeholders involved to address. These prioritised risks form the basis of a strategic approach to develop adaptation measures, both 'reactive' and 'proactive', that allow for an appropriate climate change response to be implemented effectively over time.

### **Successfully managing climate change scepticism in adaptation planning group processes**

**S Losee<sup>1</sup>**

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Climate change practitioners working with organisations to plan adaptation invariably encounter sceptics. Undoubtedly, the very use of an expression like 'climate change practitioners' has the potential to raise the ire of die hard sceptics. This is a fundamental problem in engaging with groups of people who must be involved for effective adaptation planning.

If one ignores or mishandles scepticism, it can undermine group efforts on adaptation planning and potentially set back an adaptation agenda in an organisation for years (e.g. if the social dynamics of an organisation force an alignment with a sceptical view).

The purpose of this poster is to share approaches that have proven to be effective in acknowledging scepticism and then moving forward with collective risk assessment and adaptation planning. It is based on the view that it is imperative for organisations to undertake adaptation activities to respond to the climate change impacts identified through the Intergovernmental Panel on Climate Change (IPCC) processes as a minimum.

The first step is to acknowledge scepticism and the likelihood that any room of people is likely to include at least one person who sees themselves as a climate change sceptic. Nobody readily accepts the idea, upon first hearing it, that human beings can have such an immense impact on the planet that they could actually alter its climate. This means that everybody starts from a position of scepticism and that people who currently hold these views in good faith must be respected.

Nonetheless, accurately presenting locally relevant scientific information, together with a proper interpretation of the meaning of uncertainty in science, is an essential step in gaining group engagement and understanding. The climate change practitioner should be versed in the dominant challenges to climate change theory (e.g. attribution to changes in solar radiation) as well as popular press themes (e.g. the pre-Copenhagen email controversy).

It is then useful to introduce the notion of a scepticism-acceptance continuum. The continuum ranges across 'denial', 'informed scepticism', 'accept there is a risk', 'IPCC consensus view' and 'IPCC is too conservative view'. The practitioner's goal should be to educate those who are at the sceptical end of the continuum, or who perhaps have not given the question much considered thought, to at least the level of accepting there is a risk. When a group obtains consensus on the need for risk management in the face of uncertainty, it has reached the minimum level for proceeding with adaptation planning without disenfranchising those who might otherwise see themselves as sceptics.

Finally, there is a need for practitioners to be able to deal with ardent sceptics who can negatively affect adaptation planning. Some people have a contrary nature and others have a conviction that either climate change is a conspiracy or an undue distraction from more pressing global concerns.

This poster will illustrate a range of experiences that AECOM climate change practitioners have encountered and some practical strategies for continuing sensible adaptation planning amidst a highly contentious public debate.

## Climate Change Action Planning Workshop Package

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Local councils in NSW are increasingly seeking to prepare for the likely impacts from unavoidable climate change and are at various stages of formulating responses. Several councils have included climate change in State of the Environment Reporting, followed the Cities for Climate Protection program, sought grants and developed policies and management plans. The Local Government and Shires Associations of NSW (the Associations) are encouraging councils to adopt a strategic approach to climate change mitigation and adaptation in order to adequately and efficiently address risks, limit their liability, budget for impacts, minimize disruption to council services and fulfill their duty of care to local communities. The Associations are supporting councils to strategically address climate change by providing a Climate Change Action Planning Workshop Package, which is available on the Climate Change Action Pack website.

The Workshop Package is intended for councils, or Regional Organisations of Councils, to use to facilitate workshops and meetings to plan actions for mitigation and /or adaptation. The climate change actions can be integrated into existing corporate plans. The Package advocates that risk management principles (ISO 31000:2009) underpin climate change action planning. Particularly, that action planning should take into account human and cultural factors and be inclusive, iterative and adaptive. The Package includes step by step guidance for preparing for and facilitating workshops and meetings along with practical tips and templates. It includes risk assessment tools, technical guidance, PowerPoint presentations, details for group activities and facilitation techniques. The modular format of the Package means councils can select relevant modules and tailor a program to their particular needs.

The Workshop Package has been designed based on feedback received in 2009-2010 from a reference group and focus group and earlier feedback from a needs analysis survey in 2006 and workshops in 2008. In 2006, councils called for advice on how to undertake risk assessments for climate change, information about insurance and checklists to address climate change. The Workshop Package, together with the comprehensive Climate Change Action Pack website, addresses these needs.

The Associations pilot tested the Workshop Package by partnering with four organisations: Clarence Valley Council; Bland Shire Council; The Hills Shire Council; and The WBC Strategic Alliance comprising Wellington, Blayney and Cabonne Councils and Central Tablelands Water. The testing phase involved the pilot councils using the Workshop Package to commence drafting climate change action plans. This aided in improving the Package and lessons learnt from applying the Workshop Package are likely to be of interest to other organisations at various stages of planning a local climate change response.

Challenges in applying the Workshop Package for council officers at the pilot councils included securing a sufficient number of staff members to attend the workshops and sit on a working group. The council officers also needed to handle divergent views and keep the working group engaged in the development of the action plan which was achieved by providing positive feedback and follow up information. Competing demands and other issues for the pilot councils' climate change action planning demonstrated the importance of having more than one other council officer actively involved in preparing for and facilitating the action planning. The planning process was most productive where these officers possessed confidence, commitment, enthusiasm and skill in organizing workshops, facilitating groups, researching and presenting climate change information and building support from senior staff.

Participants in the action planning process frequently reported that they enjoyed the practical group work; group discussion and hearing other participants' view points; being presented with statistics and understanding climate change projections for their region; and hearing experts talk about specific issues for their region. Participants most commonly called for more time for the workshop activities, more interactive discussion and funding or consideration of how climate change actions could be resourced. The experiences of the pilot councils are outlined in case studies which along with the Workshop Package are available from the Associations' Climate Change Action Pack website.

The project was funded by the NSW Environmental Trust which is also providing funding to the Associations to deliver workshops using the Workshop Package to five regional councils in NSW in 2010-2011.

## An integrative approach to understanding the pest and disease threats to agricultural biosecurity under future climates

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Climate change predictions for Australia include increasing CO<sub>2</sub>, temperature and humidity, decreasing frost events, and an increasing incidence of heavy and unseasonal rains, droughts, and storm events. These changes present a major threat to our horticulture and natural environments. Growth, development, physiology and behaviour of pests and pathogens will be altered, but the extent of these effects, and subsequent impact on host plants, is

not well understood. Bioclimatic models, like CLIMEX, showed the potential geographical distribution of exotic citrus canker (*Xanthomonas citri* pv *citri*) would shift to southern coastal and inland regions under increasing temperatures, based on its current climatic range overseas. However, this type of modeling was limited by the inability to assess pest-host interactions such as pathogen life cycle, competition and host availability.

To address this, an integrative modelling approach was developed, based on the concept of the plant disease triangle, where the successful development of a pathogen requires the interaction of host, pest and/or pathogen and a favourable environment. By coupling host-plant physiology, virus and vector population growth and climatic data with projected climate change conditions, we are able to predict individual species responses and shifts to historic geographic ranges. Strengthened by empirical data, these models are intended to be incorporated into plant biosecurity management and contingency planning, forming the basis of integrated scenario-based decision support systems for emergency pest and pathogen management.

A dynamic model was constructed in STELLA™ for the Asian citrus psyllid (*Diaphorina citri*) [Pylloidea: Psyllidae], vector of huanglongbing (citrus greening disease) using daily temperature data coupled to host plant physiology data and pest population data to determine potential distribution and abundance. The model also predicted a population shift southwards but a potential decrease in psyllid numbers due to reduced availability of new citrus growth on which the psyllids reproduce and multiply. A model based on *D. citri* climatic requirements would have accounted only for the shorter development period and predicted an increased risk of potential distribution.

Current work focuses on developing an innovative spatial modelling environment using the bird cherry-oat aphid (*Rhopalosiphum padi*) which vectors Barley yellow dwarf virus (BYDV). The effect of climate change on aphid feeding behaviour, flight time and synchrony with the crop, virus acquisition and transmission rates and wheat phenology changes and physiological responses are being incorporated.

Experiments in the Australian Grains Free Air Carbon Dioxide Enrichment (Ag FACE) research facility have enabled field based investigations of the effects of elevated (e) CO<sub>2</sub> on wheat pathosystems. Wheat stripe rust (*Puccinia striiformis*) and crown rot (*Fusarium pseudograminearum*) severity, latent period, fecundity and host resistance was assessed under ambient and 550ppm CO<sub>2</sub>. While no effects of the treatment were observed with *P. striiformis* over two seasons, an increase in *F. pseudograminearum* biomass under eCO<sub>2</sub> has been observed in 2008. Our integrated modeling and field based approach to resolving the likely effects of climate change to plant biosecurity will be presented.

## Carbon sequestration potential of agroforestry in the African Sahel

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Recent conversion of large areas of Sahelian cropland to agroforestry has shown that adding trees to existing agricultural acreage can be a strategy for sequestering atmospheric carbon. Agroforestry also has potential to help farmers adapt to climate change by providing additional sources of income, enhancing water and nutrient use efficiency and stabilizing soils. It is thus at the interface of climate change mitigation and adaptation. We aim to quantify the extent of suitable areas for agroforestry strategies in the Sahel and the amount of carbon that could be stored.

The analysis builds on a global dataset on the extent and geographical patterns of agroforestry developed at the World Agroforestry Centre. This dataset integrates information on agricultural area and land cover to estimate tree cover on cropland. Using multivariate statistics on these data, as well as auxiliary datasets and available knowledge of cropping systems across the Sahel, distinct agroforestry types are characterized. The maximum entropy approach is then employed to characterize the ecological niches of each of these types, based on regional data on temperature, precipitation and soil. The potential spatial extent of each agroforestry type is derived from its climatic and environmental requirements. Since climatic conditions in this region can no longer be assumed to be static, projections are presented for a range of climate change scenarios.

Using current and potential agroforestry areas and available information about biomass carbon in agroforestry systems, the climate change mitigation potential of Sahelian agroforestry systems is estimated.

## Climate change effects on winter chill for temperate fruit and nut trees around the world

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The economic viability of many temperate fruit and nut trees depends on the fulfillment of their winter chilling requirements, which vary across species and cultivars. Growers must identify appropriate cultivars for the climatic conditions of their production sites. Climate change threatens to reduce available chilling in many growing regions, potentially compromising the viability of orchard operations.

To estimate likely climate change impacts on fruit and nut production, we projected global winter chill for two past and 18 future climate scenarios, based on historic records from 4294 weather stations and projections by General Circulation Models (GCMs). The LARS-WG stochastic weather generator and idealized daily temperature curves were used to produce 100 years of synthetic hourly temperature records for each station and climate scenario. For two past scenarios (1975 and 2000), climatic

conditions were obtained by linear regression of monthly minimum and maximum temperatures and precipitation over the entire reference period (1973-2002). The Climate Wizard tool was used to obtain future conditions projected by three GCMs (MIROC3.2 (medres), UKMO-HadCM3 and CSIRO-Mk3.0 GCMs) for three greenhouse gas emissions scenarios (A2, A1B and B1) and for two time periods (mean conditions between 2040 and 2059 and between 2080 and 2099). Safe winter chill (SWC; in Chill Portions – CP) was defined as the 10% quantile of the distribution over 100 years of winter chill, as calculated by the Dynamic Model. For each point in time and emissions scenario, interpolated SWC was then averaged over all three GCMs.

While winter chill remained relatively constant in temperate climates, Mediterranean growing regions experienced substantial losses. Between 1975 and 2000, average SWC among 10 important Mediterranean growing regions dropped by 9% from 78 to 71 CP. By 2050, losses of 20-27% (to 57-62 CP) were projected. By 2090, climatic conditions in many regions will likely be unsuitable for many currently grown cultivars, with SWC between 30 and 48% lower than 1975 (41-55 CP). Warmer regions experienced the strongest effects. Between 1975 and 2090, average SWC over all emissions scenarios was projected to drop by 81% in South Africa, by 55% in Israel, by 53% in the Maghreb countries, by 51% in South Australia and Northern Mexico, by 37% in California's Central Valley, by 36% in the Southeastern US and by 30% on the Iberian Peninsula, in France and in Italy. The mildest losses were projected for New Zealand (26%) and Chile (26%).

Scientific understanding of plant dormancy is incomplete, so that current winter chill models are only crude proxies of the physiological processes happening within trees. Nevertheless, the extent of projected changes in all major growing regions of Mediterranean fruits and nuts indicates that growers will likely experience problems in the future. More efforts should thus be undertaken to breed tree cultivars for lower chilling requirements, to develop tools to cope with insufficient chilling, and to better understand the temperature responses of tree crops.

## Climate Change Impacts and Adaptation in the Berg Water Management Area of South Africa

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Hydro-climatic conditions in South Africa contribute to a variety of critical exposures faced by the country's society and economy, and have resulted in a large set of vulnerabilities. These will be exacerbated by climate change. To understand and respond to these vulnerabilities, information about likely climate change impacts is required, and should focus on:

- the impacts of projected future climate change on the biophysical environment,
- the socioeconomic characteristics of relevant sectors and groups, and the expected changes therein over time, and
- how the above changes will impact on overall socioeconomic vulnerability.

A case study of the Berg Water Management Area, situated in the Western Cape Province, is presented here. The Western Cape has previously been identified as a potential climate change hotspot.

The Berg Water Management Area (Berg WMA) is an economic hub of the country, with intensive irrigation as well as concentrated commercial and industrial activities. High population growth, highly specialised export orientated agriculture, and a fast growing tourism industry, have led to this area being highly water stressed. These demands must be balanced against the underlying environmental demand, including that of the ecologically important Berg River Estuary. As well as considering catchments in the Berg WMA, certain catchments in the neighbouring Breede WMA are also considered in the study. Water is transferred from these catchments to the Berg WMA, via inter-catchment transfers, to supply water to irrigated agriculture and the City of Cape Town.

To support the identification and understanding of key vulnerabilities, the potential impacts of climate change on the biophysical environment of the study area, are being investigated. Emphasis is being placed on the water sector, owing to its strategic importance. Impacts are examined via an assessment of changes in relevant variables such as streamflow, irrigation demand, soil moisture and extreme events.

Information about likely climate change impacts, on its own, does not motivate adaptation. Without a conducive regulatory environment, adaptation might not be possible. Previous research has shown that South Africa has significant potential for adaptive and integrative water management, particularly in the light of its sustainable, participatory and cooperative governance approach.

Implementation and understanding of innovative regulations and institutions of water governance is more advanced in the case study region than in other parts of the country. However, as adaptation needs a frame in which a potential to action can unfold, thus increasing the likelihood of adaptation, a framework is needed that verifies adaptation strategies in terms of feasibility and effectiveness for implementation.

The diverse interests and needs of the Berg WMA have to be negotiated within a framework that also takes note of government efforts (post 1994) to address socioeconomic imbalances. Based on the specific South African situation and adjusted to the societal, economic and governance characteristics of the Berg WMA, an adaptive process is being designed that aims at developing a tailored adaptation management plan that is capable of identifying key vulnerabilities and prioritising adaptation interventions accordingly.

## Comparison of the Potential Impacts of Changes in Mean and in Climate Variability on Wheat Production Systems

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Impact of extreme climate events on agricultural production is a big concern in Australia. Both changes in climate variability and in mean climate can lead to extreme climate events but the former contribute more. The aim of this work is to examine the impact difference of changed climate variability and mean climate on wheat production processes. Daily outputs of CSIRO Conformal-Cubic Atmospheric Model (C-CAM) were used to derive changes in mean climate and in climate variability and to construct local climate change scenarios with and without changes in climate variability considered through a stochastic weather generator: Long Ashton Research Station- Weather Generator (LARS-WG), based on the characteristics of a specific weather station. The constructed climate change scenarios were then coupled with the Agricultural Production System simulator (APSIM)-Wheat model to examine the impact differences among these two climate change scenarios on wheat production at Wagga Wagga and Condobolin in New South Wales (NSW), Australia. Impact indicators considered include an assessment of the key components of the water balance (transpiration, soil evaporation, evapotranspiration, runoff and drainage), water use efficiency (WUE), and grain yield. This study is centred on 2080 with corresponding pCO<sub>2</sub> of 682 ppm under the IPCC Special Report on Emission Scenarios A2 scenario set in the wheat model.

A decrease (5–13%) in the length of wet spells and an increase (18–19%) in the length of dry spells were projected by this climate model across the two locations considered. Rates of transpiration, soil evaporation and evapotranspiration were lower under the changed climate variability scenario compared with the change in the mean climate scenario at both locations, indicating the negative impact of drought. The same is true for yield at the two locations highlighting the negative impact of extended drought. WUE increased across the two climate change scenarios and locations due to the effect of CO<sub>2</sub> fertilization on assimilation rates and transpiration rates when compared with the baseline climate scenario. However, the increase was less under the climate variability scenario compared with the mean climate change scenario only at Wagga Wagga. We conclude that this implies a larger reduction in yield than in water use. However, there was not much difference in WUE under the two climate change scenarios at Condobolin due to the similar reduction in yield and in water use resulting from the effect of the drought.

## What people care about: focusing effort on highly effective adaptations

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Society has limited capacity to attend to problems. Slow onset and contested problems such as climate change challenge society to choose among many competing claims for societal attention and action. What things are the most important for society to attend? Of these which is most amenable to adaptive interventions? What is important to society or what society cares about is therefore important in focusing social attention and weighting action.

We present a new and simple approach to providing focus for adaptive effort in order to enhance or improve social well being in the face of stressors such as climate change. The approach is capable of dealing with multiple stressors (such as climate change and oil price change) simultaneously. In applying the approach we firstly identify what people care about. This provides a weighting function to focus attention and effort. Then for the things that people care most about we build models of the factors that cause change in the state of those things that people most care about. These causal models are then used to identify adaptation options which will have the greatest positive impact on the states of what people care about and hence people's overall satisfaction or well being. The adaptations focus on what is most important to society and on those factors that most strongly influence the state of what society cares about.

We demonstrate the approach through an application to regional Australia. We describe and present preliminary results of what people care about for the region. We then describe the process of building causal models for two elements of what people care about. Using scenarios of climate change and commodity price change we present the results of our having used these models to explore adaptation options that reduce the likelihood of negative changes in what people care about. We present the results of the analysis firstly as configurations of adaptations that society might choose to avoid as these would result in negative changes in the state of what people care about. We also present configurations of adaptations that society might actively seek to implement because they either yield no change or improvements in the state of what people care about in the face of the stressor set. We then demonstrate an expansion of this analysis to reflect the potential of the approach to identify configurations of adaptations that might be better and those that might be worse for specific social groups in the region.

## Adapting England's landscapes to a changing climate

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Adaptation to climate change for the natural environment will be vital, not just because of its vulnerability to environmental change and the associated threat to biodiversity but also because of its importance as a provider of ecosystem services that will support societal adaptation.

A key issue is the scale at which adaptation action should take place – spatially, temporally and institutionally. It is increasingly important to consider working at a ‘landscape scale’ – a scale big enough to allow us to consider natural ecosystem processes (such as dispersal of species or movement of water), how people use and value an area, and the interactions between these things, while fine-grained enough to apply and tailor general adaptation principles to specific local conditions, resources, pressures, opportunities and aspirations.

Natural England (the government’s nature conservation agency) has begun to explore adaptation at this scale, through a series of studies across a subset of England’s ‘National Character Areas’ (England is divided into 159 of these areas, which form a widely recognised national spatial framework). As a small highly-populated country in which people, food production, and nature sit side by side, England provides an interesting case study for a landscape scale approach that tries to consider both the natural and human elements of ‘the natural environment’ and to focus action at the level where decisions can most effectively be made.

The areas we have studied cover a wide range of landscapes, including upland areas, extensive and intensive farmland, chalk grassland, low lying wetlands, forest and heathland, coasts, urban fringe, and urban areas. Over the course of these studies, we have begun to develop an approach in which the overall landscape (encompassing both ‘landscape character’ (the patterns of the landscape and how people perceive it) and ‘landscape function’ (biodiversity and ecosystem services’) provides a framework for a more detailed assessment of measurable assets such as flora and fauna, historic environment, geodiversity, natural resources, and places for human enjoyment and recreation. We have used this to evaluate qualitatively the vulnerability to climate change of natural assets in the areas studied and consider how this collectively might affect the overall landscape and the benefits it provides to society.

We have also identified possible adaptation responses, with the focus being to identify action that would maintain or enhance the multiple benefits an area provides to society by reducing vulnerability to a range of possible consequences of climate change. ( In the face of uncertainty about the magnitude and timing of climatic changes and the cascade of possible consequences for natural systems, we believe this approach is more appropriate than focusing solely on trying to identify and respond to detailed projections of climate impacts.)

This paper will outline our evolving approach to addressing these issues and discuss some of our findings. It will discuss lessons and conclusions from our studies and what they can tell us about vulnerability to climate change of different English landscapes and appropriate adaptation action, including about the geographic scales at which research and action should be undertaken.

## Assessing the vulnerability of the terrestrial natural environment at a landscape scale

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The natural environment is already being affected significantly by climate change. As our climate continues to change, so too will the ecological communities that help form our landscapes. Successful conservation will require an ability to assess the vulnerability of different species, habitats and landscapes to climate change, and to understand the specific factors putting them at risk. In the face of potentially large changes, and limited resources to respond, we will increasingly need new approaches that assess the relative vulnerability of habitats and ecosystems across large areas (a ‘landscape scale’). The results of such vulnerability assessments will help identify where scarce conservation resources should be targeted.

The IPCC’s vulnerability model of exposure, sensitivity and adaptive capacity provides a logical framework, but assessing vulnerability of the natural environment in practice is not straightforward. This is not just because of uncertainties about the scale and timing of climatic changes, but because there are still gaps in our knowledge about species and ecosystem processes and we do not yet have a full understanding of the specific factors that confer a high or low ‘sensitivity’ or ‘adaptive capacity’, or what makes an ecosystem ‘resilient’.

Despite these uncertainties, there is a need to explore practical methods to estimate relative vulnerability to inform our conservation efforts. We have begun to address this by developing and testing three different but related methods for assessing the relative vulnerability of natural environment features in three regions in England, covering a wide variety of habitat types.

In the South East region we are using a GIS grid model to undertake a spatial analysis. Data, including habitat information and topography, will be input to a 200m<sup>2</sup> grid and analysed at 1km squares, based on their value (considering factors such as national or international conservation importance), sensitivity of different habitat types to climate change and adaptive capacity (including an assessment of the proximity of habitats to each other and the permeability of the surrounding landscape, and of existing conservation measures currently in place). A key output will be a map of vulnerability across the region.

In the North West, our approach was based on evaluating the vulnerability of the 29 individual landscape areas (‘National Character Areas’) in the region. We first identified the main projected impacts of climate change using the recent UKCP09 projections. All 29 Character Areas were then scored using qualitative information on factors such as whether or not the area is on the coast, elevation, topography, vegetation diversity, land cover diversity and

soil diversity, and also using quantitative data, such as percentages of open countryside, woodland and cultivated land in the area. This enabled us to assign each area an overall score of high, medium or low vulnerability.

In Warwickshire in the West Midlands, vulnerability assessment was done as part of a larger study to identify areas for potential habitat expansion. The vulnerability of possible new habitat areas was assessed using a grid square approach to create a series of GIS layers to show each habitat asset's sensitivity and adaptive capacity, with an overall layer providing a map of areas of high, medium or low vulnerability.

This paper will outline the approaches and emerging results of these different studies, and conclusions that can be drawn about practical ways to assess the relative vulnerability to climate change of biodiversity, habitats and ecosystems.

## Sustainable adaptation in English agriculture

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Agriculture accounts for approximately three quarters of land in England. Most English landscapes, even the ones people think of as being the most 'natural', have been shaped by agricultural or other human land management activity to some extent, often significantly. This agricultural land supports not just the production of food but the provision of a much wider range of environmental services that benefit society.

Services provided by agricultural land are likely to be sensitive to changes in climate. They could be affected directly as a consequence of climatic changes themselves, or indirectly as a result of human activity in response to climate change, and this will bring both threats and opportunities. Effects of climate change are also likely to interact with existing and future non-climate pressures on agricultural systems. At the same time, the services provided by agricultural land are likely to become increasingly important to buffer society from the effects of climate change, both by supporting continued agricultural production and therefore underpinning future food security, and by providing important environmental regulation functions such as flood alleviation, an important consideration in a small crowded country.

Because of the range of services agricultural land provides, and their vulnerability to climate change, adaptation will be essential. Successful adaptation for agricultural systems, to maintain or increase their full range of services, is likely to be one of the most important parts of our overall adaptation effort.

This paper will discuss a framework for sustainable adaptation we are developing for English agricultural systems, but with wider applicability for other systems. The framework is based on first considering the full range of benefits the system can provide to society, in order to establish objectives for adaptation against which both the consequences of climate change and the sustainability of possible adaptation actions can be evaluated. The rationale for this approach is the knowledge that we will need to develop sustainable adaptation solutions to address multiple objectives, and that we will need to accommodate inevitable change while trying to maintain the value of agricultural (and other) systems and the benefits they provide.

We identified 15 desired outcomes, encompassing the key benefits that appropriate use and management of agricultural land in England can provide to society; these cover biodiversity, ecosystem services and natural resources, agricultural productivity, culture and recreation, and agricultural communities and livelihoods.

We identified a wide range of direct consequences of climate change for these outcomes. We then identified over 100 specific actions land managers could take to address the consequences, either to reduce vulnerability to threats or to seize opportunities. To assess the sustainability of the different actions and identify risks of maladaptation, and to consider some of the indirect consequences of climate change, we evaluated the likely effect of each action on each of the 15 outcomes. This enabled us to identify an initial set of about 50 priority adaptation actions, which would address important or multiple consequences of climate change, and/or have multiple benefits against desired outcomes.

These priority adaptation actions range from planning and monitoring, to changing or diversifying crop types, to land management activities that will create important 'green infrastructure', to new technology, to improved management of water, fertiliser and pesticides, livestock and crops. This illustrates that, to adapt successfully, land managers collectively will need to carry out a wide range of activities, tailored to local circumstances. It is clear that adaptation for agriculture cannot be condensed to a single issue or a single solution.

While significant changes to agricultural landscapes and systems appear inevitable in the long term, requiring eventual 'transformative adaptation', we need to start with flexible, incremental steps. Many of the priority adaptation actions we have identified correspond to existing good environmental and agricultural management practices, providing a clear starting point for action.

We will outline the results of this work and some emerging conclusions, and discuss some of the issues and challenges facing policy makers and decision makers, who need to balance an increasingly large number of demands on agricultural land.

## Adaptation Decision Making in New Orleans: Wetland Assimilation Feasibility Planning

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The effects of Hurricane Katrina remain indicative of the vulnerabilities of people, infrastructure, and environments to global climate change. The 2005 hurricane season resulted in widespread devastation of water-related infrastructure. Following the devastation caused by Hurricane Katrina, the realization emerged that the sustainability of the coastal region of Louisiana is dependent on the condition of the natural environment and the need to address the multitude of other issues that contributed to the region's vulnerability. As a result, a comprehensive systems analysis approach to water resource management has been developed to address the restoration of wastewater infrastructure through a wetland assimilation project, which also incorporates the societal needs of safety, economic development, environmental stewardship, and wetland restoration.

The New Orleans Regional Wetland Assimilation System will utilize natural wetlands to assimilate over 350,000 m<sup>3</sup> a day of secondarily treated municipal effluent to restore approximately 12,000 hectares of critical cypress wetlands. On a global level, the wetland restoration project offers emission-avoidance and sequestration benefits. Locally, the project functions as an intervention to reduce the vulnerability to climate change and build adaptive capacity. Implementation of the system presents many challenges. Realization of the project will necessitate transparent decision-making, integration of institutional structures, stakeholder involvement, and increased institutional capacities. This will require a paradigm shift in the way local agencies and the public interrelate, particularly regarding climate change adaptation and the sustainability of the region.

The Wetland Assimilation Feasibility Planning Multi-Criteria Decision Model utilizes an analytic holistic approach to assess the feasibility and planning process of wetland assimilation for wetland restoration, tertiary treatment of wastewater, and climate change adaptation for the New Orleans region. Multi-criteria decision theory was used to integrate aspects of wetland assimilation ecological and engineering design with aspects of sustainable development, urban planning, and public health. Simple Multiattribute Rating Technique (SMART) was used to assess the value trade-offs made by stakeholders composed of governmental and policy decision makers, science and technical experts, industry representatives, environmental advocates, and citizens. The results of the decision model will enhance the analysis of wetland assimilation as an alternative, prioritize actions and resources, and facilitate the inclusion of aspects that are currently not included in water resource decision making. The tool can also be used to identify gaps in planning, understanding, and stakeholder consensus in addition to providing a method for public involvement. With these attributes, the model can be used in the development of innovative approaches to climate change adaptation using scientifically sound management decisions to guide policy formulation, and implementation.

The success or effectiveness of adaptation plans and policies directly correlate with community support and participation, political considerations, and available funding. This requires managers to make complex decisions involving trade-offs among the conflicting objectives of multiple stakeholders. As such, reasonable trade-offs need to be determined directly from stakeholders. Decision analysis can assist decision makers to structure complex problems so they can be understood as decisions-based upon acceptable trade-offs. Decision tools such as this model can facilitate the assessment of sustainable alternatives that balance the social, economic, environmental, and technical elements of an adaptation project to ensure successful civic-society engagement and support. Nowhere is the need for such an integrated assessment tool greater than in the city of New Orleans where the recovery of Hurricane Katrina is riddled with stakeholder conflict and distrust. This decision model has been designed to provide a systematic and logical approach to address climate change adaptation decision making by focusing on the New Orleans Regional Wetland Assimilation System.

## Wetland Assimilation: A case study of climate change mitigation and adaptation in New Orleans

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Climate change, particularly increases in sea level, will severely impact coastal areas around the world (Syvitski et al. 2009). This is especially true for the Mississippi delta that has large expanses of wetlands and many coastal communities at elevations near or in some cases below sea level (Day et al. 2007). Adapting to climate change will require the design of sustainable ecosystems that integrate human society with the natural environment. In order to prevent future human casualties and damage to the housing stock an effective system of disaster prevention must utilize sound land-use planning that incorporates the Multiple Lines of Defense Strategy. This planning methodology adopted both by the State of Louisiana and by the United States Army Corps of Engineers emphasizes strategic man-made features, such as levees, and natural coastal wetland buffers which directly impede storm surge or reduce storm damage. Here we present a case study of the utilization of secondarily treated municipal effluent to benefit wetlands directly east of New Orleans to increase the resiliency of the region's built environment while sequestering large amounts of carbon.



After hurricane Katrina in 2005, New Orleans and surrounding municipalities needed to restore critical wastewater treatment infrastructure. In addition, upcoming regulations mandate significant decreases in nutrient discharges from wastewater treatment facilities, a requirement conventionally met with energy intensive tertiary treatment systems. Hurricane Katrina presented the opportunity for two local governments to partner to pursue wetland assimilation of secondarily treated municipal effluent as an alternative to conventional tertiary treatment and hurricane protection. Currently, treated effluent is discharged directly into the Mississippi River. Rerouting the effluent from the river to adjacent wetlands would significantly reduce energy costs for pumping and conveyance, and the effluent would be used for wetland restoration, rather than increasing offshore hypoxia, otherwise known as the 'dead zone' (Rabalais et al., 2002). The discharge of treated municipal effluent in this way would buffer saltwater intrusion, offset regional subsidence, and re-establish favorable conditions for bald cypress growth (Day et al. 2004, Shaffer et al. 2009). This type of wetland restoration promotes additional carbon sequestration by reversing wetland loss, enhancing burial, and by reestablishing forests (Mack, 2009, Rybczyk et al. 2002, Brantely et al. 2007, Shaffer et al. 2009). The inclusion of wetland restoration management approaches in the emerging carbon market will allow for investments to be shifted into ecosystem services and reward municipalities for selecting sustainable water infrastructure that provides multiple benefits to the public while increasing community resilience and local adaptive capacities.

Using natural wetlands for tertiary treatment is a multi-benefit climate change adaptation measure. The New Orleans Regional Wetland Assimilation System will integrate sustainability with mitigation measures by utilizing natural energies and sequestering large amounts of carbon. The enhanced wetlands will help protect Orleans and St. Bernard Parishes from future storm vulnerability, while the environmental improvement will enhance the local economy and culture that is dependent on productive wetlands. Importantly, the project establishes a multi-disciplinary, multi-stakeholder paradigm for infrastructure and wetland restoration, as an international model of recovery, sustainability, hazard mitigation, and climate change adaptation.

## Responding to Community Vulnerability in the Pacific Islands

**N Maclellan<sup>1</sup>**

<sup>1</sup>Journalist and researcher, Australia

In many small island developing states (SIDS) in the Pacific islands, government agencies and community organisations are developing initiatives for community vulnerability assessment and "bottom-up" climate adaptation at village and community level.

Drawing on research for Oxfam International and fieldwork in Fiji, Tuvalu, Kiribati, Solomon Islands and other Pacific island nations, the paper will present and assess examples of community-based adaptation initiatives.

As donor governments pledge funds for climate adaptation programs, the paper documents examples of community-level "climate proofing" and disaster preparedness in the Pacific islands, which should be an increased focus for international support. It will highlight the interface between adaptation programs and planning for displacement, especially in low-lying atoll communities facing internal displacement because of extreme weather events which threaten food security, water supply and rural livelihoods.

Based on interviews and workshops run in 2010 in Kiribati and Tuvalu, the paper will also discuss the impact of climate change on children in the Pacific, in the areas of survival, development, protection and participation.

While there is an increased level of activity and programming on climate adaptation, most agencies do not have an explicit strategic focus on children and climate change, and little if any of their program activity is currently focussed on children. This provides both a challenge and opportunity for agencies that prioritise rights-based programming. The presentation will include examples where children's voice and engagement in adaptation initiatives can amplify regional and national programming on climate change adaptation.

## A conceptual framework for understanding adaptive capacity to climate change

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Adaptive capacity (AC) is generally considered as only determined by economic and technological capacities. Yet, many other characteristics of a community can play a major role in the ability of a society or a territory to react to and anticipate climate changes (e.g. territorial identity or social relationships). What we argue here is that the current limited view of AC leans on a relative immaturity of the science of adaptation in understanding the real underlying processes and factors which explain why a society/territory is (un)able to cope with future climate threats. Indeed, few frameworks for studying AC with precision currently exist. This communication will consist in a proposal for a research framework which is based upon three main fields of investigation:

- (i) The influential factors of AC – We will address the potential role of different factors (the 'general living conditions', the 'political and administrative structure', the 'societal cohesion', the 'economic diversification') in influencing AC. The role of environmental features of the territory ('spatial configuration', 'environmental sensitivity') in reinforcing or weakening AC will also be discussed. Some methodological consideration for field work will be presented;
- (ii) The relevant spatial and temporal scales of AC – This point will concern the identification of the spatial and temporal dimensions of AC: is local scale more relevant than the national and international ones for implementing adaptation

to climate change? Is long term the main temporal scale adaptation must be designed for? We will show that the relevance of spatial and temporal dimensions of AC leans on the connections between spatial and temporal scales respectively. Furthermore, we will emphasize that the spatiotemporal combinations are also of major importance, calling for example the scheme 'short term/local scale vs. long term/national and international scales' into question;

(iii) The links between AC, vulnerability and the level of development – If we consider that AC is not only dependant on economic and technological features, then the correlation between vulnerability and poverty cannot be sustained. Wealthy populations are also vulnerable to climate change, and their AC would not necessarily be sufficient to cope with future threats. Our main purpose here will be to show that poor and wealthy populations are differently vulnerable to climate change and that their AC are themselves very different. We will then emphasize the importance of the contextualisation of AC studies.

Finally, we will demonstrate how this research framework could feed a more general reflection on the adaptation pathways for dealing with climate change. Indeed, we argue that adaptation is a three-dimension concept: a process, a state and a strategy, referring to the mechanisms and steps of adaptation (theoretical point of view), the forms of adaptation (what adaptation is on the field?) and the policy dimension of adaptation, respectively. The previous fields of research should bring new knowledge on this three-dimension conception, and allow for the understanding and the identifying of "adaptation paths". These paths are entry points to a broader reflection on sustainability and "development paths".

## From Disaster Response to Disaster Resilience: An Agenda for Change

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This paper provides an outline of a change agenda for emergency management by examining ways in which current research in climate change, adaptive capacity and the resilience of natural and social systems can be used to stimulate a shift in thinking from disaster response to disaster resilience.

Climate change will lead to more extreme weather events. There is scientific uncertainty on return periods for events. Governments around Australia are motivated to assist communities to adapt to climate change. Taken together, these facts challenge emergency managers to reshape contemporary disaster management practice to incorporate a broader principle of disaster resilience.

Traditional disaster management is founded on solid principles and well-tested approaches. However, these principles and approaches were determined by policy makers who faced different problems than we do today.

Climate change does not represent a 'paradigm change' for emergency managers. Rather, it is another risk that must be incorporated into a broad-based disaster risk reduction framework. Yet, given the extreme uncertainty of events and other consequences of climate change, we must examine our assumptions and better understand how these consequences challenge traditional disaster management.

Researchers working on climate change, adaptive capacity, and resilience in social-ecological systems provide the raw materials but policy makers need to turn those ideas into practical tools and new approaches to build the resilience of organisations, communities, families and individuals to the impacts of natural disasters. What is needed is an agenda for change and this agenda should include:

- (1) finding new ways to understand the business of emergency management;
- (2) taking new approaches to existing issues; and
- (3) identifying strategic adjustments to directions and tactical variations to prevailing orthodoxy.

## The German Adaptation Strategy: good practices and lessons learnt

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The German Adaptation Strategy is based on an ensemble of climate projections and an impact and vulnerability assessment. The German government assessed possible opportunities and risks of climate change in future policy planning and identified adaptation options within 13 specific sectors and two cross cutting sectors (e.g. regional planning) after it had agreed jointly on principles for decision-making under conditions of uncertainty. Considering the uncertainties surrounding future climate and socio-economic developments that are apparent e.g. from various emissions scenarios and climate modelling the government will henceforth base its planning processes and associated adaptation decisions on plausible ensembles of climate projections, taking account of existing uncertainties, and will thus accept probability statements as a basis for planning. This process is no means a given at present and necessitates a rethink of existing practices in a number of sectors.

The strategy takes also account of the possible implications for development, migration and security policy that could be associated with the impacts of climate change on developing countries especially affected by the adverse impacts of climate change. It reflects that Germany is playing an active part in the development of relevant concepts under the UNFCCC.

With a decision to continue the adaptation process the government accepted that adaptation requires a long term perspective which certainly goes beyond its political mandate. By starting the implementation phase of the

strategy and working on an Adaptation Action Plan (to be agreed in April 2011) the government clearly committed itself and took the responsibility of coordinating the adaptation process. Moreover the strategy is explicit for two additional aspects of the implementation phase: the inclusion of all concerned stakeholders and decision levels in the adaptation process as well as the improvement of awareness building and knowledge transfer.

In general adaptation to climate change requires user oriented information about climate change, its impacts, possible adaptation options and best practice examples. The Competence Centre on Climate Impacts and Adaptation (KomPass) at the Federal Environment Agency (UBA), established by the Federal Environment Ministry in 2006, summarises and assesses the results of vulnerability research and develops concepts for the national adaptation process. It gives advice to the Federal Environment Ministry how to steer the implementation phase of the strategy. Additionally KomPass makes the available impact and adaptation knowledge readily accessible to the public. It collects information on possible adaptation options (e.g. by a lot of stakeholder dialogues), evaluates them with respect to their risks and opportunities and makes good practise results available to concerned actors.

KomPass delivers platforms for communication and transparent information access. The knowledge base is underpinned by the numerous products, services and information provided by KomPass: besides the KomPass project data base including more than 200 adaptation projects, a decision support system for communities and enterprises, vulnerability risk maps, a newsletter, studies, fact sheets, brochures and flyers. KomPass distributes this information via an Internet-based information and communication platform with continuously expanding content. This platform allows easy access for a large group of people. The Environment Ministry ensures the required personnel and financial resources to keep them updated. If appropriate, KomPass has complemented the online communication by face to face communication by operating and moderating different networks with actors from science, business and administration for six years.

We will present, how the Action Plan is developed in detail. This includes the following aspects: the necessary political agreement on a practical definition on “adaptation measure” as well as on the needed level of detail, the evaluation and ranking of principles and criteria for prioritizing action needs (e.g. timing, synergies and conflicts among adaptation and mitigation as well as other policy targets, adaptation costs, best practice). How KomPass acts as effective science policy interface. This includes a description of transfer and communication methods, experience with stakeholder processes and communication tools. We will give a short overview on how KomPass is developing its Internet platform into a national clearing house mechanism and how we will combine the efforts of different disciplines and administrations in providing climate and adaptation information.

## **Climate Change Adaptation: The Approaches and Issues in India**

**S K Mandal<sup>1</sup>**

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The projected impacts of climate change in India are an increase in average temperatures by 2-4o C and marginal changes in rainfall during monsoon months, with large changes during the non-monsoonal months. The number of rainy days during the monsoons is projected to decrease by more than 15 days while the rainfall intensity is expected to rise by as much as 1-4 mm/day. Cyclonic storms are likely to increase in frequency and intensity. Climate change increases the vulnerability of the poor, and those dependent on natural resources for their livelihoods. It leads to less secure livelihoods due to depleted social, financial, physical and natural resources and human assets. Adaptation is the response to actual or expected climate stimuli that moderates harm or exploits beneficial opportunities. Nationally, some capacity, in about a quarter of Indian states, has been built for single rapid onset (such as earthquake) and long onset (droughts) disasters and risks. By and large, the reliance is on hard resilience options. Managing a complex portfolio of hazard risks and vulnerabilities is beyond the capability of current institutional setup. India has undertaken four officially supported national technical assessments of climate change risks, impacts, adaptation and mitigation option since 1992. This paper will discuss in details about these assessments and the future action plan for its adaption.

## **Poor, Urban Planning and Adaptation to Climate Change: Tales of Indian Megacities**

**S K Mandal<sup>1</sup>**

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This paper addresses how long term and sustainable urban planning strategies can be used in a context of extreme vulnerability (physical, social, capacity and institutional) to mitigate climate change. The fundamental contention of this paper is that urban planning plays a key role in strengthening adaptative capacities. The paper underscores that climate change responsive urban planning will be adding value to ongoing efforts to address fundamental social, economic, economic and institutional challenges facing urban dwellers in Indian megacities. Providing basic necessities and ensuring safety and quality of life in a changing climate condition have become complicated management issues in the megacities of India. Cities are already under pressure from the rising population and development activities. Existing urban infrastructure is quite inadequate to face these challenges. Water and power have become expensive and the supply is unreliable. Changing climate pattern also causes serious health issues. Increasing intensity and frequency of tropical storms, and the changing sea level pose threat to three of the four megacities of India. Environmental degradation worsens the impact of climate change. The situation leads to social issues such as competition and conflicts. This paper

looks at associated discourses and actions related to climate adaptation strategies in megacities of India. In recent years, the majority of global human population now lives in urban spaces, and studies show that these trends will continue. Moreover, particularly in the last five years, city level climate governance has emerged as a fascinating site of mitigation as well as adaptation policy engagement. This research seeks to contribute to work that examines both impediments and opportunities shaping climate adaptation strategies, and seeks to identify key impediments to greater policy cooperation.

## The impact of climate factors on the prevalence of dengue fever in Cairns and Townsville, North Queensland, Australia

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Dengue Fever, a mosquito-borne disease that is very likely to respond to climate, has become a global problem nowadays. In Australia, it commonly occurs in North Queensland, especially in Cairns and Townsville. It impacts on the increase of burden of human diseases in Queensland. Moreover, as climate change is happening there with more extreme weathers and favourable climate conditions, there would be a potential risk to have more frequent dengue outbreaks. The understanding about the relationships between climate factors and dengue fever is needed to anticipate future outbreak by using climate forecasts. It can be used as a part of early warning system that will help the prevention of dengue fever outbreak. However, none of the research covered the issue about the impacts of climate factors and dengue fever in Queensland, particularly in Cairns and Townsville. Therefore, this research aimed to analyse the relationships between climate factors and dengue fever in Cairns and Townsville. This research was a quantitative research using ecological study design. It only measured three climate variables: temperature, humidity, and rainfall, in relation to the occurrence of dengue fever. It used secondary data over 18 years, from 1990 to 2007, for both climate and dengue fever data. The climate data was collected from Australian Bureau of Meteorology and dengue fever data was collected from Queensland Health. The data then analysed into three steps univariate analysis; bivariate analysis using Spearman's correlation and simple linear regression; and multivariate analysis using multiple regression. This research found that dengue fever occurred every year in Cairns in the period of 1990 to 2007; but, in Townsville, there were years without dengue fever cases. The dengue fever mostly occurred in summer and autumn season. The climate variables (temperature, humidity, rainfall index, and rain days) in Townsville were higher than in Cairns. The bivariate analysis found significant relationships between all climate variables and dengue fever in Cairns. On the contrary, there was no significant relationship found between temperature and dengue fever in Townsville. The multivariate analysis found that in the interaction with the other climate variables, rainfall index was a significant variable that influence the occurrence of dengue fever in Cairns. The increase of 1 mm rainfall would probably increase one case of dengue fever. Then, the multiple regression model for Townsville explained that in the interaction with rainfall index, relative humidity was a significant variable to predict the change of dengue fever. The increase of 1% humidity would probably increase one case of dengue fever. Beside the climatic factors, there were also non-climatic factors that took a role in the occurrence of dengue fever in the two cities such as the problems occurred in the implementation of Dengue Fever Management Plan (DFMP) for North Queensland. The problems were lack of knowledge of dengue fever, lack of knowledge of value of early notification, lack of knowledge of the value of laboratory tests, lack of knowledge of the types of dengue fever tests and their reliability, and low awareness of communities in seeking medical treatment. The climatic and non-climatic factors will go hand in hand to cause greater outbreak in the future. Therefore, this research also recommends that Queensland Health should consider climate factors (temperature, humidity, and rainfall) in its DFMP for North Queensland.

## Interacting Effects between Climate Change and Habitat Loss on Biodiversity: A Systematic Review and Meta-Analysis

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Climate change and habitat loss are two of the greatest threats to biodiversity worldwide. Surprisingly, however, we understand little about their synergistic effects on biological populations due to a lack of process understanding and complexity. This has important implications for conserving biodiversity under climate change. Therefore, there is a pressing need to identify and quantify the interacting effects between climate change and habitat loss, rather than treating each as an independent process. In this paper we present a meta-analysis of studies that quantify the effect of habitat loss on biological populations and examine whether the magnitude of these effects depends on current climatic conditions and historical rates of climate change. We examined 1125 papers, identified from the past 20 years using the ISI Web of Science Database, across a range of taxa, geographic locations and climatic conditions. The dependence between the effect of habitat loss on species' density and current rates of climate change varied significantly. Overall, as annual mean temperature or precipitation increased the proportion of negative impacts of habitat loss increased. However, species from different taxonomic groups, with different geographical ranges or habitat preferences had different responses to climate change and habitat loss probably due to their different evolutionary histories. This is the first study to conduct a global analysis of existing data to quantify and test for interacting effects between climate and habitat loss for biological populations. Thus, our results provide a significant advance in our ability to incorporate the interactions between climate change and other threatening processes into biodiversity conservation. This in turn has critical implications for our ability to support and incorporate climate change adaptation measures into policy development.

## Increasing the resilience of the Cape Floristic Region to the impacts of climate change through the wise design and implementation of systematic biodiversity plans

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The Cape Floristic Region in South Africa is susceptible to three of the most detrimental impacts of Climate Change: global warming, sea level rise and increased frequency and intensity of floods. Certain areas within this biodiversity hotspot therefore need to be maintained and protected in order to buffer the social and economic environments against these impacts and to allow for the adaptation of the natural ecosystems. By proactively identifying and spatially delineating these areas which are critical to safeguard, and by mainstreaming them into land-use planning and decision-making, we are able to minimise the detrimental impacts on the environment of the Western Cape, South Africa.

The Global Environmental Facility-funded Fine-scale Biodiversity Planning Project has produced systematic biodiversity plans, referred to as Critical Biodiversity Areas (CBA) Maps, for nine local municipalities within the Cape Floristic Region. These CBA Maps identify a network of areas whose protection is required to meet national biodiversity thresholds for ecological pattern and process. By securing these process areas we allow for the long-term persistence of the natural ecosystems and at the same time are able to buffer the social and economic environments against Climate Change.

The CBA Maps have made use of innovative design criteria to identify those process areas which should be safeguarded and achieve this by: linking coastal low-lying areas to the cooler high-lying mountainous regions; by linking the north to the cooler south; by favouring cooler south facing slopes over warmer north facing slopes; by protecting edaphic interfaces; and by buffering coastal, wetland and river corridors from land cover transformation. The result is a product which allows for species migration and speciation and aids the protection and persistence of critical aquatic processes.

These products are yielding high levels of success and have already been mainstreamed into the fields of reactive land-use decision making (Environmental Impact Assessments), forward planning (Municipal Spatial Development Frameworks), protected area expansion (Stewardship) and land-use management (Environmental Management Plans).

On display will be the Critical Biodiversity Areas Map for the Cederberg Local Municipality of the Western Cape, South Africa.

## Vulnerability, Impacts and Adaptation to Climate Change in the Semi-arid Region of Northeast Brazil

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This review represents the state-of-the-art of knowledge on climate variability and climate change in the semi-arid region of Northeastern Brazil, focusing on impact and vulnerability assessments, and adaptation options. The Brazilian Northeast occupies 1.600.000 km<sup>2</sup> of the nation's territory and in 62% of this area contains the so called "Polígono da seca" (Drought Polygon). This polygon is a semi-arid region of 940,000 km<sup>2</sup>, which covers nine states of the Northeast and which faces a chronic problem of lack of water, with rainfall levels of less than 800 mm a year. In the semi-arid region there are approximately 30 million inhabitants, or about 15% of the national population. These numbers make this area the most densely populated dry region in the world. The irregularity of rainfall is a constant obstacle to the development of agricultural activities and the lack of efficient systems to store water - which are almost always controlled by a minority - intensifies the negative social impacts. To make things worse, strong cycles of drought customarily occur in the region in intervals varying from a few years to even decades. These cycles work together to permanently destroy the already fragile living conditions of small farmers and other poorer groups, and are often the excuse needed to leave the region. Therefore, this is perhaps the most vulnerable region of South America to climate variations and change.

The main objective of this presentation is to provide tools for discussion on and the implementation of regional environmental policies for adaptation to climate change. The evidence provided by the climate history in the region suggests that the semi-arid region of Northeast Brazil is vulnerable to the extremes of climate variability, particularly to drought, as is becoming evident in the droughts during some El Niño events. On longer timescales, future climate change projections suggest the occurrence of droughts and desertification, as a consequence of global warming that may affect the population, agriculture and natural ecosystems. The contents of this study include analyses of climatic tendencies detected during the last 50 years based on observations. In addition, analyses of climate change projections up to the end of the 21st Century (year 2100) are made using the global climate change projections released by the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), as well as using the results of the climate change projections derived from the downscaling of the HadCM3 global model using the Eta regional model (40 km) produced by the National Institute for Space Research (INPE), for mean climate as well as extreme climate events.

## Pacific Storms Climatologies: Products and Applications

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Improving our understanding of patterns and trends of storm frequency and intensity - “storminess”- within the Pacific region and how this might be changing in light of a changing climate is critical to both disaster risk reduction and climate adaptation planning. Such information is needed for risk assessment scenario development related to coastal land-use planning and resource management. It also forms the basis for establishing infrastructure (e.g., roads, water, and sewer) design criteria, among other things. The NOAA Integrated Data and Environmental Applications (IDEA) Center’s Pacific Storms Climatology Project is responding to this need. The results of this effort include the development of an integrated set of ‘strong winds’, ‘heavy rains’, and ‘high seas’ extremes climatology products. These include things like the delineation of rates of sea level rise and high water return periods, changes in the frequency of both short-lived intense rainfall events and extended periods of heavy rains, and the linkages of these patterns and trends to climate indices. Results also include the identification key elements, or ‘event types’ that characterize regional extremes climatologies, as well as the formulation of extreme event case studies. Finally, attention is also being given to the tailoring of such information to address sectoral needs in the context of disaster risk reduction and climate adaptation planning. The outcome of these efforts will be a reduction in the vulnerability to the economic, social, and environmental risks associated with coastal storms, as decision-makers in the Pacific Islands are provided with information that enables them to understand, anticipate, and adapt to risks associated with coastal storm-related extreme events.

## Understanding Social Resilience to Climate Variability in Primary Enterprises and Industries

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Climate predictions suggest that the scale and rate of change driven by increases in concentration of greenhouse gases in the atmosphere is unprecedented in human history, and will significantly – and in many cases dramatically – alter the accessibility and quality of natural resources. Primary enterprises and industries, which include the sectors of agriculture, forestry, fisheries and mining, are highly vulnerable to climate change because of their dependency on climate-sensitive natural resources for their prosperity and sustainability. Specifically, primary enterprises are expected to contend with more frequent climate crises (such as drought and flood), environmental degradation (such as eroding soils and limited production during drought periods), cultural change (such as those requiring new land management practices or using climate technology) and inevitable climate-related regulatory change. These stressors occur against an existing backdrop of conventional drivers of change including economic, biophysical, institutional, cultural and political pressures. Thus, the capacity of resource-dependent enterprises to cope and adapt with the compounding influence of climate change is largely uncertain. More than ever, resource-users will need to anticipate, and prepare for, each climate-related challenge, and institutions will need to be particularly supportive, if resource industries and the extended social systems dependent on them are to be sustained.

I use the cattle-grazing industry in Australia to assess and describe the adaptive capacity of primary enterprises. Grazing lands, or rangelands, are a variably productive and mostly socially remote landscape representing some 33% of the world’s terrestrial landscapes. Graziers, like other resource-users, must contend with variability in the climate each season and an already harsh environment. Graziers who can anticipate or effectively react to climate extremes are more likely to adapt to new climate conditions. However, some graziers will be better able to adapt than others.

An understanding of why some graziers will be more resilient than others to climate change may enable resource users, industries and communities to design effective strategies for enhancing social resilience and better prepare for climate challenges. I examine the capacity of 100 cattle-graziers in northern Australia to cope and adapt to climate variability as a precursor for understanding their vulnerability to climate change by assessing: (i) their perception of risk, (ii) their capacity to plan, learn and reorganise (iii) their proximity to the thresholds of coping, and (iv) their level of interest in adapting to change. I also assess their dependency on the grazing resource by assessing their level of attachment to their occupation, employability, attachment to ‘place’, family dependency, financial circumstances, business size, business approach, environmental values and attitudes, and local knowledge and skills. Whether the uptake of climate tools such as seasonal climate forecasts is likely to occur in order to enhance adaptive capacity is also assessed. The influence of resource dependency and technology uptake on adaptive capacity is also examined.

Graziers perceived themselves to be resilient to climate variability in their perceptions of climate risk, reorganising capacity, coping, and level of interest in adapting. Highest resilience was associated with graziers who were more interested in using seasonal climate forecasts, highly attached to ‘place’, employable, strategic and financially secure. Dimensions of resource dependency were highly correlated with several aspects of adaptive capacity. Uptake of seasonal climate forecasts was also significantly correlated with aspects of adaptive capacity suggesting that use of climate technology can influence adaptive capacity (or that people with a higher adaptive capacity are more likely to use seasonal climate forecasts). Results provide practical knowledge of individual adaptive capacity that could inform climate adaptation planning. For example, facilitated collaborative learning amongst graziers and other stakeholders may assist to develop strategic skills, increase climate awareness, develop financial security and adopt climate tools such as seasonal climate forecasts. Enhanced strategies for coping with climate variability may provide a way for encouraging gradual, incremental adjustments for climate adaptation.

## A Framework for Social Adaptation to Climate Change: Sustaining Tropical Coastal Communities & Industries

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The estimated 500 million people who depend on coral reefs worldwide regularly contend with change. Whether it is the shifting demands of a global marketplace, political upheaval at the national level, shortage of local supplies such as fuel, or fickle weather, the resilience of reef dependent people is often put to the test. Despite this hard-earned resilience, coastal communities and reef-based industries are going to be challenged like never before as climate change exerts a multi-faceted influence. The ecological effects of climate change on tropical marine systems are predicted to be diverse and long-lasting. Observations are already supporting projections of increasing sea and air temperatures, rising sea levels, acidifying oceans, intensifying storms, and changing rainfall patterns and ocean currents. Widespread degradation of coral reef ecosystems will result from mass coral bleaching and consequential mortality, and from ocean acidification. Fish ranges will change and diseases will become more widespread. Unassisted, many coastal communities and reef-based industries are likely to struggle to cope with a challenge of this magnitude. Whilst opportunities to prosper will almost certainly also exist, vulnerable people will need guidance and support to anticipate the impacts of climate change and implement adaptation strategies if they are to sustain their livelihoods and quality of life into the future.

Understanding vulnerability is an important first step in preparing for a climate uncertain future. But how do we measure vulnerability in practice? And how do we reduce it? Vulnerability assessments provide information about the nature and magnitudes of impacts expected from climate change, and inform decisions about the form and urgency of adaptation activities and strategies. In this presentation, we present an approach for assessing social vulnerability that has recently been published by the IUCN to provide guidance to natural resource managers, conservation practitioners and other individuals who are interested in understanding the implications of climate change for resource-dependent people, and in helping build their resilience.

The approach is based on the exposure-sensitivity-adaptive capacity framework developed by the IPCC and others. The approach delineates the ecological and social dimensions of vulnerability and incorporates the important and dynamic linkages between them. Exposure to climate change within social systems is described as a function of ecological vulnerability; climate sensitivity is a measure of the dependency of people (individuals and communities or industries) on the marine resource, and adaptive capacity can be assessed with a range of indicators across scales. Important indicators of resource dependency and adaptive capacity will be discussed in detail.

While adaptation is clearly in the interests of those most vulnerable, it is often policy makers and resource managers who are best positioned to facilitate development and implementation of vulnerability-reducing strategies. Here, we provide guidance for understanding the implications of climate change for resource-dependent people, and in helping build their resilience. We outline four main steps in building resilience: assessing vulnerability, identifying resilience building strategies, prioritising resilience efforts, and implementing resilience-building strategies. These steps can be incorporated into project design, industry codes of practice, sectoral adaptation strategies, community initiatives and/or regional policy development.

We conclude with the optimistic message that there is much that can be done at the local level to minimise the impacts and capture the opportunities associated with climate change. While every effort must be made to stabilise greenhouse gas concentrations before climate thresholds are crossed that cause irreversible damage, we must also accelerate efforts to prepare for those changes that are inevitable. Those who influence how people utilise natural resources can play a significant role in building social resilience and supporting climate adaptation.

## An integrated regional approach to climate adaptation – the Great Barrier Reef Climate Change Action Plan

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Coral reefs are among the most sensitive of all ecosystems to climate change, and their fates have become a centrepiece of public and political campaigns for action on greenhouse gas emissions. Yet, the breadth of the implications of severe and widespread coral reef degradation have only just begun to be comprehended. While the impacts of sea level rise are often front of mind when considering climate vulnerability, the livelihoods of hundreds of millions of people inhabiting coasts and islands in the tropics are strongly linked to the future of coral reefs. Climate change is predicted to drive serious and widespread degradation of coral reef ecosystems primarily as a result of rising sea temperatures and ocean acidification. Understanding the linkages between social and ecological systems associated with coral reefs and assessing their vulnerability to climate change is critical to effective adaptation in islands and coastal areas throughout the tropics.

In Australia, the Great Barrier Reef is being used as a national case study for development of regional, integrated approaches to climate adaptation. A comprehensive first-pass vulnerability assessment provided the foundation for a 5-year regional climate change action plan. While the amount and detail of information on climate vulnerability varies immensely among different system components (e.g. there is much more detailed knowledge about vulnerability of corals than of microbial

processes), the Great Barrier Reef vulnerability assessment has identified major conservation challenges, informed high-level adaptation policy and guided prioritisation of subsequent adaptation activities in the region. Under the Action Plan, second-pass assessments are currently under way for highly vulnerable sectors and ecosystem components. These assessments focus on priority ecosystem components and major reef-dependent industries and communities.

In partnership with key stakeholder groups, the Great Barrier Reef Marine Park Authority is currently facilitating sector-specific adaptation plans that are tailored to sectoral needs and capabilities. Key outcomes to date include a Climate Change Action Strategy for the \$2.6 billion tourism industry, a Stewardship Action Plan for the coral and aquarium fishery, an adaptation planning process for other major commercial fisheries, and a community based reef resilience program in the southern Great Barrier Reef. Already, sectoral engagement in assessing climate vulnerability and exploring adaptation options is translating to large increases in adaptive capacity and greater alignment between resource managers and resource users in sustainability and conservation goals.

## **Cyclone Tracy: A case study on adapting building regulations to minimise the impact of extreme wind events**

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Tropical Cyclone Tracy laid waste to Darwin early on Christmas morning 1974. Tracy was a small but intense cyclone that generated gust wind speeds in excess of 217 km/h and destroyed much of the city's housing and infrastructure. Approximately 60% of all homes were completely destroyed, with only about 6% left immediately habitable. This damage left 40,000 people homeless and necessitated evacuation of 80% of the city's population. Cyclone Tracy showed the Australian, and international, engineering community that the magnitude and duration of cyclonic winds could be far greater than anyone had previously thought possible. Cyclone Tracy awoke everyone to the true risk of cyclonic wind storms and highlighted the consequences of deficient engineering design practices. In Darwin, the responsibility for the devastation clearly lay with those in charge of the construction of her buildings, which en masse, failed so spectacularly. The ensuing human catastrophe in essence stem from the simple fact that the places people went to shelter during and after the storm were not resilient enough to withstand the force of the cyclonic winds. Cyclone Tracy therefore represents an engineering failure, and necessitated an engineering solution to be found.

Unlike many other natural disasters, the solution for minimising losses during extreme wind events can largely be found with better engineering. In the aftermath of Tracy it was concluded that destruction was so vast because the structural integrity of housing had not been given the priority it deserved. This led the engineering community to promote the radical idea that housing be treated in the same light as all other, mostly larger, engineered structures, and be scientifically designed to withstand expected wind forces. This notion led to an outburst of research in the field and led to the introduction of new engineering based housing design standards, more specific design specifications for all buildings in cyclone regions, and the application of a more scientific method for the analysis of cyclonic wind risk. In short, a complete overhaul of the way housing was built in this country. It was no longer acceptable to suggest that the low cost of housing justified an unscientific approach to its design; after all, this was where the majority of the city's population sheltered during a disaster, and integrity had to be ensured to maximise occupant safety.

In all, this presentation investigates the response of the engineering community to the significant structural failures observed during Cyclone Tracy, and highlights the lessons learnt and the road taken to implement these lessons into present day building practices. Changes to building design philosophy, design standards and the construction inspection process are discussed, with positive and negative components highlighted. An attempt is made to quantify the improvements to structural resilience, with results broadly suggesting a reduction in damage of the order of 80%; a level that would likely alleviate the necessity of an evacuation. The presentation will conclude with a brief discussion of outstanding issues with the current design/building process, that if addressed, could minimise the future cost of similar extreme wind events.

## **Impact Assessment of Climate Change on Irrigation and Adaptation by a Distributed Water Circulation Model**

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The paper summarizes impact assessment and adaptation of climate change on irrigation carried out by using a distributed hydrological model for the Mekong (7,950,000km<sup>2</sup>) and Sekikawa (1,140km<sup>2</sup>) River basins, which are representing examples for large international and irrigation dominant river basins, respectively. A large proportion of the water used in monsoon Asia is used for rice paddies, and the mechanism of use varies from area to area. Water use is influenced by the type of irrigation and by the distinct occurrence of dry and rainy seasons. Hydrological models, however, do not necessarily describe these various types of water use. At first, therefore, we proposed a distributed water circulation model incorporating variations in agricultural water use, so that the model provides useful information on paddy cropping area, actual water intakes for irrigation, actual evapotranspiration, soil moisture and runoff at arbitrary times and points in the basin. It was firstly applied to the Mekong River Basin, in which we compared discharges and actual evapotranspiration estimated by the model with the observed data. The comparisons revealed the high degree of reliability and usefulness of the model. The model was then strengthened with snowing/melting and dam operation models developed and combined with the model mentioned above for the Sekikawa river basin in Japan. Eventually, the model proved to be a useful tool for evaluating the effects of human activity on agricultural water and for predicting these effects of climate change on agricultural water use in future. Secondly,



the estimation of future climate condition by MRI-CGCM2.3.2 and MIROC3\_2\_HIRES was inputted into the above model and the results obtained are as follows: 1) Bias corrections are necessary to assimilate probability distributions between the observed and recreated (GCM/RCM) meteorological data series. 2) Snowmelt runoff decreases in early spring, minimum flows decrease from May through September, and maximum flows increase after June, due to global warming. 3) Actual agricultural intake at the 'Itakura' head works decreases especially during puddling periods due to the above decrease in snowmelt runoff, 3) Although cropping areas of rain-fed paddies increase due to the increase of rainfall, the areas in drought years in the future (2046-2065, 2081-2100) decreases compared to those of present period (1981-2000). Then, thirdly, a new-type of irrigation planning method was proposed for national adaptation measures as namely "basin-wide integrated irrigation scheme," in which the model mentioned above is fully utilized as an evaluation tool for the change of water circulation and agricultural water use in future and as a planning tool for proposing measures against predicted affects on irrigation.

## Development of a model for predicting the damages of typhoons on paddy rice in Japan

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**Introduction:** 2.6 typhoons hit Japan in a year on the average and those have had significant impacts on agricultural production every year. What is worse is that global warming is predicted to enhance the intensity of typhoons because of the increase in sea surface temperature (Oouchi et al., 2006). Against this background, prediction of the detailed spatial distribution of the damages of typhoons before typhoon's landfalls can give useful information for taking prior and posteriori actions to reduce the damages. However, there are no studies on prediction of the detailed spatial distribution of the damage of an individual typhoon on crops in Japan. The objective of this study is to develop a model which can predict the detailed spatial damage of an individual typhoon on paddy rice in Japan.

**Method and materials:** We developed a statistical model for predicting the damage of a typhoon grids by grids (6\*6'). The formula of the statistical model is "damage=a+b\*maxwnd\*\*3+c\*maxpre; if damage<0, then 0; if damage>1, then 1." "Damage" indicates reduction rate of production for each grid. "Maxwnd" and "maxpre" are maximum wind and maximum precipitation for each grid from emergence to disappearance of a typhoon. The model parameters, a, b, and c, are obtained for each prefecture by least squares method using reported prefectural damages of typhoons for "damage" and gridded data on wind and precipitation for "maxwnd" and "maxpre." The gridded meteorological data are made by spatially interpolating observed values at stations to each grid. Information on typhoons is used from the Best Track Data. 62 typhoons from 1991 to 2007 are used for determining the model parameters.

**Model performance:** We confirmed that the model could reproduce typical spatial distribution of typhoon damages. The comparison of damages for 62 typhoons between simulated and reported values for Kyusyu region, where typhoons hit most frequently in Japan, showed that there was good agreement, especially for large damages. The average of error (=average value of (|reported value-simulated value|\*100/|reported value|)) was 21.3% for typhoon damages over 10000t and 33.7% for those over 5000t. The rate of average error (=average of |reported value-simulated value|\*100/average of reported values) was 37.1%.

## Tourism and Adaptation to Climate Change in Switzerland : an example of public participation in the Aletsch region

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Climate change is a global phenomenon, but its effects occur on a local scale. An example is provided by tourism. Tourism is closely interlinked with climate change both as culprit and as victim. On the one hand, it is responsible for a large portion of GHG emissions from leisure-related transport and high energy consumption in the accommodation and activity sectors. On the other hand, sea level rise, snow pack reduction, glaciers melting, increase of frequency of natural hazards, among other negative impacts, both modify tourism flow and damage infrastructures. This will lead to many regions and nations to become more vulnerable and fragile.

One of the concerned regions is the Alpine chain and its villages. The Alpine region is highly affected by climate change (snow pack reduction, glaciers and permafrost melting, increase in flood, landslides, and rock falls events). Because this region is highly dependent on the tourism sector for its subsistence and that the tourism sector is highly dependent on climate conditions and on the frequency of natural hazards, it is essential to reduce vulnerability and to start planning and implementing proactive adaptation measures. In order to do so, it is important to define which areas face which problems and to recognize vulnerability hot spots. A vulnerability map was created in the first stage of our work.

This article first presents an overview of the stand of the knowledge on the impacts, the vulnerability and the possible adaptation measures of the tourism sector in relation to climate change. It then describes the results of a participative process carried out in one of these hotspots in the Swiss Alps, the Aletsch region. This region - which encloses one of the longest glaciers of Europe (the Aletsch glacier) - is part of the Jungfrau-Aletsch Unesco natural World Heritage property. It is well-known for its beautiful landscape, for its hiking trails, and for its ski resorts. It is therefore no surprise that the region highly

depends on tourism, with the majority of the jobs directly or indirectly linked to this sector. During the three workshops carried out in the region with local public and private stakeholders, impacts were defined and possible adaptation measures and strategies sought. Efforts were made in order to integrate stakeholder perceptions, and initiatives in other sectors.

## Proving the Adaptation Pudding: Prioritising Local Government Climate Change Investments

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The climate is changing. Responsible and cost effective action is urgently required to both mitigate (reduce and remove) pollution and adapt to inevitable changes. While national governments and international organizations debate greenhouse emission reductions,

local governments around the world face pressing demands to invest wisely to prevent, or at least reduce, negative impacts of climatic change on their communities. Model predictions offer little assistance because of poor spatial resolution and uncertainties associated with the future. However, local councils know weather extremes will continue and many could increase in intensity or frequency. Climate adaptation linked to extreme events is a necessity especially at local scales since the impacts and adaptation measures are often uniquely location specific. Moreover, climate extremes result in economic, social and environmental damage making it imperative for local authorities to take precautionary adaptation measures. Despite the urgency, local level climate adaptation actions are often delayed by the lack of prioritization guidance and timely responses are budgeted below other local priorities.

In this paper we present a novel method which includes both past observations and projections resulting in a prioritised set of adaptation measures for climate extremes at local levels. This new process is tested in two contrasting local government jurisdictions

Ku-ring-gai Council in New South Wales, Australia and Cochin Municipal Corporation in Kerala, India. Here we report an evaluation of heatwaves, bushfires, floods and droughts for the two contrasting case study regions and the consequential priority setting for local government climate change adaptation investment.

## Unique Responses by the Sheraton Fiji Resort to the Impacts of Climate Change

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The focus of this paper is the unique proactive adaptation initiatives in response to the impacts of climate change that have been undertaken by the Sheraton Fiji Resort, located on the shores of Denarau Harbour, a major tourism destination in the South Pacific Island nation of Fiji.

Resort staff participated in a systems-based methodology to firstly identify the perceived impacts of climate change on the resort. Reported climate change impacts included hygiene issues, water shortages, insect and vermin outbreaks, beach erosion, coral bleaching and the inability to offer and conduct daily tourist activities. These negative impacts flowed on to the Sheraton tourists' actual experience, their perceptions and overall levels of satisfaction at the time of their visits. In the long-term, climate change impacts have the potential to reduce tourism visitation due to cancellation of future bookings, thus causing an overall economic downturn across the nation (Aguirre 1991; Tisdell 2008; Davenport and Davenport 2006). Climate change impacts are therefore regarded as a considerable threat to the small island nation's main economic driver.

Resort staff identified several context-specific impacts of climate change and the strategies that have been implemented. Of the specific impacts, the most serious was the massive erosion and consequential loss of thousands of cubic meters of the original white sand beach from the resort. This event reduces the tourist's overall satisfaction levels, the capacity and potential for marketing and promotion of the resort, the capacity of the resort to remain attractive and market competitiveness. The erosion and loss of the main beach was due to construction of a sea wall at a neighboring resort. Three unique strategies developed by the Sheraton provided an insight to the initiative and capacity to adapt to specific climate change impacts.

Firstly, a major renovation project was recently completed at the Resort which included installation of a considerably larger multi-pool complex in place of the single pool and eroded dark sand beach. Secondly, resort guests can be ferried from the eroded home beach to a small nearby island which the Resort also owns several hundred meters away. Here, guests can enjoy a more secluded experience on a pristine white sandy beach. Thirdly, the Sheraton Fiji Resort collaborated with the two adjacent and expansive five-star properties: the Westin Denarau Island Resort & Spa and the Sheraton Denarau Villas, to give guests from each property access to, and use of the combined facilities of the three resorts. This arrangement includes unlimited access to the beach where the eroded white sand from the Sheraton Fiji was conveniently deposited.

The Sheraton marketing strategy now includes proactive promotion of the innovative cluster of resorts, an emphasis on the added value resulting from three times the number and variety of activities and facilities, highlights and photos of the multi-pool complex and the offer of the unique opportunity to enjoy a half or full day "escape" on a secluded, white sandy beach on the uninhabited island.

The perceived generic and context-specific barriers, opportunities and unique strategies in response to climate change impacts provided insights into the adaptive capacity of three luxury resorts. Stakeholder collaboration has: increased the economic viability and sustainability of this cluster (especially the Sheraton); developed new opportunities for tourism development; increased the variety of activities and choices for tourists; added value to the overall tourist experience;

enhanced positive perceptions and levels of overall visitor satisfaction. This unique example of adaptive capacity to climate change impacts provides a potential model for other tourism destinations to consider and expand upon.

## More than CO2: the role of native vegetation in climate change mitigation and adaptation

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The climate change projections for Australia show a significant economic and social impact of climate change resulting from increased frequency and severity of climatic extremes (heatwaves, bushfires, droughts and floods). The results of our research demonstrated potential for mitigation of climate extremes resulting from increased concentration of greenhouse gases by restoring native vegetation in eastern Australia. In this paper, we highlight the risks of ignoring the role of land surface feedbacks in current climate change policies. Currently, there is still little recognition by policy makers and research community of the close coupling of the human-modified land surface and the atmosphere. A number of studies show that reforestation in the tropics and sub-tropics could be beneficial to mitigating global warming as well as having other benefits such as carbon sequestration and maintenance of ecological services including biodiversity, clean air and water. Restoring native vegetation at a regional scale also has the potential to reduce the impact of climate extremes. We highlight the potential benefits and risks of large scale revegetation in climate change mitigation and adaptation.

## Communicating Climate Risks and Adaptation Strategies Across Stakeholders Using Video

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While a growing body of research is discovering the barriers to effective communication about climate risks, little work has attempted to implement solutions to these problems through the creation of new, evidence-based communication tools. Consequently, there is a great need for communication regarding climate adaptation that moves beyond these barriers to make risks tangible, place-based, and actionable. This project offers a model in which video tools can be used to communicate climate risks and stimulate behavior change. I develop and test participatory, place-based, risk-specific video segments for fostering climate adaptation. I hypothesize that:

- Participatory video can uniquely facilitate learning across diverse perspectives and experiences of stakeholders.
- Participation in cross-stakeholder video production results in feelings of accountability and connection with others addressing a particular risk.
- Perceived shared experience is more likely to lead to behavioral change than knowledge-deficit approaches.
- Viewing a video that relates to an individual's localized or regional concerns facilitates behavior change about localized risks.

To test these hypotheses, I incorporate affective and analytic information in video production. It includes engaging multiple perspectives in a participatory manner, a focus on a particular risk, and is place-based. I develop documentary video segments that address climate risks and adaptation strategies in three test cases: 1) heatwaves in Philadelphia, Pennsylvania, 2) coastal flooding in Mississippi, and 3) wildfires in California.

The development of these documentary segments and the selection of participants involves three steps. First, background research is conducted on each case, as well as on stakeholders critical to mitigating risk and creating adaptation. Stakeholders are selected from four categories of central decision-makers that shape adaptation processes: regional EPA officials, city officials, non-governmental organizational leaders, and community residents. Additional interviewees may include experts and federal-level decision-makers. Each interviewee is selected to represent a set of experiences on the part of the group from which the specific stakeholder is selected. Second, subsequent to the collection of background information on each stakeholder, the stories of four people are filmed. Narratives are based on their experiences with the particular risk and any additional relevant experiences, such as perceptions, experiences, capacities, and obstacles that each stakeholder faces. Finally, footage is edited into short video segments based on narratives of individuals in each location. Narratives of stakeholders are interwoven with one another in order that perspectives can be shared and a collective identity of those managing risks at diverse scales is created. As such, the final video product also addresses challenges to bridging stakeholders to find consensus on adaptation strategies.

The central aims of this work include: addressing the barriers to effective climate communication, fostering the collective action on adaptation, and filling the gap between research on communication and the creation of communication projects that implement these findings. An evaluation component is implemented before and after participation in or exposure to the video segments in order to measure the achievement of these aims. This includes a short survey regarding beliefs, opinions, and intentions to take particular kinds of actions. The survey is administered to those who participate in each project. The survey will also be re-administered at a later date to better measure behavioral change.

Preliminary conclusions in this project indicate that stakeholders are often unaware of the needs, perceptions and possibilities of other stakeholders, resulting in misunderstanding and even controversy in the selection of adaptation practices. Second, bridging these differences can stimulate new thinking about the risks of climate change and create relationships that lead to improved conceptualizations about adaptation.

## Transforming domestic consumption patterns in urban water supply in South East Queensland

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South East Queensland is Australia's fastest growing region. Its current population of 2.5million is projected to increase to 4.4million by 2031 (Queensland Government 2009). This rapid urbanisation and population growth, combined with its coastal topography and unique biodiversity makes the region the nation's most vulnerable to the impacts of climate change (IPCC 2007, PMSEIC 2007). Sea level rise, flooding, habitat loss, and water scarcity all pose major threats (PMSEIC 2007).

The "millennium drought" (Australian Government 2006) of 2005-2009 produced a water security crisis in the region. Dam levels in 2007 fell to 16.7% (Queensland Water Commission). Major initiatives were introduced to address water governance, supply and demand. The Queensland Government took control of water supply and distribution from a dozen local governments and created the Queensland Water Commission to centralise authority and initiate reforms to supply and demand management (Spiller 2008). Water storage and supply capacity was increased through infrastructure works, including desalination plants, new water supply dams and water recycling proposals.

A range of measures was also introduced aimed at modifying household demand. These included extensive public education campaigns and warnings about the region's dwindling supplies, prohibitions on types of water use, and financial incentives for behavioural change. The measures produced major changes in water consumption: from an estimated 700 litres per person per day (Spearitt) in the 1990s, when water use was unrestricted and unmetered, to 140 litres per person per day at the height of the drought (QWC 2008). There is a range of anecdotal evidence that it also effected lasting cultural shifts in attitudes towards water and water scarcity (QWC 2008). This is borne out by the negligible increase in consumption that followed when heavy rainfall since November 2008 led to a progressive easing in water restrictions. The SEQ drought officially ended in May 2009. To date, household water consumption habits have not returned to pre-drought conditions and it appears that the behavioural and attitudinal changes achieved during the drought have persisted. A range of theories have been advanced to explain the success of these demand-side reforms over such a short period of time (Buth 2008, Cooper and Crase 2009, Shearer 2008, Gardiner 2009, White 2008, Roseth 2008).

Liberal democracies around the world have shown a reluctance to regulate individual consumption habits or prescribe certain standards for private property (Salzman 1997, Vandenberg 2004), yet such measures may become more necessary if householders do not take their own steps towards adapting their homes and lifestyles for changing climatic conditions. Regardless of whether the Millennium Drought can be attributed to climate change (Australian Government 2006, Karoly, Risbery & Reynolds undated), the success of water demand management in South East Queensland in achieving profound and (it would appear) lasting behavioural change may offer valuable insights into how best to design and implement strategies for climate change adaptation more broadly.

## The Devil and the Deep Blue Sea: Legal Responses to Climate Change Risks in Australian Coastal Communities

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Australians have a love affair with their coastline. 85% of the population lives in the coastal zone (NRMMC 2006). As climate change brings increased threats from sea-level rise, storm-surge, erosion and coastal flooding, the protection of coastal communities and property has become a national priority. Yet management of Australian's coastal zone has a history of fragmentation, poor coordination and inconsistency across jurisdictions (Hunt et al 2007, House of Representatives 2009).

Local and state government agencies with development authority over coastal areas face an invidious choice. Do they risk virtually certain legal challenge, by constraining development rights in order to protect against climate change risks, or do they chance the less-certain but potentially-costlier risk of extensive liability to future landowners, by continuing to allow development on coastal land (McDonald 2007)? The fear of future liability for climate change impacts is hampering coastal development in many vulnerable locations (Gurran et al 2008). Without clear guidance on what is appropriate for projected risks, local authorities are reluctant to approve new activities (House of Reps 2009, McDonald 2010).

Five Australian states have developed coastal policies or planning instruments that require development authorities to consider the impacts of climate change on new development. Most of these documents impose binding legal obligations on local government to allow for a sea level rise of either 0.8 or 0.9m by 2100, with additional allowance for the effect of storm tides (England & McDonald 2009). Where these policies remain merely advisory, there is an alarming difference in implementation and uptake at the local level. Some local authorities have declined to follow the guidance (Smith 2010), while others are seeking to impose even stricter controls on coastal development (Byron Shire Council 2009). New South Wales is legally entrenching the right of property owners to protect their own properties against coastal erosion (NSW Government 2009). With such a wide range of local and state approaches, and uncertain legal implications of each choice, there is growing pressure to develop nationally-consistent guidelines (House of Reps 2009).

Courts in four Australian states have considered the relevance of climate change projections to development assessment processes (England & McDonald 2009, Bonyhady 2010). These cases must all be understood in their own specific contexts, but all point to the importance of strong statutory and spatial planning provisions that specify climate change impacts as a relevant consideration. Courts have upheld the decision of councils to refuse development consent in places where a clear coastal management plan is in place and have overturned approvals where councils have failed to give appropriate consideration to climate change impacts.

In many cities around the Australian coast, the options for safeguarding against sea-level rise are more limited because historical development has created a massive infrastructure legacy in vulnerable coastal locations (Thom et al, 2010). In these places, councils and state agencies must find ways of minimising future exposure through technological approaches to coastal fortification and restrictions on redevelopment, or craft mechanisms by which to fund the costs of repair, retrofit, relocation and retreat arising from past decisions. These choices involve careful assessment of the costs of constructing and maintaining such works, as faulty or poorly maintained structures that cause property damage are likely to create their own liabilities (Byron Shire Council v Vaughan 2010).

## When should we stop learning about climate impacts on biodiversity and act?

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It is widely recognized that changing climatic conditions will lead to shifts in the distribution of many species. It is now apparent that our response to climate change impacts on biodiversity must include both actions to reduce further climatic changes (mitigation), and actions aimed at buffering species from the impacts of climatic change (adaptation). So ubiquitous are the impacts of climate change, that adaptation actions will constitute an increasingly important part of the toolbox of environmental managers worldwide. An important issue for biodiversity management is that climate change introduces additional uncertainty about how ecological systems function and how this functioning is likely to change through time-factors that are both crucial for good decision-making. Decision-making frameworks for managing biodiversity in the face of potential climate change scenarios and impacts must both acknowledge and incorporate this uncertainty, and the potential to reduce uncertainty. Our understanding of climate change and the response of biodiversity can be improved through monitoring.

However, monitoring requires time and resources, both of which could otherwise be dedicated towards conservation actions. In this context, an important question is how long should we monitor to understand how systems are changing, and thus which climate scenario is most likely, and what level of confidence in our predictions do we need to before deciding to act?

We provide an explicit framework for making tradeoffs between learning about the true impact of climate change from a suite of possible futures, and making a decision to take management actions in response to a particular future. We highlight the use of this framework for making decisions about the emerging and highly controversial management action of assisted migration (also known as managed relocation or assisted translocation). Assisted migration involves physically moving species from their current location to new habitats where persistence is predicted to be more likely with a changing climate. Current frameworks for assessing if assisted migration do not enable managers to tradeoff between acting now or reducing uncertainty about the risks and benefits of moving a species through active learning.

By taking action too early we risk moving species to areas where persistence likelihood is lower than at present, with the removal of individuals condemning the existing population to certain extinction. If action is delayed for too long, we risk losing species entirely if climate change rapidly degrades habitat quality as low numbers of individuals will significantly reduce the probability of successful translocation to a more suitable area. The framework presented here will aid managers in deciding how much time to invest in improving our knowledge on which model of habitat change is most likely before deciding whether to relocate a species to a new area. We construct models for the impact of two climate change scenarios on a threatened species for which assisted migration is a potential adaptation action. These models represent the change in habitat suitability as either the climate shifts (model 1 - climate change impact) or remains constant (model 2 - no impact of climate change) and are used to assess the number of individuals in a population (the state of the system) and our understanding regarding which model of climate change is most likely (our knowledge state).

We use a belief Markov decision process to derive the optimal strategy for when to learn and when to move the species to a new area given both the current state of the population and our current understanding of how climate change is impacting our population. Explicitly characterizing and solving the tradeoff between learning and management will allow managers to make confident decisions about conservation actions despite the severe uncertainty of climate change impacts on biodiversity.

## Adaptation challenges facing the State of Victoria, Australia: an exploration of the evolving institutional response

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Australia is a continent that has been shaped throughout history by the combined influences of harsh climatic and environmental conditions; a country in which its communities have become accustomed to dealing with weather-related challenges, from flooding and cyclonic storm events in the north, wide-ranging droughts experienced across many parts, to episodic outbreaks of bush fires. As a consequence of these natural hazards, organisational and individual responses to the vagaries of the weather have traditionally been framed in the context of coping with 'natural variation' rather than being an explicit recognition of the need to adapt traditional practices to longer term trends in the climate. In this paper, however, the authors will argue that the antipodean perspective of climate risks is changing (and hence accentuating the need for planned adaptation), driven not only by personal experiences of recent extreme events but also by shifts in the political landscape. The focus of this presentation's attention is Victoria, a State considered by many to be at the leading edge of these changes.

Although located in a predominantly temperate part of the country, in recent times communities in Victoria have been subject to the adverse impacts of several high-impact extreme events; the most high profile being an ongoing ten year drought and related water restrictions, and a series of severe bush fires which devastated peri-urban areas surrounding Melbourne in February 2009 ('Black Saturday'). Looking to the future, there are also significant public and policy concerns about areas of low lying coastline and the vulnerability of valuable regional assets to a rise in sea levels. Responding to this emerging and important adaptation agenda, the presentation will set out the challenges to the State-level strategic response according to four main themes. The first of these will be to identify and elaborate on the main regional climate impacts that are likely to affect the region in the future. These will be addressed according to landscape type, sector, and different elements at risk; in order to highlight the regional context underlying the adaptation agenda. Following this opening narrative of potential future risks, the Victorian policy response will then be critically analysed; this will not only include adaptation policy (which is only a relatively recent political development) but will also reflect on the wider picture, in particular the discrete 'policy silo' responses which have traditionally characterised public action to deal with the impacts of weather-related hazards in the past. The third strand of discussion will then narrow down the scope of analysis to consider the policy developments relating to adaptation specifically, describing its recent evolution at the State level and institutional 'fit' within the embryonic framework of multi-level climate policies beginning to emerge in Australia.

The concluding section of the presentation will focus on the rationale behind an innovative institutional response - the newly established Victorian Centre for Climate Change Adaptation Research (VCCCAR). It is the first State initiative of its kind with a role to support the mainstreaming of climate change considerations across a range of sub-national policies. Particular attention will be paid to the potential to promote the building of local adaptive capacity as represented by knowledge generation, new platforms for knowledge transfer, creation of spaces for learning and consensus building etc; and how it is intended that these goals will be achieved through a suite of different mechanisms: for instance the commissioning of research projects (targeting regional priorities as identified by policy makers), regional think tanks to promote new interactions between scientific, policy and wider stakeholder communities), the hosting of visiting research fellows (international exchange), and annual forums (dissemination of research findings to a regional audience).

### **Tailoring mental health promotion in rural and remote areas in the context of climate change: a non-government organisation perspective**

**A McEwan,<sup>1</sup> J Bowers<sup>1</sup> and T Saal<sup>1</sup>**

<sup>1</sup> Centre for Rural and Remote Mental Health Queensland, Australia

As we are currently witnessing in the domestic climate change debate, conflict between interest groups who have different stories about how climate change adaptation strategies will impact on their rights is unavoidable and is likely to intensify as strategies are developed and implemented. Successful adaptation to climate change will demand that the many interconnections between rights as asserted by individuals and those of groups or collectives at national, regional and local levels are negotiated skilfully and equitably. This discussion draws on human rights discourse and the VicHealth mental health promotion framework. The Vic Health framework identifies three key social determinants of mental health: social inclusion, freedom from violence and discrimination, and economic participation. Taking a human rights perspective is consistent with Ross Garnaut's view that tackling the climate change problem is essentially an ethical problem. On this basis we argue for community-based mental health initiatives that integrate equity and opportunities for civic participation. The Centre for Rural and Remote Mental Health Queensland's community-based initiatives have strong frameworks for community engagement and are designed to support participation, strengthen social support networks and develop life-skills and mental health literacy. There is great potential to:

- integrate climate change information into these community-based project frameworks,
- tailor these activities for specific groups and
- create opportunities for participation, sharing information, experiences and building trust within and across cultures to develop wider shared values about climate change adaptation and mental health that are supportive rather than divisive.

This paper addresses Herrman's assertion that 'politicians, educators, and non-government organisations are key agents in mental health promotion' (2001) and it is in this context that we explore the form and content that future initiatives of the Centre and other non-government agencies might take in order to successfully support individuals, families, and communities to cope with change and to maintain and enhance social and emotional wellbeing. With strong, well-designed evaluation processes these initiatives have the potential to make a substantial contribution to Australia's national climate change research priorities and the broader evidence-base for mental health, communities and indigenous health.

### **Development of climate change projections for Southeast Asia and Pacific Islands**

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Coupled atmosphere-ocean Global Climate Models (GCMs) are increasingly being used to simulate future climate change under various emission scenarios. Because of their computational expense, the grid resolution of those GCMs is typically around 200 km, which is too coarse to directly provide realistic climate simulations for most islands, or regions with steep orography or complex land-use. An approach that has become fairly common, is to use regional climate models, driven in some manner by a coupled GCM, to simulate the climate at smaller length scales. Some groups use limited-area models

for this purpose, driven at the lateral boundaries by a host GCM, and this approach was originally used at CSIRO with the DARLAM model. For about the last 10 years, downscaling at CSIRO has been performed instead with a variable-resolution global atmospheric model, the Conformal-Cubic Atmospheric Model (CCAM). With computational and technical advances, it is now possible to run models, such as CCAM, downscaled from a variety of host models and scenarios.

A number of simulations will be shown over the Australian region, showing the monsoonal precipitation response. These include 140-year simulations at 60 km resolution, driven by the sea surface temperatures (SSTs) and sea-ice distributions of the CSIRO Mk 3.5 coupled GCM, as well as for five coupled GCMs from the IPCC Fourth Assessment (AR4): GFDL2.1, GFDL2.0, HadCM2, ECHAM5 and Miroc-Medres, all for the A2 emission scenario. This set of downscaled simulations produces an ensemble of regional climate change scenarios.

Quasi-uniform global CCAM simulations have also been performed at 200 km driven by the SSTs of the same coupled GCMs. These have been further downscaled to a resolution of 60 km over Southeast Asia, employing a digital filter technique to preserve the large-scale patterns of the 200 km simulations. The same technique is being used for downscaling to even finer resolution over individual islands. The various simulations are compared for their present-day climatology and for their climate change response. Downscaling simulations are also being performed at high resolution over selected Pacific island countries as part of the Pacific Climate Change Science Program (PCCSP).

## Characterising tropical cyclone seasons and understanding past variations in cyclone activity

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The development of a tropical cyclone is dependent on a number of factors. In addition to a suitably warm ocean surface, dynamic factors such as low-level cyclonic flow and low vertical wind shear, there must be a suitable thermodynamic environment in which the storm can develop. The nature of this thermodynamic environment determines how intense any storm can be and so imposes a maximum potential intensity (MPI) on the storm (Emanuel 1988; Holland, 1997). The nature of this thermodynamic environment appears to be a good indicator of cyclone activity in a season. Thermodynamic models of maximum potential intensity of tropical cyclones, which use meteorological data for the estimation of the maximum theoretical intensity of tropical cyclones in a given environment have been adapted as climatological schemes and as indicators of cyclone genesis potential (Camargo et al., 2007) and can be used to provide an assessment of tropical cyclone seasons.

Overall, there is general acceptance of these thermodynamic approaches in the scientific literature as a means of analysis of tropical cyclone climatology. The summary statement from the International Working Group on Tropical Cyclones (IWTC-6) in San Jose, Costa Rica, warned that although the MPI approach is valuable, the fact that many storms fail to reach their maximum intensity because of factors other than the thermodynamics of the atmosphere means that the cause of variability and change is difficult to assign to individual forcings. Despite such caveats, there is potential to use MPI as a means of characterization of tropical storm activity. A seasonally integrated calculation of maximum potential intensity offers an assessment of the tropical cyclone hazard for a particular season and an understanding of the large-scale factors determining this risk could assist in planning adaptation to any changes in extreme events such as tropical cyclones.

In this study the thermodynamic intensity computed from NCEP reanalysis for the Australian region is analyzed over the period 1948-2009 and compared with the historical record of cyclone activity derived from the Bureau of Meteorology Tropical Cyclone database. Maximum potential intensity can contribute to an index of seasonal cyclone activity (or potential activity) and this idea is developed here as a tool for characterizing cyclone activity.

## The drying of Lake Boga – what it tells us about community responses to climate change

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The town of Lake Boga in northern Victoria experienced the loss of its lake in early 2008 due to ongoing drought conditions across south eastern Australia. A qualitative study of the town was undertaken by the Victorian Department of Planning and Community Development in order to understand the experience and impact of this environmental event. By selecting a case study which has already experienced an environmental event that might be envisaged under climate change scenarios, the researchers were able to investigate, in more concrete terms, ways in which a community experiences, responds and adapts to such change. Findings from this research are relevant to climate change adaptation policy and debate.

The drying of Lake Boga is generally not seen by residents as being caused by climate change. In fact there is widespread scepticism about climate change theory and governments' focus upon it. Because the lake was recently incorporated into an irrigation project, locals expect water to return to the lake. The hope of water returning is an important factor in sustaining the community's morale. When attention was drawn to other lakes that have remained dry for up to 10 years, respondents appeared not to have considered such a scenario for Lake Boga. Nevertheless, uncertainty exists around timing of the water's return and this has created stress for many residents, especially those who need to make decisions about whether to stay or leave.

Those with lakeside property and business owners have borne the economic brunt of the lake drying through declining property values and the loss of tourists. However, out-migration has been a relatively small part of the community response to the drying lake. Some are 'trapped' by loss of asset value and are waiting for water to return before selling their property.

Others regard the local area as 'home', with or without the lake, and are likely to stay irrespective of any long term environmental change. The proximity of a regional centre, Swan Hill, has played an important role in limiting the economic impacts of the dry lake as it continues to provide sources of employment, and hence income, for working age people. Swan Hill also continues to offer a range of goods and services which continue to be accessed by the residents of Lake Boga.

The use of mobility (travelling for work, shopping and recreation) as an adaptive response is not confined to environmental change – it has been occurring over many decades in the face of rural depopulation and service loss. The major question regarding such an adaptive response to climate change events is its sustainability should fuel prices rise. It is in this way that less wealthy residents of regional Australia may be most impacted by future change.

People respond to critical environmental change in different ways and within different timeframes – this has implications for how government interacts with communities that are going through change. It confirms the need for government to better understand community dynamics and customise responses accordingly.

## **Thermal Stress and Microclimatic Adaptation of Outdoor Public Space – a Western Sydney Case Study**

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The use of outdoor public space is important for human health and key to healthy planning and urban design strategies focused on integrating physical activity, social interaction and connections with nature back into urban lifestyles. Thermal stress has a fundamental effect on human behaviour, both indoors and outdoors. This research focuses on the everyday use of outdoor public space, and the related influence of climatic conditions on health and well-being, especially urban and global warming, reflecting on microclimatic and climate change adaptation.

There is limited research exploring the relationship between thermal stress, use of public space and human health, and poor interdisciplinary communication inhibits urban heat being understood and prioritised in planning and design practice. Existing studies exploring thermal comfort, outdoor environments and use are few and limited to the northern hemisphere. They identify complex interrelationships between use and physical parameters, cognition, emotion, perceptions and actions, and that findings are specific to regions due to differing climatic conditions and social, cultural and environmental contexts. Existing studies investigating the climate sensitivity of human health are mainly concerned with mortality data, reflecting only extremes. However, thermal environments also impact on morbidity and the ability of normal individuals to perform everyday activities, particularly those activities requiring use of outdoor public spaces, such as streets, squares and parks. Healthy planning identifies outdoor activities, such as walking and cycling, as important core daily activities and as yet, gives marginal consideration to climatic and microclimatic influences, particularly heat, on outdoor public space use.

Anticipated climate change scenarios for Australia include significant increases in temperature and frequency of extreme heat events. Not insignificantly, the Fourth Report of the Intergovernmental Panel on Climate Change states that 'an increase in heat-related deaths in temperate cities is one of the most significant health impacts of climate change for Australia'. Those most vulnerable to heat-health effects are children, elderly people, Indigenous communities and people with pre-existing diseases and disabilities. These scenarios have serious implications for planning and urban design in general and microclimatic adaptation of public space specifically.

Vulnerability and adaptive capacity of human populations and natural systems differ substantially across regions and across populations within regions, requiring assessment of the coping capacity of individual regions and communities to inform climate change adaptation strategies. This research explores the adaptive capacity of Fairfield City in Western Sydney with regard to thermal stress and the influence of physical, social and cultural environs on the use of a main civic park, particularly Fairfield's rank as the most disadvantaged Local Government Area in Sydney with higher than average rates of non-communicable diseases, obesity and overweight in people over 55 years, psychological stress and unemployment, and lower than average rates of adequate physical activity.

Based on the author's current research doctorate commenced in 2006, methodologies align fieldwork meteorological measurements and behavioural mapping with heat-health research variables and warnings. Suggested relations between climate and patterns of public space use from fieldwork are presented. Questionnaires, analysis and results are yet to be undertaken.

## **Building agricultural adaptation through understanding farmer attitudes, knowledge and responses to a changing climate**

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The impact of climate change on agriculture in southern Australia is likely to be severe. There is evidence now emerging that farmers are changing management practices in response to changes in the climate.

This paper provides evidence that these changes are occurring, the extent and why some farmers are more likely to be adapting to climate change than others. It focuses on farmer views about climate change and their current and planned responses. It reports on a survey of more than 1500 farmers across the state of Victoria.



The research was undertaken in 2009 by the Water in Drylands Collaborative Research Program (WIDCORP), University of Ballarat in collaboration with the Department of Primary Industries Victoria. It explores how farmer attitudes towards climate change may influence how they are changing the way they farm.

International research suggests agricultural adaptations to climate change are largely place and context specific and are unlikely to be independent of risk management decisions. They are influenced by economic and regulatory environments, technology and social norms and the characteristics of the innovation itself. Farmer's capacity to adapt continues to evolve. This adaptive capacity can also be influenced by a person's level of education and training, diversity of on and off-farm income sources, and levels of income.

Using statistical regression analyses, survey data collected in this study was interrogated to identify if different attitudes, levels of knowledge and types of farming influenced the forms and extent of farm practice change in response to changes in climate. The study highlights the diverse range of views and actions of Victorian farmers in relation to climate change and variability. These differences occur across farming sectors (for example; grains, dairy, horticulture, forestry, livestock or mixed farming as well as peri-urban farmers) and across different regions. The results suggest however that adaptation action is more closely aligned with sector-specific rather than regional impacts. The data also suggests that different groups of farmers with common attitudes and behaviours had, or plan to, adapt farming practices in certain ways independent of the sector or region in which they operate.

It appears those farmers who agree with statements aligned with Changing Weather (attitudes towards change in weather patterns and rainfall), are more likely to actively change their farm practices, when compared to those who relate to the Anthropogenic Climate Change (attitudes towards climate change, its seriousness and its human cause). Whilst it seems counterintuitive to the assumption made about the need to believe in climate change to undertake adaptive actions, this analysis provides a basis to question this assumption.

It is also becoming increasingly clear that the development and promotion of specific adaptation choices or policy prescriptions (that is direct adaptation measures) may not be the most useful means of promoting agriculture to adapt to climate change. This prompts the question of what is driving agriculture to adapt and reinforces the need to understand farmer attitudes, knowledge and how they are responding to a changing climate to enhance the types and rate of adaptation.

### **Adapting through local planning: barriers and opportunities for climate adaptation**

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Local planning has been voiced as an important avenue for achieving adaptation and addressing the local environmental and social impacts of global environmental change. Planning is a fundamental activity for local governments, which play a key role in developing and implementing planning at the community level. Local government planning takes two forms. The first is the strategic planning process, which fosters community vision, aspirational goals and place-making, along with defining pathways to achieve these goals. The second form operates at a more immediate scale: the execution of statutory planning and zoning instruments including development approvals which are informed by local environment plans and development control plans. Although these two types of planning are quite different in practice, and in many cases are managed by different departments, both are highly important to climate change adaptation.

To explore these issues, a case study focusing on local government planning was conducted in Sydney as part of a broader project called 'The Systems Approach to Regional Climate Change Adaptation Strategies in Metropolises' conducted from 2007-2009. This project was a partnership between the CSIRO Climate Adaptation Flagship, the Australian Government Department of Climate Change, The University of the Sunshine Coast and the Sydney Coastal Councils Group.

The case study data consist of in-depth interviews with staff from three municipal Councils in 2008 from across the Sydney region: Mosman, Leichardt and Sutherland. The three Councils were selected to reflect diversity in terms of their size, demographic profile and location within Sydney (northern, central and southern). A total of 33 participants from these three Councils took part in the interviews: (12, 11 and 10 each respectively).

The results draw attention to the following factors: leadership, competing planning agendas, lack of information, and limited recognition of climate change in the institutional arrangements that guide local planning. It was evident from interviews that adaptation represents only one area of priority amongst other competing interests for local government planning. Across all three case study councils, interview participants emphasised that climate change was part of their strategic plan in some form, either specifically or grouped as one of a suite of environmental issues. This demonstrates that climate change is being considered in the guiding strategies of the three Councils to varying degrees. However the focus was on mitigation, more so than adaptation. Participants also identified another barrier in the lack of useful, credible and relevant information about the nature of the climate risk to which they must adapt.

Across all three case study Councils, there was consistent evidence that climate change adaptation was not explicitly incorporated into local environment plans and development control plans at the time of conducting this research. We conclude that local planning represents a major avenue for achieving adaptation at the local scale, however significant constraints need to be acknowledged and addressed if adaptation is likely to advance along this pathway. This research was supported by the CSIRO Climate Adaptation Flagship and the Australian Government Department of Climate Change.

## Climate Change and Child led Disaster Risk Reduction in East Godavari District

G P Meda<sup>1</sup>

<sup>1</sup>Coastal Area Disaster Mitigation Efforts, Indonesia

CADME a coalition of 20 organisations working to mitigate the effects of natural / man made disasters.

*Where:* Twenty five vulnerable schools in East Godavari district of Andhra Pradesh.

*For whom:* 17,436, children and 6722 families from 25 disaster prone villages and schools.

*What:* One thousand and hundred task force members are well aware of 'Development and disaster preparedness.

*Replicability Potential:* The most significant replicability potential is to adopt this best practice to hazard prone vulnerable schools in the country.

*Looking Back:*

*2001 Bhuj Earthquake:* 971 Students, of which 31 students died.

1884 school buildings collapsed, leaving a loss of 5950 classrooms, in addition to 11,761 school buildings suffering major to minor damages.

*Kumbakonam fire tragedy:* A deadly fire raged through Lord Krishna School killed 93 children, all below the age of 11 years. Let us learn lessons from earlier tragedies & make our schools a safer place for children.

*Development and Outputs:* Two thousand three hundred children have taken lead in developing the risk maps and safety nets of their respective schools. Nineteen hundred and sixty children are well trained in early warning systems, emergency rescue and emergency medical care in order to help their co vulnerable children in the event of Disaster.

## Exploring Vulnerability and Local Adaptation Options to Climate Change using Participatory-Action Research of a Forest Community in Lekié, Cameroon

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While there is uncertainty in the projections with regard to the exact magnitude, rate, and regional patterns of climate change, yet its consequences climate change will likely change the fate of many generations to come and particularly impact on the poor if no appropriate measures are taken. Most especially, climate change will disproportionately hit African people and vulnerable poor such as women will likely shoulder the most the consequences of climate change. Temperature is rising faster than the global average and rainfall is becoming unpredictable in almost every African country. Many communities are struggling to cope.

Adapting to current and future climate change is one way to responding to these rapid changes. However, African countries and their local communities have a very low adaptive capacity i.e. having constrained ability to cope with the impacts and risks of climate change, including limited ability to take advantage of opportunities. In this regards, vulnerability assessment to climate change of local people help understand how they will be affected by climate change, how they might respond with the resources they have, and how these conditions can be reflected and built upon for successful adaptation strategies. In this regards, vulnerability assessment to climate change of local people help understand how they will be affected by climate change, how they might respond with the resources they have, and how these conditions can be reflected and built upon for successful adaptation strategies.

In the framework of the IDRC-DFID funded project executed by CIFOR entitled "Congo Basin Forest and Climate Change Adaptation", Participatory Action Research has been used in a forest community in Lekié in Cameroon to assess the vulnerability of various social groups, to identify livelihood strategies that are the most vulnerable to climate change and what component in the strategies are threatened, and to facilitate knowledge sharing. The process led to participatory diagnosis and visioning, conceptualization of change and identification of specific strategies for climate change adaptation in the community. Based on the Participatory Action process therefore, this paper shows that the adverse effects of climate conditions to which this community is exposed are already being felt and exerting considerable stress on most of the important activities to their livelihoods such as agriculture and exploitation of national resources. It also highlights that although this community has been struggling to cope; effective adaptation strategies should reduce present and future vulnerability and should include changes in current practices in response to rapid changes. The paper finally calls for an urgency of mainstreaming climate change in national planning and policies and highlights the need of incorporating local knowledge in the design and implementation of modern adaptation strategies.

## Climate Change Impacts on Chilean Agriculture: Estimating sectorial adaptation based on changes of productivity and land allocation, under two Climate Change scenarios

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Agriculture in Chile is one of the most important economic sectors, representing a significant proportion of the gross domestic product, mainly due to its participation on exported products, as well as the main source of livelihood of rural families in the country. Because of the strong linkages between climate and crop growth and development, climate change represents a challenging problem, since projected scenarios show increases in temperature coupled with important reductions of precipitation in the areas that currently support most of the agricultural activities of Chile.

This study analyses the consequences of climate change on several agricultural crops of Chile, mainly looking at impacts on crop productivity. Since a reduction of precipitation and changes in seasonality of snowmelt directly impact soil water balance of both rainfed and irrigated agriculture, our study incorporates a restriction in water availability consistent with climate change projections.

Crop productivity was estimated using crop simulation models (SIMPROC-Crop Simulator) fed with downscaled climate change HadCM3 projections of the A2 and B2 scenarios. Crop yield results elucidated the complex regional patterns of projected climate variables, CO<sub>2</sub> effects, and agricultural systems. We then used this information to run an econometric allocation model that allowed us to predict future changes in crop surface, based on productivity trends and its economic impacts upon gross income. As a consequence, we are able to evaluate changes in labour demand and the future economic value of this activity. Results represent the future map of Chile's agricultural sector and provide information about sectorial adaptation from a geographical stand point.

## Adaptation to climate change. Case studies of two rural Australian communities

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Communities are already adapting to the effects of climate change. Documenting the decision-making process and ways in which a community experiences and adapts to changing conditions is one way to identify means of enhancing adaptive capacity. An understanding of the adaptation process is important for rural communities as adaptations that are potentially successful in the short-term may have longer-term implications and unintended consequences. In this paper we report the initial findings of two rural community case studies (Sunraysia and Wimmera), both of which rely heavily on the agricultural industries in the area. The case studies are part of a five year CSIRO project following the adaptation process of a number of Australian primary industries and communities. The research program addresses how these industries and communities transform in response to climate change.

First, the paper presents the findings of a sustainable livelihoods analysis conducted through a workshop in November 2009 with key Sunraysia stakeholders. The focus of the workshop was to examine the vulnerability context within which these stakeholders operate. Second, the paper includes an analysis of transcripts from 26 semi-structured interviews with key informants from the case study areas. The sustainable livelihoods analysis workshop established that the Sunraysia community faces several challenges, those directly related to climate change such as water quality and quantity, and other factors such as a community identity centred on a 'green oasis' landscape and an ageing population. These factors formed the context within which adaptation occurred.

The interviews indicated that adaptation on an individual scale to climate change was occurring in both communities, but not necessarily with the explicit acknowledgement of climate change as a driver. Farmers had been adapting to various drivers for years (such as the costs of production rising faster than the prices received for produce) and adaptation to climate variability has been interacting with these other influences. Indeed, a level of scepticism was seen to exist among some, in part as a coping mechanism which has presented a challenge to agencies attempting to engage the community. Interviewees reflected upon levels of adaptation success. The fact that there were still highly successful farmers in the region (despite many exiting, exacerbating small town decline) and the presence of innovative industries were cited as evidence of successful adaptation. Findings point to the different definitions and criteria of what is a successful adaptation at different spatial and temporal scales.

Interview findings revealed successful engagement in adaptation to climate change and variability, as well as identifying various challenges, from the individual household to the wider community. This is the first phase of a longitudinal study of the communities of the Sunraysia and Wimmera. Future research will focus on following community adaptation to climate change and understanding the economic and social conditions required to support the Sunraysia and Wimmera communities. Overall this research project will add to the understanding of long-term adaptation and decision making in the context of rural communities.

## Impacts of ENSO on rice production in China

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The relationship between rice production and precipitation anomalies and temperature anomalies in mid and east China during different phases of El Niño and the Southern Oscillation (ENSO) was examined. The NOAA National Weather Service Climate Prediction Center Merged Analysis of Precipitation (CMAP) monthly mean precipitation and the NOAA National Centers for Environmental Prediction (NCEP) (Reanalysis-2) monthly average temperature in the period of 1979-2008 were used. Agricultural output data at province scale from 1979-2008 were obtained from the China Statistical Yearbook. The relationship between the mid and eastern China rice yield and the Southern Oscillation Index (SOI) was built through correlation/regression and Empirical Orthogonal Function (EOF) analyses.

Mid and eastern China were chosen because these areas are the major rice growing areas and are very sensitive to weather fluctuations. The data set was processed to remove seasonal trends and highlight the inter-annual changes for analysis. EOF analysis was then used to establish the first EOF time series modal field. This was then correlated with SOI fluctuations and an economic model of rice production was built.

The contribution of monthly data's first pattern time series to the variance is relatively small (30%) which suggests that monthly data's relevant correlation with SOI is not obvious. But the relationship identified by the EOF analysis of the seasonal (spring, summer) temperature and precipitation anomaly is good (>50%). January, March, April, June, September and October's SOI have significant relationship with temperature and precipitation at 95% confidence in the statistic model. The model is well fitted with  $R^2 = 0.990253$ . Looking at the relationship identified, it is obvious that the agricultural machinery and electricity in rural areas, followed by the fertilizer application rate and the state financial expenditure items of expenditure in the agriculture have more significant influence on China's rice production (the coefficient are 1.33, 0.8 and 0.85). However, SOI is one of the most uncontrollable factors in rice production and cannot be overlooked.

Finally, SOI of last January, September and October, as well as present March data are used which is comparative ahead of the annual grain harvest period. It brings a certain reference value for national food policy formulation and adjustment.

## Building adaptive capacity in the water sector through scenarios and simulations: examples from Phoenix, Arizona

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Increasing adaptive capacity requires an improved understanding of the underlying causes of the vulnerability of urban areas to the impacts of multiple stressors. This entails an examination of institutions and the ways they interact with cultural, economic, social and political processes. One of those processes is the interface of science and policy, where strengthening the transfer of knowledge between researcher and practitioner may increase the ability of institutions to adapt to change. Scenarios and simulation can be used to increase shared understanding of possible futures by transferring knowledge in a way that is accessible to a wide range of stakeholders.

Phoenix is a metropolitan area of almost 4 million people situated in the Sonoran Desert of North America. The area receives less than 8 inches of rain per year, making it dependent on water from the local Salt and Verde Rivers, the Colorado River via the Central Arizona Project, and groundwater. Until the current economic crisis, Phoenix had been one of the fastest-growing cities in the United States.

This presentation examines the use of scenario development as a tool in the water planning process in Phoenix through two examples that incorporate the dual stressors of drought and growth by analyzing the process and product of the 2005 City of Phoenix Water Plan Update, and the impact of the scenario and simulation tool, WaterSim, on the water resource community.

Case Studies: The heart of the metropolitan area is the City of Phoenix, home to 1.6 million residents, almost half of the metropolitan area's overall population. The city has traditionally taken a leadership role in metropolitan governance due to its size and available resources for planning and management. The 2005 City of Phoenix Water Plan Update recognized drought and population growth as major threats, noting "...the region's recent experience with relatively severe and lengthy drought conditions in its major source watersheds has reinforced the need to further assess Phoenix's vulnerability to long-term water shortages. In addition, Phoenix's growth patterns, and thus water demand, may be significantly affected by changing economic or demographic trends." The selection of key supply and demand variables provided 144 possible scenarios, of which six were considered representative and written into the water plan.

The Decision Center for a Desert City (DCDC), funded by the National Science Foundation's Decision Making Under Uncertainty research initiative, has worked with a broad range of stakeholders on water issues over the last five years. Users of the Center's website are greeted with the Center's goal of "conducting climate, water, and decision research and developing innovative tools to bridge the boundary between scientists and decision makers and put our work into the hands of those whose concern is for the sustainable future of Greater Phoenix." One of its primary tools is WaterSim, a simulation of water supply and demand for the Phoenix Metropolitan area that integrates information about climate, land use, population growth, and water policy. Users can adjust water supply and demand in response to climate change, drought, population growth, technological innovation, as well as policy decisions about the nature of the region's built environment, landscaping practices, and recycled water.

## Assessing the impacts of climate change on the water resources in the Nile Basin using a regional climate model ensemble

Met Office Consulting Team, United Kingdom

The Nile represents a crucial resource for the economy of eastern and north-eastern Africa on which agriculture, energy production and livelihood are largely dependent. The objective of this study is to assess the possible impacts of climate change on the Nile river flow and in particular the inflow to the High Aswan Dam. Using climate models to inform water-related policies over eastern Africa is a complex matter: the range of projections of change in both precipitation and river runoff tends to be wide with no consensus even on the sign of change. This problem is partly caused by uncertainties in how to represent the physical processes in the climate system, which in turn lead to widely different responses to anthropogenic forcing. In this project a regional climate model [Hassell & Jones 1999], driven by multiple global climate model data, is used in conjunction with a basin-wide hydrological model to assess changes in water resources. This study is carried out in close collaboration between the Ministry of Water Resources and Irrigation in Egypt, UK Met Office Hadley Centre and DHI, and will also link up with the Nile Basin Initiative.

## Impacts of climate change on the UK energy industry

Met Office Consulting Team, United Kingdom

The impacts of climate change on the UK energy industry were recently examined in a year-long project undertaken by the Met Office and eleven UK energy companies. The project was industry-funded and focussed on the knowledge and data gap priorities identified by an earlier scoping study. Innovative new techniques that apply climate modelling to energy applications have been developed, and a climate change adaptation planning guide has been presented, illustrating the likely timescales over which the climate-related risks to various energy assets and infrastructure will require adaptive action. Experts within the energy industry, supported by leading-edge science from the Met Office, worked together to understand their precise requirements. A number of work programmes spanning demand, generation and transmission of electricity in the UK were devised. These developed practical applications and business strategies designed to improve business resilience in a changing world.

## What is Successful Adaptation Research? Science policy challenges for an emerging outcomes-focused discipline

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Science policies have proven immensely successful with the task of advancing knowledge. However, they often falter when it comes to producing useful information for decision makers. For example, the US has invested more than \$30 billion in global change research since 1990, yet the government research program continues to get poor marks on its ability to inform decision making on important environmental policy issues (e.g. NRC 2007, 2009b), a central component of its mission.

The disconnect between advancing knowledge and useful information results from a divergence in the priorities driving scientific research and the urgent needs of society. Calls for increased “stakeholder engagement,” and for “participatory research” both in Australia and in the U.S. (e.g. Cash et al. 2006, Nelson et al. 2008, Gardner et al. 2009, NRC 2009a) tacitly recognize this disconnect. But such appeals often focus on scientists and stakeholders themselves, leaving out a crucial discussion about science policy. The institutions, policies, and individuals who implement science policy have a duty to guide research toward the kinds of societal benefit that justify research investments.

Adaptation research in Australia represents an important opportunity for innovation and learning when it comes to the management of research for beneficial social outcomes. This highly interdisciplinary field has a common goal of developing useful information for people dealing with the effects climate change. Generating useful information implies far more than the traditional metrics of academic success such as peer-reviewed publications. Thus, it is useful to ask, what is successful adaptation research? How is it evaluated? How is it different from other kinds of research? What are its core values? What does it demand from funding organizations? The ways in which researchers, managers, and users answer these questions will contribute valuable insight to the adaptation research enterprise and, more broadly, to the growing field of science and technology policy.

I will present the results of a series of interviews with individuals in three groups important to adaptation research in Australia: researchers; science policy decision makers; and the users or potential users of adaptation research. This approach draws on the Reconciling Supply and Demand, and Public Values Mapping frameworks, each of which has emerged as an important tool for assessing science policies.

## The value of time-series data to track climate-driven changes in coastal systems and use in the provision of policy-relevant evidence and advice

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Climate change is having a profound impact on coastal regions globally. Changes in species distributions, invasions and localised extinctions are driving alterations in biodiversity. To form testable hypotheses of the future impacts of climate change, a sound knowledge of current processes set against benchmark reference conditions is urgently needed. Long-term, broad scale datasets,

time series and individual studies dating back to the 1950s for rocky intertidal species have been collected at locations spanning 24 degrees of latitude along the coastline of Europe. These datasets have been continued or re-started on an annual basis since 2002 by the MarClim project and are being used to determine the impacts of climate change on coastal marine ecosystems.

Intertidal habitats exist at the margin of the terrestrial and marine realms, and species occupying these ecosystems are subject to environmental challenges posed by both aerial and aquatic regimes. Their sessile or sedentary nature and relatively short lifespans mean they show fast responses to climate change, providing a unique insight into the impacts of climate change in coastal environments. To date, the greatest effects in the marine environment are occurring in the regions of biogeographic breakpoints, where many species reach their distributional limits. MarClim has identified some of the fastest changes within coastal ecosystems globally since the current period of warming began in the mid-1980s, and demonstrates how intertidal invertebrates and macroalgae are sentinel species, 'canaries in the coalmine' for climate change.

Rapid poleward extensions of warm water species and contractions of cold water species have occurred in the region of the transition zone between boreal and Lusitanian waters in the north east Atlantic. Rates of change up to 50km per decade far exceed recorded changes in the terrestrial environment, with concurrent increases in abundance over several degrees of latitude. Phenological shifts including earlier onset of reproduction, changes in reproductive strategy and increased overwinter survival of recruits are driving biogeographic shifts in warm-temperate species. The species-specific nature of these shifts are driving alterations in community composition and ecosystem structure and function with subsequent impacts on primary productivity and organic flux between benthic and pelagic zones. In addition, warming temperatures are enhancing colonization by non-native species and these changes have implications for coastal marine biodiversity.

Increasing awareness of climate change as a key pressure on marine systems and biodiversity has firmly established global warming on political and science agendas. National and international directives require information on biodiversity, ecological status and stability of marine environments to provide a knowledge base from which to develop fit-for-purpose management and adaptation action plans. The MarClim time-series are being used to provide fit-for-purpose, expert scientific advice and supply evidence to UK and European government conservation agencies. This knowledge is assisting the development of effective management and adaptational strategies for marine biodiversity resources and ecosystem services, ensuring compliance with national and European policy directives and informing national assessments of the status and socio-economic importance of coastal ecosystems such as the Marine Climate Change Impacts Partnership Report Cards, Charting Progress 2 and the National Ecosystem Assessment. The data is also providing a contextual basis to monitoring within marine protected areas, allowing changes within MPAs to be compared to local and regional trends.

Integrating monitoring schemes across national and regional scales through the formation of national and international networks enables the relative contributions of natural and anthropogenic drivers to be separated. The spatio-temporal extent of the dataset facilitates analyses at species, assemblage and community levels, and comparisons of responses at local, regional and national scales. Ecological forecast models have been developed to predict future changes in distributions of intertidal species against various emissions scenarios. Already, field data is supporting predicted exponential declines in keystone species with cooler water affinities. The MarClim methodology is recognized in the UK as an example of best practice, and has recently been extended to New Zealand, where a national baseline has been established to monitor future impacts of warming and sea level rise. These methodologies could also be applied to the Australian coastal region, and would be particularly valuable with a focus on biogeographic boundaries between temperate and subtropical regions, where invasion and loss of species is already thought to be occurring.

## Environmentally Induced Migration and Sustainable Development

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The impact of environmentally induced migration (EIM) on sustainable development and on the achievement of the Millennium Development Goals is an emerging and relatively unexplored issue.

This paper analyses the nexus between environment change and migration from the angle of sustainable development at national, regional and international levels with focus on migration induced by environmental degradation and exacerbated by climate change.

The importance of taking a comprehensive approach to environmentally induced migration and socio-economic factors is stressed in Chapter 5 of Agenda 21, which states: "Research should be conducted on how environmental factors interact with socio-economic factors as a cause of migration" (Paragraph 5.20). Environmental factors should not be singled out when studying the migration decision; on the contrary, they should always be studied in connection with other socio-economic factors.

In the first part, the authors review the science of EIM. Conceptually, there are three different but strongly interrelated ways the environment can lead to population movement: environmental degradation, natural disasters and climate change. Factors driving EIM can be divided into push and pull factors: push factors (from origin regions) include natural disasters, gradual climate-driven environmental changes and armed conflicts over shrinking natural resources while pull factors (from destination regions) include better economic opportunities, better ecosystems and networks in the destination regions.

In the second part, the authors analyze its connections to sustainable development and the impacts on the progress in meeting the MDGs, especially MDG7, in vulnerable countries, mainly the poorest in the world that lack the means to deal with EIM. Remittances are the main channel through which environmentally induced migration can have a positive impact on MDGs.

There is a lot of concern, both at the political and at the academic level, about the risks related to population growth and migration that might exacerbate economic, social and political pressures in the receiving regions. Unfortunately, less attention is paid to the risks for the sending regions that are facing the environmental hazards pushing their populations to move and that will suffer from the consequences of a decrease in their populations.

The third part addresses the relative policy implications, exploring the adaptation and other policy options and recommends policies and actions for the policymakers. Economic diversification should be pursued in countries that rely on agricultural production and that might be threatened by soil erosion, land degradation, desertification and other factors threatening the efficiency of the agricultural system; the same holds for countries primarily relying on fishing.

The importance of including EIM in NSDS and in other relevant country policies and programs comes from the fact that early planned population movements can be mutually beneficial for sending and receiving regions while sudden forced migration is usually not. Sending and receiving countries should also work together to conserve biodiversity and to avoid the cultural loss related to the abandonment of the origin countries.

Adaptation strategies that allow potential migrants to remain in their home community should be the priority; planned environmentally induced migration should only be used as an adaptation strategy when it is not possible for the migrants to stay.

Environmentally induced migration may hinder the implementation of measures and policies aimed at environmental sustainability. The study emphasizes that countries include EIM into their National Sustainable Development Strategies and National Adaptation Action Plans.

A EIM is a complex and interdisciplinary issue; sustainable development can be an effective and comprehensive way to deal with it through slowing down environmental degradation, adaptation to climate change, food security, water availability, conservation of biodiversity, reduction of vulnerability, early warning systems and risk management.

## Assessing uncertainty in projections of future climate change in cool temperate rainforest biota of southeastern Australia

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Many of Australia's unique ecosystems are potentially under threat from climate change, particularly temperate systems such as the cool temperate rainforests (CTRF) of south-eastern Australia. To assess potential impacts of climate change on CTRF, we developed current species distribution models for the dominant rainforest tree, *Nothofagus cunninghamii*, and four allopatrically distributed, CTRF restricted snails from the genus *Victaphanta*, using the program MAXENT. Resulting distribution models were then extrapolated to climate forecasts downscaled from six of the general circulation models recently considered as part of the IPCC 2007 report. The main focus of this study was to quantify the uncertainty in species predictions that is due to variability in GCM output. Different GCMs predicted different regional climate patterns, with variance highest for precipitation. On average, based on an ensemble approach, *N. cunninghamii* is predicted to decline by 30% by 2050 and 50% by 2080 when compared to current predicted distributions. On a regional scale, *N. cunninghamii* is predicted to be most impacted in the Otway Ranges of Victoria with a predicted decline of 95% and 100% for 2050 and 2080 respectively. The greatest variability in predictions due to GCMs was seen in north-eastern Tasmania for the regional endemic species *Victaphanta lampra*, where predictions ranged from a 10% increase to a 40% decrease in suitable habitat in 2050. The extent of this variability illustrates the importance of assessing multiple GCMs when making predictions of how species will respond to climate change, particularly for use in applied management and conservation decisions.

## Adaptation to and impacts of climate change on UK agricultural sectors

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UK crop production and the natural environment are vulnerable to changes that will occur through climate change over a relatively short time scale. These changes will provide both constraints and opportunities. Temperature rises in the UK are likely to result in a gradual realignment of zones suitable for production of specific crops. Evidence suggests that there will be a shift of between 200 and 300 kilometres northwards for every one degree increase in temperature. As an example, this would result in the south of England having a similar climate to the Loire Valley in France, by 2060. UK crops and natural environments are likely to change. It has been suggested that novel or unusual species and varieties in the UK such as sweetcorn, sunflowers, soya and maize, could provide opportunities for UK agriculture.

However, farming and environmental management practices will need to adapt to meet these changes. Climate change will affect maturity and harvest dates and have significant impacts on water requirements. The ability of agriculture to adapt

to and cope with climate change depends on factors including arable-land and water resources, farming technology, crop varieties adapted to local conditions, access to knowledge, infrastructure, and appropriate knowledge transfer mechanisms.

An Innovation Network was established at the University of Warwick as a vehicle to aid with the identification of potential climate change adaptive activities in the agricultural sector. Use of the Delphi technique for identification of innovations was a key component to the success of this project. The value and limitations of the Delphi technique are critically reviewed.

Further stakeholder engagement was achieved through building consortia to deliver innovative activity. A range of delivery mechanisms for innovative activities were employed which involved up to seventeen organizations. Innovative activities put in place included i) use of differential thermostats to improve the efficiency of grain cooling ii) pack-house cooling and crop storage: a commercial demonstration and economic evaluation of ground sink refrigeration; iii) adapting to changing water availability: demonstrating technology and innovation in agricultural water management; iv) exploring the role of science, policy, and the food chain in identifying opportunities for growing new crops in Britain's future climate.

The Innovation Network is a classic example of how the process of conception, design and delivery of innovations is an iterative process between stakeholders and success was achieved through interaction of different stakeholders within different disciplines across several organisational boundaries. The outputs of this initiative will be presented in terms of the induced innovation hypothesis and the role of networks in the delivery process.

In addition, an appraisal has been undertaken for the UK strawberry industry as a case study on the impacts of climate change on an agricultural sector within UK production. The UK strawberry industry has undergone significant changes in recent years, in particular a move from open field cultivation to production under protection. Changes in disease incidence have occurred over the last century driven in part by changes in varieties, through pesticide availability and also as a consequence of Government plant health policy decisions. In addition to this temporal variation, it is also apparent that disease incidence varies between regions of the UK. The UK Climate Impacts Program 09 scenarios have been used to determine probabilistic projections for three pathogens in strawberry growing regions of the UK for 2020 and 2080. These projections suggest that diseases of strawberry will present different risks in different regions over these time periods. Based on these projections, detailed grower interviews have been conducted to determine awareness of risks and to assess potential consequences and responses. There is evidence that the sector is already adapting to climate change with measures being put in place such as reservoir construction and increased use of misters on crops grown under protection. Evidence is also presented on geographical variation in the response to risks across the UK.

## **Development of a Strategic Decision Support System to Support Strategic Decision Making Process in Local Governments**

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The purpose of this paper is to investigate the impact of climate change on strategic decision making and to offer a practical solution for responding to the uncertainties associated with climate change impacts. The paper suggests that achieving a fit between climate change impact and Local governments' decision making capacity is key to successful adaptation to the impacts of climate change. The study attempts to model the dynamics of such strategic fit as a way forward towards establishing a strategic decision making framework that can support an adaptive strategic decision making process for local governments.

The main contribution of the study to existing literature is the introduction of a Strategic Decision Support System (SDSS). Such SDSS will help senior management to more directly interact with data and information and enable them to navigate through a scientific and systematic decision making process and therefore result in consistency in strategic decision making across the Government. This system comprises of a suite of computer models, data, methodical processes and multi-criteria evaluation methods and is used for continuous improvement of management decision making in an uncertain environment. This system is developed on the premise that strategy is about the synthesis of facts and that a strategist needs to synthesise isolated pieces of knowledge into an integrated picture and this picture should be updated continuously. On this basis the suggested SDSS has three main components:

1. A process to collect data, convert data to information, establish facts from information and generate knowledge.
2. A process that can synthesis isolated pieces of knowledge into the large picture.
3. A process that feedbacks midcourse learning to the system in order to update knowledge regularly and continuously.

The suggested system, once in operation

- Continually scans the environment to capture data.
- Models the impact of future climate change scenarios on planning and design parameters in a systematic and unbiased way.
- Provides plausible policy responses for given future scenarios.
- Estimates the consequence of each policy response.
- Provides a prioritised list of alternative policy responses based on criteria that are determined by stakeholders.
- Monitors, evaluates and assesses the consequences of the implementation of the selected policies.



- Feeds back midcourse learning from this assessment into the decision making process.
- Iterates this process, when new knowledge of future climate or midcourse learning warrant a review, and improves previous management decisions accordingly.

The benefits of such a system includes:

- Provision of integrated problem assessment-solution options to management, releasing them from being the first point of integration.
- Filtering great quantities of information about different parts of the decision context into a few, critical elements.
- Allowing for better framing of the problems and therefore, giving a better chance for correct evaluation of the problem.
- Provision of plausible alternative solutions in a short timeframe.
- Assisting organisation leaders to make efficient and effective decisions while maintaining intuitive aspect of decision making process.

## Adaptation and mitigation: developing a tool to achieve an integrated climate change response

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Practitioners working with organisations to develop responses to climate change are often tasked with addressing either adaptation to possible future climatic changes or mitigation of greenhouse gas emissions. Often these organisations have made a deliberate decision to manage their adaptation and mitigation responses separately.

Whilst climate change practitioners understand and are able to readily distinguish between the two responses, it is often very difficult for those who are not well engaged on climate change issues to do the same. In particular, organisations can at times have difficulty understanding the integration and relationship that exists between adaptation and mitigation, or can only see relevance in one response to their organisation. Such an approach does not enable consideration of synergies and trade-offs between the two types of responses.

Through working with a range of organisations, AECOM's climate change practitioners identified the need for a simple, easy to use tool which can help organisations to better understand the relationship between adaptation and mitigation responses to climate change and can encourage and facilitate action on both fronts.

The AECOM climate change and carbon management matrices can be used to assess where an organisation sits on the spectrum of possible adaptation and mitigation responses across a range of business areas, including governance, risk, actions, assets, information and culture.

By identifying where it currently sits on the spectrum of possible responses – from Stage 1 (Latent) through to Stage 5 (Leading) – an organisation can assess its progress to date and identify options for the path forward. Such an approach can drive change throughout an organisation by embedding the full range of climate change responses into planning and decision making across a range of business areas. It also allows an organisation to develop an understanding of how adaptation and mitigation influences each business area.

For a number of 'real world' AECOM projects the matrices were used to assess each organisation's position along the spectrum of adaptation and mitigation responses prior to their project and identify what advances were made through completion of the project.

## Adaptation for Water Scarcity: Rainwater Harvesting Experiences from Sri Lanka

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Water scarcity in the dry zone areas of Sri Lanka is one of the crucial factors constraining the development. Nearly 80% of the annual flow in the dry zone rivers occurs in the four month period from October to January. The water scarcity in the dry zone is expected trigger with the predicted climate change of reduced major monsoonal rain of dry zone areas by 26-34%. Other major feature of rainfall change is increased intensity of rainfall with shorter duration and therefore increases runoff. One of the feasible strategies to address the increasing problem of non availability of sufficient quantity of rainfall at correct time is harvesting runoff rainwater to use it during dry periods. Water storage is just one component of multipronged approach to adapting agriculture to climate change. The lack of storage infrastructure means farmers have limited ability to cope with droughts and floods. There are wide ranges of storage options available. However it is essential to consider the appropriateness, sustainability and effectiveness of the storage systems.

The government of Sri Lanka and various NGOs have implemented Runoff Rainwater Harvesting (RRWH) projects in the rain fed agricultural areas of dry zone. The paper is based on the research conducted in the poverty stricken dry zone districts of Moneragala, Hambantota and Puttalam Districts on the recent interventions on promoting RRWH techniques in the area. One of the major impediments in developing these districts was lack of water, which would be expected to aggravate with the predicted climate change. The major objective of the paper is to discuss the effects and impacts of RRWH interventions with special focus on agricultural development.

The study findings shows that the usefulness of harvested rainwater is multifaceted including annual crop cultivation, perennial crop cultivation, livestock rearing, aquaculture, meet the domestic household needs and different combination of the above requirements. About 62% of the beneficiaries have utilized the systems for cultivation purposes, 40 percent are using to fulfill the various needs of livestock and 49% of the beneficiaries have utilized the water for various household water needs other than drinking. About 31 percent of sample beneficiaries have used the RRWH systems for aquaculture, while performing crop cultivation activities. Only 9% of the RRWH systems have been abandoned due to various reasons. Farm level data indicates that, the number of farmers involved in seasonal crops cultivation has increased significantly after introduction of RRWH systems. In addition to the increase in numbers of cultivators, there is a change in cropping pattern and increase in extent of cultivation. A substantial numbers of farmers have introduced high return new crops to their farming systems. The changes in cropping system, introduction of high value crops and increased extent of cultivation in the past have been effective in enhancing agriculture production and household income, especially in dry (yala) seasons.

About 91 percent and 28 percent of farmers who under take seasonal crops cultivation are using runoff rainwater stored as a supplementary water source during wet (maha) and Dry (yala) seasons respectively while about 72 percent of yala cultivators are using runoff rainwater as a sole source or main water source for their cultivation, which indicate the water scarcity condition in the area during dry seasons. About 68 percent of perennial crop cultivators use the RRWH systems as a supplementary source of water, while rest of the people depends on them as a main or exclusive water source.

Almost half of the sample households are utilizing the harvested runoff water for various household needs except for drinking while utilizing for cultivation and other purposes. As RRWH systems are constructed in the water scarce and marginal rainfed areas, the beneficiary perception on the impact of the systems on local micro environment around the tanks was elicited. According to the beneficiary perceptions, 85 percent have realized the changes in the surrounding micro environment after construction of RRWH tanks mainly in the form of the survival of vegetation in the surrounding environment of RRWH system during dry spells, which were severally effected prior to the project.

The rainwater harvesting intervention experiences shows that it has a great potential in developing the rain fed marginal areas of the dry areas and mitigates the effects of drought disaster. Systematic interventions with the participation of all stakeholders are vital to achieve the expected results.

## **Biofuel crops as a strategy for adaptation to climate change in the Semi-Arid region of Brazil**

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The demand for vegetable oils has increased considerably in Brazil since 2003, due to the launch of the National Program for the Production and Use of Biodiesel (PNPB, in Portuguese) and will reach around 840 million liters of biodiesel in 2008. The government expects that part of this demand will be met through the supply of raw material by family farmers in the north and northeast areas of the country. This goal is supported by state governments in the northeastern region, which are encouraging social and regional development. Poor communities that depend on climate-sensitive resources, such as water supply, are particularly vulnerable and are likely to have more restricted adaptive capacities. The majority of the poor population of the Northeast's semi-arid depends on the natural system for survival and food security. Small farmers from the northeastern, in the semi-arid region are among the low-income social groups most vulnerable to climate change. Improvement of the social and economic conditions in these rural communities through the growth of vegetable oil crops is an adaptation strategy vis-à-vis future climate change, constituting an income-generation activity in the biodiesel production chain. The use of vegetable oils as a feedstock for biodiesel production and fuel reduces CO<sub>2</sub> emissions due to the displacement of diesel oil, thus it also contributes to mitigation. We analyze crop diversification, such as the combination of subsistence and vegetable oil plants. Crop diversification helps to enhance the resilience of the natural system. Farms that use crop diversification tend to have more options to adapt to climate change impacts. Vegetable oil crops that are potentially suited for planting by family farmers in dry areas include peanuts *Arachis hypogaea*, sesame *Sesamum indicum*, sunflower *Helianthus annuus*, cotton *Gossypium hirsutum*, castor oil *Ricinus communis* and purging nut *Jatropha curcas*. These crops, with the exception of cotton and sunflower, can be planted alongside subsistence crops, such as corn and beans. They do not require mechanization and allow crop rotation. These crops are sufficiently robust to resist severe drought conditions in this region, even if aggravated by climate change in a scenario of a 2°C average temperature increase in the northeast region. Castor beans, peanuts, cotton, sunflower and purging nut represent good prospects: assuming a 30% reduction in rainfall, all these crops can still survive in the semi-arid, northeastern region. Biodiesel production from vegetable oils by small family farmers in the semi-arid region of northeast Brazil certainly exhibits great potential to promote climate change adaptation and mitigation. Their social, economic and environmental benefits may be crucial to socially vulnerable groups, such as family farmers, also menaced by the drought conditions that are expected to be aggravated by climate change. The main challenge remains in the implementation of appropriate policies to overcome the existing barriers to more effective participation of small farmers in the PNPB and achieving the required institutional setting, capacity building, technological and financial support, and logistics infrastructure.

## Enhancement of the GRAZPLAN grazing systems models for climate change adaptation studies

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Adaptation to climate changes by Australian broadacre farmers will largely take place via changes to paddock-scale management by individual landholders. As a result, the interacting consequences of changed climate and management on the agro-ecosystem must be understood concurrently in order to evaluate the effectiveness of proposed adaptation strategies. Simulation models based on equations describing the physics and biology of soil processes and the physiology and ecology of plants and animals have long been used to gain insights into these interactions.

The GRAZPLAN grazing systems models are widely used by Australian livestock producers and their advisors via the GrazFeed and GrassGro decision support tools. GrassGro consists of a simulation model (soil water budget, pasture growth model and livestock intake and nutrition model) of a simplified grazing enterprise, a flexible representation of the management of the livestock and an economic analysis module. The GrassGro software contains powerful facilities for carrying out and reporting modelling analyses.

To extend the GRAZPLAN models for use in climate change adaptation studies, we reviewed the literature on the likely impacts of increasing temperatures, altered rainfalls and increasing atmospheric CO<sub>2</sub> composition. Effects of changes in rainfall can be represented by the existing water balance model. The key effects of increasing temperatures – at least to 2070 or so – are accounted for by existing model equations describing effects of increased temperatures on VPD, pasture phenology, rates of assimilation, respiration and decline in the digestibility of herbage, seed dormancy release, reductions in animal intakes on hot days, decreased energy expenditures by livestock in winter and lower peri-natal mortality of lambs.

The GRAZPLAN pasture model was generalized to account for the effects of increasing atmospheric CO<sub>2</sub> composition. Four CO<sub>2</sub> effects were added to the model: reduced transpiration due to partial stomatal closure, a direct CO<sub>2</sub> fertilization effect, increase in specific leaf area and decrease in leaf nitrogen content. There are few data describing these effects at a field scale; our modelling approach was therefore to reason from physiological principles and to define parameters that could be estimated from the physiological literature. Relative changes in specific leaf areas and leaf nitrogen content per unit leaf area are modelled empirically. Transpiration rate at a given CO<sub>2</sub> concentration is related to that at a reference concentration using the Penman-Monteith equation. Leaf stomatal resistances are modelled empirically as a linear function of external CO<sub>2</sub> concentration. The direct fertilization effect of CO<sub>2</sub> concentration under radiation-limited conditions is modelled using the equation of Reyenga et al. (1999), which is based on a consideration of leaf-level photosynthesis. Under transpiration-limited conditions, a linear CO<sub>2</sub> response is modelled, with the slope depending on the transpiration rate sensitivity parameter.

Parameter values for these effects were derived from the literature for C<sub>3</sub> grasses, C<sub>4</sub> grasses, legumes and other dicotyledons. The extended pasture model has been incorporated into the GrassGro decision support tool with only minor changes to the user interface. Application of the new model to climate change adaptation studies is reported in a companion poster (Alcock et al.).

## Effective climate change adaptation process for business

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Today, business communities respond to growing debates on climate change and realise the importance of focusing their efforts to incorporate climate policies into their core business strategies. However, the effectiveness and efficiency of such efforts have been in question since robust approaches for implementing their climate strategies are currently scarce. Moreover, many industries tend to emphasise on mitigating climate change impacts, yet efforts made for adaptation appears to be somehow more limited at present. Given the huge uncertainty of the climate change impacts, proactive actions are urgently required by business communities to adapt increased climate risks. Therefore, both mitigation and adaptation strategies need to be included together in effective decision making processes.

This paper examines how global business could effectively adapt adverse impacts of climate change, such as increased temperature and intensified extreme weather, by modifying their services and products. Due to the global nature of climate change impacts, more efficient co-operation between different stakeholders seems to be essential. This paper proposes a holistic approach that could facilitate business communities to clearly define and systematically implement long term climate strategies effectively, namely stakeholder and systems approach. The emphasis is given to the importance of effective communication between different stakeholders in a structured and integrated manner and applying a systematic as well as traceable approach to improve efficiency. The detailed application process and the benefits of the recommended approaches are presented in the paper. Furthermore, how business could prioritise different adaptation processes is explained.

## Climate Adaptation within Risk- and Vulnerability Analyses in Swedish Municipalities

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Existing climate adaptation research points out the importance of local adaptation analysis being done on a local level by people familiar to local conditions. It also stresses that climate adaptation should be integrated into existing decision-making processes rather than creating new ones. Furthermore, it has been found that current climate

variability and extreme weather events can be an appropriate starting point for reducing vulnerability in the long term perspective. Based on such experiences, we have identified one of several mandatory processes in Swedish municipalities, the risk- and vulnerability analysis (RVA), as an appropriate process to incorporate climate adaptation.

The aim of this paper is to introduce and discuss a preliminary content of a methodological toolbox which aims at incorporating climate adaptation into mandatory RVA processes in Swedish municipalities. In the study, so far, we have identified parts in the process where climate adaptation can be integrated and suggested how adaptation can be considered in these parts by including decision-making tools.

In Sweden, much of the responsibility for crises management and reduction of the society's vulnerability to different threats, including climate extremes, is delegated to the local authorities governing the 290 Swedish municipalities. Extraordinary events are studied in the RVA process which aims at finding measures both to handle a crisis when it occurs, and to reduce vulnerabilities in society. The process involves officials from most administrations within a municipality which is an advantage also in the adaptation work. A drawback, on the other hand, is that the time frame only spans the near future, less than 10 years.

The design of the methodological toolbox is based on the result from literature studies, meetings with officials in several municipalities and interviews with three safety coordinators. The toolbox contains independent tools to be used within the different steps of the RVA process. One tool is an introductory screening of changes in climate threats in the local region, including how to find and interpret regional climate data. Another tool is guidelines of how to identify local vulnerabilities in relation to identified threats. A third tool is guidance about how geographical information systems can be used to visualise and analyse consequences of an extreme weather event. Another important issue being discussed is how to consider the long risk perspective connected to climate changes. This can be done both by considering a more distant future within the RVA process and by a more developed communication with municipality processes with a longer time perspective, e.g. processes dealing with physical planning.

The toolbox will be tested during 2010 in different municipalities and the work will be presented and discussed in the paper. One challenge with the study is to develop tools that are useful for the majority of Swedish municipalities. Apart from those in metropolitan areas, most of the Swedish municipalities are small, 210 having less than 30,000 inhabitants. An additional challenge is that the way the municipalities work with risk and vulnerabilities vary significantly with regards to comprehensiveness and scope.

## Adaptation Measures in Zapata face to climate change

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**Introduction:** Zapata is the biggest wetland in the Caribbean islands. The low lying land and other physic-geographic conditions make the Zapata an especially vulnerable place to climate change and variability. Its population is also vulnerable so it is necessary develop an adaptation program with an integrated participation of scientists, specialists, decision makers and stakeholders.

**Method:** Knowing the physic-geographic conditions of the wetland, the antropogenization in the municipality was possible understand the natural and human vulnerability in the territory. The climate knowledge, was analyzed, not only studying future climate scenarios, but also considering the current variability, trends and meteorological and climate extremes. The accessibility to future climate scenarios (2030, 2050 and 2100) and the current climate variability, (hurricane frequency, temperature trend, drought frequency, intensity and duration) moreover the future socio-economic perspective (considering land use change, urbanization), allow have an idea of how will be the future. For this topic were used statistic method (regression, time series analysis) and climate change models for different emissions scenarios.(IS92a, Kyoto A1) Studying the climate present and the future scenarios according IPCC models it is possible to know the impacts. With this information some 'brain storms' and workshops with specialists from different branches, scientists, decisions makers, and community participation allow develop an adaptation measures program. Always focusing to an integrated and holistic analysis. Statistical softs and GIS were also tools used in the study.

**Results:** The current climate shows a trend to change, more droughts, higher temperatures, more tropical storm are features of the climate today. The future scenarios show a different climate too. Sea level rise is other hazard. Ecosystem and people are vulnerability.

Some land should disappear. Adaptation measures are necessary among then:

'A new university in the municipality follow develops future professionals in different brands, preparing the people for the life in other environment.'

'Improving the civil defence and the early warning'

'Improving the advising to decision makers'

'Improving the educational and cultural work.'

'Decreasing invasor species.'

'Decreasing the hazards associated with the traditions.'

'Rescue the mangrove.'

'Decreasing the stress in the ecosystems.'

Conclusions: The peninsula is very vulnerable to climate change. Loss of land is hoped. The droughts, forestall fire, tropical storms, sea level rise and higher temperature are present today in the wetland. Measures of retreat are necessary, but also accommodation and protection face to climate change. An adaptation program with them is been developed. The new university plays an important rol in the preparation of future specialists for the possible emigration to land far away to the coasts. The early warning and the advising of decision makers are more important everyday. This adaptation program was developed with holistic and integrated focus.

## Talking climate change with the bush

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Climate variability and climate change are critical issues for Australia, particularly for those in rural communities and agriculture. Ongoing rainfall deficiencies in south-west Western Australia since 1970 and in south-east Australia since 1996 have already sharpened interest on future climate, particularly with respect to future rainfall. What do those involved with agricultural industries want to know about the changing climate? How can that information best be communicated?

The 'Communicating Climate Change to Agricultural Industries' project addressed these core questions, using a multidisciplinary and consultative approach. The project was collaboration between the Bureau of Meteorology, the Birchip Cropping Group, Meat and Livestock Australia and the Bureau of Rural Sciences. Running workshops with other organisations meant that the discussion could progress well beyond observed and future meteorological changes – the usual Bureau of Meteorology scope. Project findings presented will have a meteorological bias, given that the authors all work for the Bureau of Meteorology.

The project sent a group of climate change experts to three centres in Australia's southern cropping regions with the aim of improving the understanding of the implications of climate change on farm businesses and the environment by increasing the knowledge of the professionals that support farmers.

Initially, information on weather drivers, past and future climate trends, mitigation practices and options for producers, emissions trading, farm revegetation, carbon and soil carbon, commodities, water resources, sustainable production and managing risk was presented to a group of agribusiness consultants in Victoria, South Australia and Western Australia. Healthy discussion ensured that the two day workshops were lively.

The information was delivered as presentations and printed fact sheets on the day and was available on the Birchip Cropping Group website for reference afterwards ([http://www.bcg.org.au/cb\\_pages/Communicating\\_Climate\\_Change.php](http://www.bcg.org.au/cb_pages/Communicating_Climate_Change.php))

Follow up meetings were held in each of three locations aimed at the wider farming community.

This work has since been extended, with weather driver information now available for other states. Presentations have also been given at meetings with similar formats/topics.

Formal workshop evaluations provided useful feedback about the content and presentation of material provided. Informal discussions were sometimes just as useful as the formal presentations - both as a way of learning about farmers concerns and ensuring that the messages being delivered were clear.

Many informal discussions started with 'how much rainfall have you had; how much rainfall will I get in the next few days/weeks/months?' One of the key findings from this project was that farmers prefer the focus of climate change material to be on the next 10 years, as participants generally saw this timeframe as their realistic planning horizon, rather than a future climate 20 or more years away. This will require a restructure on the way the science is presented.

It was clear from the discussions and feedback that much on-farm climate change adaptation is already happening in response to adverse seasonal conditions. As one farmer said: "I don't believe in that climate change stuff, but "geez" the weather is changing"!

## Assessing the impact of the 2009 heat wave on Melbourne's infrastructure

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This poster will reflect on some of the key findings from ongoing actor-based research into the impacts of the 2009 heat wave on Melbourne's critical urban infrastructure (water, energy, telecommunications, and transport). This research activity is a discrete component of a larger study looking at the wide-ranging impacts of this climatic extreme event on South East Australia (led by Queensland University of Technology, and funded by the

There is increasing evidence that the potential impact of climate change on infrastructure is now receiving greater attention at both state and federal levels. This emphasis is particularly noticeable since 2007 when the first significant scoping of this topic was commissioned by the Victorian Government (CSIRO 2007), and has subsequently been followed by other key documentation which has considered the vulnerability of different types of infrastructure to future climate risks (see for example: (CSIRO 2008; IA 2008; Stevens 2008; Victoria 2008). Importantly, 2008 also witnessed the establishment of a new organisation 'Infrastructure Australia' and the release of the influential Garnaut Climate Change Review. Most recently, Engineers Australia have produced an infrastructure 'report card' for Victoria which sought to provide an assessment of fitness for purpose of the State's key assets. This latest edition included an explicit consideration of climate change scenarios (EA 2010). However, in-depth and critical analysis of the implications of climate change for Australia's infrastructure remains limited at this stage.

Drawing on findings elicited from a process of engagement with key personnel responsible for managing different types of urban infrastructure, this poster will provide bottom-up (real world) evidence of the impact on infrastructure of the 'exceptional' heat wave of 2009 that affected south-eastern Australia. In Victoria specifically, this event was notable not only for three consecutive day time temperatures over 43°C, but a significant number of nights where the temperature stayed above 20°C (NationalClimateCentre 2009). Based on an understanding that the frequency and intensity of extreme events are forecast to increase under a changing climate, such events may become more commonplace in the future. As such, there are valuable lessons that can be learned from this recent experience, not only in terms of understanding the direct impacts of heat stress on physical assets (and the strengths and weaknesses of different parts of the urban system) but also the opportunity to identify some of the indirect or knock-on effects between sectors, and ultimately what adaptation responses are likely to be needed to enhance the resilience of infrastructure assets to future climatic conditions.

### **Climate Change and its Impacts on Coastal Tourism: a case of Bagamoyo District**

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This paper assessed the climate change impacts on coastal tourism along the coast of Bagamoyo including two villages of Dunda and Kaole. It identified impacts on coastal resources that are used as tourist attractions, and assessed the vulnerability of coastal tourism, how it is adapted to climate change impacts. Further, the study examined the existing policies that are addressing mitigation and adaptation to climate change in Tanzania. The methodologies employed in this study include GIS and remote sensing (images used were of Spot for the year 1988 image scene of Bagamoyo and Landsat TM of 1995 and Orthophoto of 2000). Purposive samplings for key informants as well as random sampling were used in the collection of data on local perceptions on the climate change impacts. Participant observation and literature reviews were extensively used. Results observed from Tanzania Meteorological Agency (TMA) rainfall data from 1950-2007 showed that, the rainfall availability trend is declining over the years as well as rainfall variation and changing patterns of rainfall is significant in Bagamoyo areas. Temperature has also increased by approximately 0.50C and 20C (for mean maximum and minimum temperature respectively) whereas the average annual temperature increases of 10C from 1978 to 2008 which causing discomfort to tourists as well as local communities. The threats from sea level rise and coastal erosion is of significant whereby destructions of infrastructures such as hotels, cultural, historical and archaeological sites, sea walls and sea water intrusion into hotels compounds are common. Also occurrences of climate-related diseases such as malaria, dysentery, boils and skin rashes, pose a threat to coastal tourism activities in the areas as it was observed. The paper concluded that incidences related to climate change are increasing and have impacts on coastal tourism. And it was recommended that emphasis should be on adaptation measures, as well as enforcement of institutional capacity building and policy formulations, such as proactive forward planning on coastal management and ecosystems, enhancing public awareness and provision of education on climate change impacts to the coastal community, tourism stakeholders, private sectors and government officials.

### **Planning for resilience through effective governance: improving climate change adaptation in subtropical coastal cities**

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Adapting to the unavoidable impacts of climate change has emerged as one of the great challenges of the 21st century. Governments have a key role to play because they act as the central mediator between the economy, the community and the environment. Among other things they regulate access to natural resources, deal with waste, plan urban development, provide physical infrastructure, fund research and training, manage environmental risks, and coordinate responses to disasters. Identifying the features of governing institutions that have the potential to act as enablers or barriers to effective climate change adaptation should therefore be a research priority. This paper argues that a carefully constructed comparative analysis of key case studies is one approach that could generate some valuable results. As an example, the paper offers a preliminary comparison of the Australian Gold Coast to two of its sister cities: Fort Lauderdale in the USA and Beihai in China. These cases have been chosen for several reasons. First, they are all subtropical coastal cities with similar geographies that are highly vulnerable to the impacts of climate change. This means that they offer highly sensitive subjects that will more easily reveal major adaptation issues. Second, they all have comparable development patterns and have all experienced rapid population growth over recent decades. This reinforces the validity of the comparative analysis in producing meaningful results. Third, by contrast, they all have a diverse arrangement of governing institutions,

they are at varying stages of responding to climate change, and they have adopted very different adaptation policies and plans. This permits the study to identify the features of government that are enablers or barriers to effective action. This paper provides a preliminary review of some of the pertinent similarities of the case studies, points out the significant differences in their governing institutions, and compares their relative progress to date in responding to the challenge of climate adaptation. The main focus is on key government organisations, policies and plans. Potentially useful analytical techniques, derived from the theoretical frameworks of strong ecological modernisation and environmental justice, are also identified. Overall the aim is to provide a prelude to an ongoing research project being undertaken by the authors.

## **Understanding adaptation perceptions through policy frameworks: a case study from South East Queensland, Australia**

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Climate change adaptation has emerged as an important focus in the current climate change debate. Discussions within the policy field have centered on how to develop cost-effective adaptation options at a global scale and across multiple tiers of government (ECA, 2009, Parry et al., 2009). In a European context, adaptation has been approached through a multi-level governance framework in which national, regional and local levels interact with the aim of producing a coherent European Adaptation Policy (Aaheim et al., 2008). In an Australian context particular focus has been on defining the liability and responsibility of different levels of government in providing and developing adaptation strategies for human settlements (DSE, 2008, Standing Committee on Climate Change, 2009).

However, it has been suggested that adaptation strategies are based on the underlying assumptions and beliefs of the system characteristics and people's capabilities to adapt (Reilly and Schimmelpfennig, 2000). These assumptions are also based on different perceptions on the nature of adaptation processes (Adger and Barnett, 2009), the magnitude and speed of climate change (Adger et al., 2009a, Tompkins and Adger, 2004) and goals and values for and in adaptation respectively (O'Brien, 2009). Nevertheless, little research has critically examined these differing and possibly conflicting adaptation perceptions especially regarding public adaptation policies.

This paper therefore adopts a critical approach in examining the newly formulated climate change management strategies both regional and local scales in Australia with a specific focus for South East Queensland and the area of Gold Coast in particular. The aim is to show through a detailed content analysis what the perceived drivers are for local and regional adaptation, what assumptions are made of adaptation's nature, timescale and goals in the policies and how these correspond with the definition of effective governance of climate change adaptation.

## **Impacts of Climate Change to Asian Coastal Areas: The case of Metro Manila**

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Climate models supporting the IPCC Fourth Assessment Report predict that climate change will increase local temperatures and precipitation in monsoon regions in Asia, where the number of large cities is increasing and existing urban areas are expanding, particularly along the coasts. In this study, Metro Manila, typical of Asian coastal megacities, is used as a case study to comprehensively simulate impacts of future climate change and identify necessary adaptation measures.

In spite of the various uncertainties inherent in predictions, this study translates future global climate scenarios to regional climate scenarios, a process called "downscaling". The B1 and A1FI scenarios of the IPCC SRES framework provide a basis for discussing local temperature and precipitation changes in Metro Manila. Based on these scenarios, hydrological conditions such as river overflow and storm surge were projected. Flood simulation maps were then constructed showing the range of potential spatial spreads, inundation depths and flooding durations anticipated in the metropolis.

Based on the flood simulation maps, socio-economic impact analyses were applied to understand the characteristics and magnitude of flood damage anticipated in year 2050. The benefit side of the analysis calculated avoided damage at the aggregate level. Tangible direct losses were assessed as in conventional flood control project analyses. Incremental costs to transportation (VOC and time costs), and lost wages and income (sales) due to flooding were combined for tangible indirect costs.

If flood control infrastructure improvements were stopped now, and the A1FI climate scenario is assumed, a 100-year return period flood could cause aggregate damages of up to 24% of the GRDP, while damages from a 30-year return period flood would be about 15% of the GRDP. If, however, infrastructure improvement based on the 1990 Master Plan is continued and climate scenario B1 is assumed, the projected damages would be only 9% of the GRDP for a 100-year return period flood, and 3% for a 30-year return period flood.

Finally, options for adapting to the scenarios were selected, with the objective of eliminating as much as possible of the flooding projected in the flood simulations. Economic evaluations using economic internal rate of return (EIRR) and net present value (NPV) were conducted by combining the costs of the adaptation options with the damages avoided by implementing those options. The EIRR and NPV evaluations yielded different results, but they both suggest that filling the infrastructure gap identified under the current Master Plan (for status quo climate) is the first and foremost priority.

## Enhancing cooperation between the health and climate sectors for adaptation to climate change

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According to World Health Organization (WHO) estimates, climate change may already be causing more than 150,000 deaths per year, a number that is expected to grow in the future. The most recent report of the Intergovernmental Panel on Climate Change (IPCC) cites overwhelming evidence that human actions are contributing to climate change, with a wide range of implications for human health. Some of the impacts are direct, including mortality and morbidity resulting from more intense weather events, heat waves, and floods. Potentially larger impacts, though, may arise indirectly from mechanisms such as climate's effects on agricultural production and water resources--linked to major killers such as malnutrition and diarrhea--and common vector-borne diseases that are highly sensitive to changing temperatures and precipitation.

Effective adaptation strategies are therefore needed to reduce vulnerability to the health impacts and projected future health risks of climate change, particularly in the developing world. Adaptation responses will be shaped by the role of various institutions, their processes and relationships. It is therefore important to understand the role of different institutions at different levels in shaping adaptation strategies.

This article explores two instrumental global institutions in relation to health and climate change, the United Nations Framework Convention on Climate Change (UNFCCC, Germany) and the World Health Organization (WHO), to assess how the health sector is addressed by international actors and institutions in on-going national and global adaptation action and discussions. The article reviews country-level responses in the form of UNFCCC-sponsored National Adaptation Programs of Action (NAPAs) and how they incorporate the health sector in adaptation. Forty one least developed countries that have submitted NAPAs to the UNFCCC identify health, or the health sector, among the most vulnerable to climate change. Despite this recognition, however, fewer than half of the countries have identified a single adaptation project in the health sector among priority projects in their national plans.

Cooperation between UNFCCC and WHO to this point has been minimal. UNFCCC adaptation projects, including those outlined in NAPAs, are supported financially through the Global Environmental Facility (GEF), which operates adaptation funds such as the Least Developed Country Fund and Special Climate Change Fund. GEF facilitates the implementation of on-the-ground projects and programs through GEF agencies, including institutions such as UNDP, UNEP, and the World Bank. Unfortunately, WHO is not currently a GEF agency, and health is not among GEF's focal areas.

The article provides recommendations for greater integration of health considerations and health sector engagement in climate change adaptation efforts. Greater participation of WHO and other health sector representation and expertise in UNFCCC negotiations and evolving institutions should ensure that health is adequately in the agenda. Likewise, greater engagement of WHO in GEF adaptation efforts—perhaps through engagement as an official GEF agency—also could help to raise the profile and priority given to health in adaptation planning and programming.

## Causes of Death and Demographic Characteristics of Victims of Meteorological Disasters in Korea, 1990-2008

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**Introduction and Object:** Information about the causes of death and the long-term trend of the numbers and characteristics of deaths from meteorological disasters are necessary for evaluating the effects of climate change on public health and establishing future adaptation measures. This study analyzed the causes of death of victims of meteorological disasters in Korea, as well as demographic and geographic vulnerabilities and their changing trends.

**Methods:** The causes of death, accident location, year of death, gender, and age of the victims of meteorological disasters were examined from 2,045 cases in "Investigation Reports on Victims" prepared by 16 local governments. Types of meteorological disasters were classified into flood, typhoon, storm, cold wave, and lightening. Direct causes of death were classified into drowning, structural collapse, electrocution, lightening, fall, collision, landslide, snow-slide, lapse of disease from disaster, and others. Drowning was subdivided by place into river, sea, ship, house, road, and drain. For the trend of deaths from meteorological disasters, the data of 1990s and 2000s were compared. The analysis period was from 1990 to 2008.

**Results:** The total deaths from meteorological disasters between 1990 and 2008 were 2,045. The largest number, 966 deaths (47.2%) died from flood, followed by 748 deaths (36.6%) from typhoon, and 316 deaths (15.5%) from storm. The highest cause of death was drowning (1,237 deaths, 60.4%), followed by landslide (403 deaths, 19.7%), and structural collapse (206 deaths, 10.1%). Among the deaths by drowning, drowning by river (743 deaths, 60.1%) was the most frequent, followed by drowning by sinking boat (368 deaths, 29.7%), and drowning by sea waves (60 deaths, 4.9%). By gender, the ratio of annual average death of men per 1,000,000 people was 3.11, and this was 1.9 times as high as that of women which was 1.63. By age, the death rate was higher among older people. By region, the ratio of annual average death of coastal provinces was the highest at 6.19 per 1,000,000 people, followed by inland provinces (3.23), coastal metropolitan cities (0.94), and inland metropolitan cities (0.55). For the period of 10 years,



the annual average number of deaths by flood decreased by 3.9 times from 80.2 to 20.5, whereas that by typhoon increased by 1.7 times from 31.1 to 54.4. Furthermore, the average number of deaths per meteorological disaster by flood decreased by 2.2 times from 27.6 to 12.3, whereas that by typhoon increased by 1.3 times from 22.2 to 29.9. This shows that the meteorological disaster that causes the most victims in Korea is changing from flood to typhoon.

Discussion & Conclusion: This study found that flood caused the highest number of deaths, but it is slowly changing to typhoon. The highest direct cause of death was drowning. The factors that raised the vulnerability to meteorological disaster were living in the coastal provinces, older age, and male. In order to establish effective measures for adaptation to meteorological disasters, we need to build a more precise monitoring system for disaster epidemiology.

## **Exposure of Settlements and Infrastructure for Climate Change Adaptation Research and Decision Making**

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As severe effects from climate change appear inevitable [1] the need for countries and communities to adapt to the consequences of climate change is clear. Nations actively involved in climate change adaptation can mitigate much of the risk from the increased severity of tropical cyclones, storm surge inundation, riverine floods and disease spread. Integrating exposure information for decision making related to adaptation will make the strategies developed more effective. It helps decision makers to be better informed, and the decision making process to deliver more rational, representative and objective climate change outcomes. Hence, it is critical to spatially understand the exposure of the elements at risk from climate change. Elements with exposure to these increased climate related hazards include: communities, businesses, services, lifeline utilities and infrastructure. The thorough understanding of the exposed built environment, population and infrastructure under current and future climate projections is fundamental to the research required for future capacity building.

Exposure information has been developed at Geoscience Australia through the development of the National Exposure Information System (NEXIS). It is derived from a combination of statistical and specific approaches and includes information about human populations, buildings, businesses and infrastructure. NEXIS is a significant national capability which provides comprehensive information representing the exposure profile for the entire nation. It is extractable for any area of interest including Statistical Divisions, Local Government Area and Statistical Local Area. The information is at building level resolution but can be aggregated in terms of the buildings, people, land use, business activity, employment, customer capacity and infrastructure assets in the area of interest.

NEXIS maintains current and consistent exposure information for Australia today. Further, this exposure can be projected based on population projections by the Australian Bureau of Statistics for the estimation of the impacts due to climate change in the future. This process has been demonstrated for several national projects including adaptation research projects, energy efficiency tools, National Coastal Vulnerability Assessment, Garnaut review on climate change and the National Wind Risk Assessment.

## **Assessing potential impacts of climate change on berry quality for major wine grape varieties**

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The projected climate change is likely to impact on wine quality as climate is a dominant factor that influences wine grape quality. Wine grape quality at harvest is the key variable determining the subsequent wine quality. However, the direction and magnitude of climate warming impact on fruit quality of wine grape varieties are unknown. For this study we carried out fruit sampling for major wine grape varieties from ten vineyards with varying growing season temperature and assessed some key quality parameters at uniform maturity level of 22 °Brix. At this maturity, the level of titratable acidity in all varieties showed significant negative trend as the growing season temperature increased. The rate of acidity loss per degree increase in growing season temperature is found to be highest for Chardonnay followed by Shiraz and Cabernet Sauvignon. Similarly, berry anthocyanin level declined with the increasing growing season temperature. However, the rate of anthocyanin loss per degree increase in average temperature was higher for Cabernet Sauvignon than Shiraz indicating different sensitivity to temperature. Since climate projections from the various emission scenarios fall within the range of the temperature gradient from this study, these results provide estimates of the likely impact of climate change on some of the key berry quality parameters for major wine grape varieties.

## **Adaptation Challenges to Climate Change Disasters in the Karamoja Cluster (Cattle Corridor) in Uganda**

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One of the challenges the world is facing today is global climate change and its associated impacts. Uganda is a climate sensitive country with over 90% of the population dependent on climate sensitive sectors. Gradual and sudden variations in climatic parameters therefore render the livelihoods of Ugandans very vulnerable. A number of approaches to enhance

the resilience of communities to climate change and variability in Uganda exist. This paper attempts to review and assess the effectiveness of institutional mechanisms and governance arrangements that are/have been put in place to enhance the adaptive capacity of pastoral communities in the face of increasing occurrence of climate disasters. Special attention is given to the pastoral communities in the Karamoja cluster / cattle corridor of Uganda, which holds over 90% of the national livestock. Evidence from the cluster indicates that livestock mobility is the major adaptation method to floods and droughts among pastoral groups. Other measures include reliance on remittances and social networks for support. Several adaptation challenges among the pastoral groups include: increasing frequency of droughts and water shortages, cattle rustling, land tenure systems and gradual collapse of informal institutional/cultural systems that held communities together in times of crises. Formal multi-level governance structures and institutional mechanisms have been put in place such as: the National Adaptation Plan of Action (NAPA), National Development Plan [NDP], Karamoja Development Programme, Northern Uganda Development Programme and the restructuring of the Ministry of Disaster Preparedness, to take care of abrupt events and further enhance the livelihoods of affected communities. Worse still there is a general lack of awareness about appropriate adaptation measures. This paper argues that community adaptation capacities have not been fully understood in Uganda and need to be framed appropriately within the national development agenda.

## **Climate change adaptation: amphibian physiological response, including immune function and chytrid intensity, along altitudinal and temporal gradients in South-east Queensland, Australia**

**E J Narayan<sup>1</sup>, J-M Hero<sup>1</sup>**

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Global climate change is considered one of the key threats to amphibians (Hero et al. 2006). Amphibians are extremely sensitive to small changes in temperature and moisture (Corn, 2005), and El Niño events or global warming have the potential to alter the timing of breeding, immune functions and sensitivity to pathogenic infections such as Chytridiomycosis (Beebee 1995; Berger 2001; Blaustein et al. 2001, 2003; Bradley et al. 2002; Carey and Alexander, 2003; Gervasi et al. 2008; Gibbs and Breisch 2001). The physiological mechanisms, behavioural responses and morphology of amphibians have enabled species survival under extreme terrestrial environments for millions of years. However, currently amphibian populations are declining worldwide and majority of the declines have been concentrated in upland or montane areas with varying environmental conditions and a key question arising is whether the frogs at higher elevations are able to adapt to short and long-term changes in their surroundings. Recent studies have shown that the endogenous reproductive hormonal mechanisms in amphibians (e.g. initiation of spermatogenesis and oogenesis) are strongly associated with climate (Lynch and Wilczynski, 2006; Narayan et al. 2010; Rastogi et al. 2005). Traditionally, ecologists rarely considered the physiological mechanisms controlling the breeding phenology of amphibians, leaving substantial gaps in knowledge on how amphibians might adapt to climate change. In this study, we attempt to bridge the gap between the physiological and ecological processes by investigating the changes in physiological (hormonal) mechanisms of wet forest frogs living along altitudinal and temporal gradients in South-east Queensland. The effects of temperature and rainfall on the endocrine system and, changes in immune function and susceptibility to chytrid fungus are explored, thus discussing the physiological adaptation of wet forest frogs to climate change. Furthermore, this study provides new information on reproductive hormonal cycles of various native Australian frog species. This information is urgently needed to understand the physiological response of wet forest frogs to climate, providing new insights into amphibian population declines and adaptation for climate change.

## **Reducing Drought Vulnerability by Drought Characterizing Using Meteorological Data and Spatial Soil Moisture Modelling**

**B H Narendra<sup>1</sup>**

<sup>1</sup>Mataram Forestry Research Institute, Indonesia

To reduce drought vulnerability, people must be familiar with drought characteristics in the area. Referring the research, drought can be characterized based on meteorological data and soil properties. The first approach uses rainfall data and Standardized Precipitation Index (SPI), the second is defined by soil moisture drought modeling using PCRaster, a dynamic modeling system. The result reveals that soil moisture modeling generated by PCRaster can describe drought characteristics based on soil moisture deficit with flexible time scale. PCRaster output provides information about when, where, and how much water deficit occur in each time step, better than information provided by SPI.

## **Can we save the Great Barrier Reef? An exploratory investigation of climate change communication in Australia**

**C Naum<sup>1</sup>**

<sup>1</sup>James Cook University, Australia

Global climate change is cited as being one of society's greatest challenges that is threatening the future sustainability of vital ecosystem services. Despite mounting evidence for anthropogenic climate change and corresponding empirical evidence to support the degradation of valuable ecosystems in Australia, most notably the Great Barrier Reef World Heritage Area (GBRWhA), inaction is pervasive. This may in part be attributed to communication of the phenomenon.

Climate change communication is a burgeoning field of research. The growing body of literature reveals numerous challenges to communicating the issue of climate change. These include lack of immediacy, remoteness of impacts, and time lags.

Compounded by these, is the need for dramatic reduction in greenhouse gases to below 350 ppm if the future of the Reef is to be secured. To achieve this will require sweeping change. How can communication play a role in making this possible?

Therefore, the current research aims to explore: 1) how the impacts of climate change on the GBRWHA are currently being communicated by practitioners; 2) climate change communication perceptions of Australian leaders with expertise and experience relevant to climate change; and 3) potential communication strategies to bridge the gap between knowledge and action in target audiences, and facilitate the kind of change that is required to respond to Reef protection.

The present study follows a qualitative research design utilizing a constructionist approach to define parameters of the problem and solutions through semi-structured interviews with experts in the fields of climate change, coral reef ecology, education and communication. The interviews will be transcribed and thematically analyzed in efforts to identify central themes. Ultimately, analysis of interview data will be reviewed by a cross section of communication practitioners through a series of focus groups to determine feasible communication strategies. Preliminary findings of an exploratory pilot study with key informants will be presented here and discussed within the theoretical positions of communication theorists.

## Climate change, land use policies, and adaptation in Alxa region, Inner Mongolia, China

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The Alxa region of Inner Mongolia, China, is characterized by a temperate desert to steppe ecosystem and comparatively high population density. Low water availability is the key limiting factor but over the past 20 yr overgrazing and irrigation farming on marginal sites have led to increased land degradation, desertification, aquifer depletion, and soil and water salinization. The rising number of dust storms can be directly attributed to desert growth as function of mal-adapted land use practices.

Temperature is showing a strong warming trend since 1970, and regional climate models predict a further rise, ranging from 4.4 to 5.2 °C and from 3.4 to 4.0 °C above preindustrial values by 2100 for the A2 and B2 IPCC SRES scenarios, respectively. Precipitation changes are predicted to be rather small, with a slight upward tendency. As a result, aridity and the overall vulnerability of the region's ecosystems will further increase, leading to more desertification, reduction of available water resources, and other impacts such as an increase in vector-borne diseases and invasive species. Hence, a further rise of human pressure on the ecosystems is likely if management systems are not adapted.

In recent years Chinese government has introduced a number of new environmental and land use policies, aiming to invert degradation. Policies include: rotational grazing or grazing bans; tree shelterbelts; resettlement programs. The policies have been very successful in reducing the pressure on the rangelands. However, collateral effects include an accumulation of dry litter, raising the threat of steppe fires; groundwater decline where unadapted tree species have been planted to reduce desert expansion; and groundwater depletion and salinization as well as soil erosion and degradation as result of increased agricultural activities after resettlement.

Within the ADAM project (Adaptation and Mitigation Strategies: Supporting European Climate Policy) response strategies and possible innovative policies are being studied in our Inner Mongolia case study, among other regions. In this context a survey questionnaire was carried out among farmers and herders to investigate their perceptions of climate risks for the past, present and future; responses to and costs of climate impacts; perceptions of policies and other measures to address climate risks; vulnerabilities and adaptive capacities; and willingness to pay for protection from climate risks. The responses were analyzed statistically to understand differences in perceptions between: gender; occupation; income; level of education; and place of living.

Main results of the analysis are:

- 90% of the interviewees have heard of climate change, but only 40% relate it to changing temperatures;
- 70% have noticed a decrease in rainfall and an increase of dust storms;
- 25-50% have experienced income losses of over 25% due to extreme weather events;
- Herders were less vulnerable to weather extremes than farmers;
- Economic diversification was considered the most useful response to climate risks followed by shelterbelts and controlled grazing;
- Grazing bans and resettlement programs were considered the least useful responses to climate risks and environmental degradation;
- Herders were willing to pay twice as much on climate insurance than farmers;
- The majority indicated to be better off than in the past, to be generally content with their situation now and to expect the situation to improve in the future.

The poster presentation at the conference will discuss these apparently contradicting results and provide the participants with information on adaptation in one of China's environmentally most vulnerable regions. Lessons from the surveys and stakeholder workshops will be discussed in relation to adaptation in other dryland areas under different institutional settings and livelihood conditions.

## Trees on farms: Tackling the triple challenge of mitigation, adaptation and food security

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Human induced change of ecosystems will seriously limit the ability of ecosystems to provide basic needs for food, water, timber, fibre and fuel for the future if current trends are not reversed through significant changes in policies, institutions and practices. At the same time, population growth, particularly in the developing world, to approximately 9 billion people by 2050 will require at least 70% increase in food production, if current mal- and undernutrition are concomitantly to be reduced.

While agriculture, forestry and land livestock management are strong contributors to climate change, accounting for approximately 20% of greenhouse gas emissions, climate change threatens progress already made towards achieving the Millennium Development Goals and in providing sustainable livelihoods to millions of smallholders.

Agriculture of the future must meet the triple challenge of: raising food production per unit area; reducing the vulnerability of agricultural systems to climate change; and reducing greenhouse gas emissions from agriculture. Agriculture with trees is ideally placed to tackle all three challenges.

1. Trees on farms sequester carbon and contribute to mitigating climate change  
Carbon sequestered by trees and stored in aboveground biomass and soil contributes to reducing greenhouse gas concentrations in the atmosphere. While estimates of their carbon sequestration potential vary greatly, agroforestry systems tend to sequester much greater quantities of carbon than agricultural systems without trees. Analysis of the spatial distribution of existing agroforestry systems shows a wide potential for increasing tree cover on agricultural lands and rangelands. Research from Indonesia suggests that the opportunity cost of increasing tree cover on agricultural lands is generally below USD5 and therefore offers an efficient and cost effective way of mitigating climate change.
2. Trees on farms enhance resilience to climate variability  
Trees on farms help adaptation to climate change by reducing vulnerability to climate impacts .  
The ability of agroforestry to generate more income and hence raise the adaptive capacity of smallholders is described in the section on food security.  
Trees on farms can diminish the effects of weather extremes such as droughts or heavy rain. Research has found that the tree components of agroforestry systems stabilize the soil against landslides and raise infiltration rates. This limits surface flow during the rainy season and increases groundwater release during the dry season. With rainfall intensities expected to rise with climate change this feature of agroforestry systems to prevent landscape degradation will become more important in the future.  
Using the right agroforestry species in connection with annual crops has also been shown to beneficially redistribute water in the soil profile, providing annual crops with greater water availability. Using appropriate agroforestry species can also provide fodder and shade for livestock, protect soils against irradiation during the dry season, and provide organic fertilizers for annual crops during the rainy season. Whilst important today, these factors will become even more important in the future.
3. Tree-based agricultural systems improve food security and livelihoods  
Diversification of food production is a key strategy to increase food security. By integrating trees in their farms and rangelands, farmers reduce their dependency on a single staple crop. For example, if a drought destroys the annual crop, trees will still provide fruits, fodder, firewood, timber and thereby sustain the farmers' livelihoods.  
Higher soil organic matter and available nutrients in tree-based agro-ecosystems can also significantly increase yields in smallholder farming systems. This is of particular importance where access to mineral fertilizers is restricted by high costs or limited availability.  
Various studies have shown the importance of this additional income to smallholder food security. Less dependence on a single commodity and higher yields raise the adaptive capacity of smallholder farmers against climate related risks.
4. Policy recommendations
  - Increased adoption of agroforestry should be supported through finance for agricultural development and adaptation as well as mitigation.
  - Payments for environmental services –including carbon finance - geared towards increasing the extent of trees on farms
  - More support is needed to increase the contribution of tree-based crops to smallholder incomes, thus diversifying income sources and increasing food security in the face of climate change.

## Environment Protection, Biodiversity Conservation and Climate Change ADaptation: Australia's EPBC Act, with reference to a case study from Australia's largest river system

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To date, research and assessment efforts relating to climate change impacts and adaptation have focussed on terrestrial ecological systems from the northern hemisphere. There has been limited opportunity to incorporate aquatic and marine ecosystem knowledge and southern hemisphere case studies into the mix. Consequently, outcomes of the IPCC Fourth Assessment Report (released in 2007) entailed these inherent biases.

Australia's national environment law, the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

enables the listing of threatened ecological communities (TECs) and a recent review of the Act (the Hawke Review) recommended amendments to allow for a greater focus on a landscape/systems approach'. Indeed, many of the 47 already listed TECs have taken a landscape and/or regional approach with respect to their definition and scope. At present, the first complex aquatic and marine systems are under assessment for listing as TECs – the Lower River Murray (from the sea to the junction with the Darling River), Wetlands of the Darling Basin, and the Giant Kelp Forests of south eastern Tasmania. The listing process includes the preparation and publication of a comprehensive 'listing advice' which provides information on ecological character and function, biodiversity, threats, and thresholds.

A recent assessment of the vulnerability of Australia's biodiversity to climate change proposed that management objectives will need to reorient from preserving all species in their current locations to maintaining the provision of ecosystem services through a diversity of well-functioning ecosystems. There is wide scientific acceptance that those ecosystems that are threatened by other pressures will fare worst under the impacts of climate change. There has also been a call to go beyond analysis of biophysical impacts and to invest in building ecosystem resilience – by improving adaptive capacity, reducing vulnerability, managing risks, and identifying and managing the thresholds and tipping points that can lead to irreversible system change. The listing of TECs offers a significant and strategic contribution towards meeting these challenges and details will be discussed. It also offers a unique opportunity to provide case study material to the broader international analytical effort on climate change adaptation with respect to southern hemisphere information and increasingly, aquatic and marine ecosystem examples. Aspects from assessment of the Lower River Murray (part of the Murray-Darling Basin, Australia's largest river system) will be presented.

## **A Reliability Assessment of Railway Track Performance in Extreme Heatwave Events**

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Railway networks are essential transportation infrastructure for Australian cities. Structural buckling failures of railway tracks due to extreme heatwave events had caused service disruption of the networks, as observed in the heatwave event of January 2009 in Melbourne, during which the daily maximum temperatures exceeded 45°C for 3 consecutive days. In addition, climate change research indicates a future of more frequent and more intense extreme heatwaves in Australia; assessment of heatwave hazard to the rail track buckling failure is needed for future planning and management of railway network services.

This paper presents a reliability assessment of railway track buckling under extreme heatwave events. Monte-Carlo simulation is used to estimate the buckling failure probability in Melbourne. The effects of important predictor parameters such as the effective buckling lengths and buckling modes of the rails, as well as the rail temperatures at the time of installation and during heatwaves are considered. The result shows that the buckling failure probability of railway tracks in Melbourne under a heatwave is about 2/100,000, which is in good agreement with the number of the buckling observed along the Melbourne railway network during the January 2009 heatwave.

## **Communication and the resilient community**

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Traditional emergency management theory refers to the four stages of emergency: prevention, preparedness, response and recovery; but recent thinking suggests that resilience and adaptability need greater focus for both pre-disaster strengthening of communities, and for the longer term psychosocial welfare of communities affected by disasters. In this context, governments are rightly concerned with the maintenance of a robust and fully functioning society that is able to withstand the shock of disaster, whether caused by nature or human intervention. However, the problem for government agencies is how to communicate with 3 people at risk – which, given recent extreme weather events, is virtually the entire population – initially to foster preparedness (the recent development of new colour-coded warnings following the “Black Saturday” bushfire disaster in Victoria is an example of this); to encourage mitigation activities; and to assist with recovery following disaster. Communication strategies for each of these stages are difficult to implement well and can be politically risky. This paper examines the components of resilience in the context of disaster, the role communication can play in promoting resilience and, using case studies from the ACT bushfire of 2003 and the 2009 Victorian bushfires, proposes some pointers toward the use of communication to assist in building and maintaining resilient, adaptable communities.

## **(HOPE) Householders' Options to Protect the Environment Inc at 21: An environmental history perspective on the community capacity building work of a voluntary Australian NGO. Which way forward now for effective civil society engagement on adaptation to and mitigation of anthropogenic climate change?**

**A Nicholson<sup>1</sup> and N Kimball<sup>1</sup>**

<sup>1</sup>Householders' Options to Protect the Environment (HOPE), QLD Australia

If you spend time with community groups and communities active in combating climate change, you'll soon understand that they know what they are talking about. They are alarmed by the rapid impact that climate change

is having on our environment and communities. They are frustrated that actions to immediately reduce emissions are not being taken and that emissions continue to rise. And they are frightened that without urgent action, our future will be full of drought and devastating bushfires, record temperatures and lost lives. But they fight on anyway because the scale of change needed to transform our country to a low carbon economy is large.

Combating climate change cannot be achieved without extensive community leadership and engagement, a point well recognised and made often in government strategies and programs engaging communities around climate change and sustainability, but seldom acted upon.

In this paper, the authors draw upon the historical experience of HOPE, the voluntary community environmental NGO of which they are members, to explore how community based processes are currently faring in combating climate change, arguing that participatory strategies and actions must improve in order for communities to move beyond the realm of 'response' to undergoing a 'transition'. Focus is placed on what present challenges are faced by community groups such as HOPE to harness communities in working towards fostering a movement for change.

Presenter, Andrew Nicholson undertakes this exploration from the position of someone who is involved at the grass roots level - as a volunteer climate change educator within Householders' Options to Protect the Environment (HOPE).

HOPE, recently celebrated its 21st birthday, and is a politically unaffiliated group of concerned householders from around Australia who wish to see immediate & decisive action on anthropogenic climate change. The organization was founded on a vision of a society which is sustainable ecologically, economically and socially. The core idea of HOPE is that, while we have to think about the environment as a whole – on a planet-wide scale – we need to act locally, in our own communities in a way that's effective and meaningful.

And so, putting its money where its mouth is, HOPE undertakes local community-based projects to address climate change as well as a range of other initiatives to promote the cause of sustainable development generally.

## The unfolding story of heatwaves in Adelaide

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Two extreme heatwaves occurred in South Australia in 2008 and 2009. It is of interest how these two unprecedented heatwaves compare to averaged heatwave risks preceding these events.

Using case-series analysis, daily morbidity and mortality rates during heatwaves were compared with rates during non-heatwave periods within the respective years and restricted to the warm season (October-March). Health outcomes examined were total, age group and disease-specific hospital admissions, emergency presentations, ambulance call-outs and mortality. Heatwave definition was maximum temperature  $\geq 35^{\circ}\text{C}$  for 3 or more days.

Dose response effects of duration (increasing number of days within a heatwave) and intensity (by increments of  $1^{\circ}\text{C}$  above  $35^{\circ}\text{C}$ ) of heatwaves using health and temperature data from 1993-2008 were also examined. In addition to this, the relationship between temperature triggers for community interventions in South Australia and health outcomes was assessed. Currently the triggers are based on average daily maximum and minimum temperatures (ADT) (extreme heat watch:  $28^{\circ}\text{C}$ ; extreme heat warning:  $32^{\circ}\text{C}$ ; 3 or more days of the respective ADT).

Ambulance call-outs increased by 10% during the March 2008 heatwave and by 16% during the 2009 event exceeding call-outs from averaged preceding heatwaves. They were mainly cardiac and neurologically-related in nature. An estimated extra 519 call-outs occurred during the 2009 heatwave.

Only small increases in total hospital and emergency visits were observed in 2008 and 2009. Renal-related disease increases were manifest in the hospital and emergency setting. The young and the old were impacted in 2008, while in 2009 renal-health related emergency presentations were seen throughout the age groups. Direct heat-related admissions increased 14-fold for hospital admissions and 12-fold for emergency presentations in 2009 compared to 3-fold during averaged heatwaves and during the 2008 event.

While no increases were observed in ischaemic heart disease in the averaged heatwave data or during the 2008 event, marked increases were seen in the hospital and emergency setting in 2009 in the 15-64 years age group.

Increases in mortality were observed during the 2008 heatwave in the young age groups only, while during the 2009 heatwave, the major impact occurred in the 15-64 years age group, for which mortality increased by 37 % (95% CI, 1.09-1.71). Older age groups were not affected.

Significant dose-response relationships were observed for heatwave duration (ambulance, hospital and emergency setting) and for intensity (ambulance and mortality). Assessment of current extreme weather warnings indicated that the temperature triggers are suitable for prevention of health effects in the community.

These findings indicate greater risks of ill-health during the recent severe heatwaves compared to previous events.

In comparison to other cities, Adelaide's health outcomes were relatively contained. This may be explained by interventions that were directed at the vulnerable population during the 2009 heatwave. Further investigations are underway that will investigate risk factors of ill-health during the recent extreme heatwaves.

## Investment Decisions for Climate Change Adaptation

M Nolan<sup>1</sup>

<sup>1</sup>AECOM, Australia

The majority of investment decisions for development are being made based on past climate, rather than the climate conditions that assets and their users will experience during the assets' expected life. Decisions based on a false assumption in this way present a significant risk to infrastructure intensive corporations, authorities and departments.

Having the right information to make decisions is critical. Michael will explore a range of key issues related to making informed climate change decision making based on several projects for local, state and federal government and the private sector.

Climate change impacts on infrastructure for example will have a direct financial and reputational impact to corporations and government especially where unexpected degradation and reduced life of an asset from changed climatic conditions results in service failure.

AECOM has worked with the Australian International Development agency (AusAID) to develop guidance for activity managers in Asia and the Pacific for screening investment in infrastructure for climate resilience.

A range of climate change adaptation responses will also be discussed using several AECOM climate change projects completed in recent years including climate change impacts to infrastructure in Australia developed for the Garnaut Climate Change Review which received a High Commendation for Environment and Sustainability in the Victorian Engineering Excellence Awards 2009.

## Potential economic impacts of climate change on Australian salmon

A Norman-López<sup>1</sup>

<sup>1</sup>CSIRO, Australia

This study investigates the economic benefits to the Australian salmon industry, and associated sectors, if it accounts for the impacts of climate change on their future development. The Australian salmon industry is the second most valuable fishery after rocklobster and is anticipated to continue growing into the future. Nevertheless, expected increases in sea surface temperatures could have implications for salmon production. In this study we consider two scenarios; firstly where the industry continues with business as usual, and secondly where adaptive measures aimed at mitigating the probable impacts of climate change are incorporated and accounted for. Estimates of climate change impacts in the Australian salmon fishery and their associated probability distributions were derived from the literature and expert consultations. An Input-Output model of the Australian economy was used to determine the flow-on effects of these impacts. Monte Carlo simulations were then undertaken on the basis of the associated uncertainties of climate change predictions. The results, based upon the best available biological projections, highlight the great capacity of adaptation for the salmon industry and the economic benefits the industry are likely to realise if adaptive measures are put in place.

## Barriers to Effective Climate-Change Adaptation on Islands

P D Nunn<sup>1</sup>

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In recognition that islands have a special set of vulnerabilities that place them in the "front line" of climate change, external assistance has poured in to many independent island nations over the past two decades to embed and sustain adaptation initiatives. Most of these have failed because material solutions did not acknowledge the singular environmental and cultural context of islands and because donors did not understand the pathways of effective environmental decision-making.

Two examples are discussed. The first is the "seawall mindset" that has seen an epidemic of locally-made seawalls in response to island shoreline erosion, most of which collapse and fall into disrepair after a few years. This example shows both the dangers of uncritical emulation of adaptive solutions and the potential for disseminating effective solutions in such a manner. The second example is the incomplete understanding of the nature of future climate change and the imperative for adaptation by key island decision-makers, which is resulting in both flawed national policy and an unnecessarily extreme exposure to disasters at local and community level. While both these examples are also found in non-island environments, the nature of island environments and culture make them greater barriers to effective adaptation.

The development of effective adaptive solutions on islands requires a good understanding of island environments and island cultures, much of which can be gleaned from studying the effects of past climate-forced societal changes on islands. The imperative of developing effective solutions is becoming daily greater as island communities throughout the world continue to interact with their environments as they believe they always have.

## Planning for the Coast: Sea Level Rise and Preserving Land and Development: An Analysis of New South Wales Coastal Policy

T O'Donnell<sup>1</sup>

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In Australia, town planning decisions are primarily the responsibility of local Council. Coastally based local Councils are faced with overwhelming evidence that sea level rise requires changed planning and development strategies. This evidence, and the associated discourse, raises questions regarding the mitigation of risk and who is or should be responsible for the preservation of both development and land.

In New South Wales, sites such as Byron Bay/Ballina, Old Bar in Taree, the Central Coast/Hunter Valley regions and the Northern Beaches have all begun to experience dramatic changes to their coastline and other low lying lands. Such changes have led to the introduction of a number of planning policies aimed at reducing this risk and preparing coastal communities for climate change adaptation. Such policies have had varying successes; the juxtaposition of long standing and inherent private property rights with policies that seek to provide community as well as individual benefit, has and will continue to cause conflict. The economic and social cost of this conflict was detailed in late 2009, when a Commonwealth of Australia parliamentary enquiry on climate change released its state by state analysis of the climate change issues as they apply to coastal regions. It called for nationally consistent planning guidelines and benchmarks. Due to the impact of sea level rise increasing in the event of storm surges, tidal systems and the nature and type of localised environment, a black and white national approach to adaptation is fraught with difficulty. Such difficulties are exacerbated by the perceived urgency to minimise the economic and social risks many coastal Councils are currently facing. Further, the Federal, State and Local layers of Government in this area creates delay in any adaptation approaches due to the unwillingness of any of the stakeholders to accept legal liability.

My research will detail and review these New South Wales local and state based policies. It focuses on sea level rise adaptation measures utilised in three case studies, arising in Byron Bay/Ballina, Taree, and Lake Macquarie respectively. Amongst other things, these occurrences offer insights into societal impacts when the preservation of land, and the developments thereon, become threatened. In some instances, legal proceedings have been undertaken by private land owners against their local Council in the Land and Environment Court of New South Wales, with varying results. The question of who bears responsibility for any adaptation measures, and the associated costs, development approvals, public land use, and future liability, is a vexed and ongoing debate. These issues illustrate the risks associated with sea level rise, as well as offer insights into mitigation and adaptation strategies.

Finally, these risks will be considered in the context of potential social outcomes. For example, how can urban growth be managed when an overwhelming majority of the population reside, work or otherwise enjoy the public spaces near the coastline and the threat of sea level rise looms?

## Effects of Changing Climate and Sea Ice Extent on Dynamics of Russian Arctic Coasts

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About a half of the Russian Arctic coasts is formed by ice-rich permafrost deposits. The mean annual coastal retreat rate can reach up to 1-5 m per year. In general, the exact processes which affect thermal-erosion coasts and the intensity of these processes are determined by a combination of and interaction between thermal and wave-energy factors.

The thermal influence shows itself as energy transmission to the coast, which is composed of frozen sediments, via radiative and sensible heat fluxes from air and water. Correspondingly, higher air and water temperatures together with longer ice-free period and longer period with positive air temperature, affect the stability of frozen coasts.

The wave-energy factor acts via the direct mechanical impact of sea waves on the shore. In arctic seas the wind-induced waves are predominate. The effectiveness of this factor is determined by storm-driven sea surge intensity as well as by the length of the stormiest period. Conversely, surge intensity substantially depends on the fetch, which is intrinsically linked to sea-ice extent.

The evolution of Arctic coasts over the coming decades will be governed by changes in the natural environment caused by the effects of climate warming. Rising temperatures are altering the arctic coastline by reducing sea ice and permafrost thawing, and larger changes are projected to occur as this trend continues. This is an important topic to pursue given the direct impacts to human communities and infrastructure already being felt along Arctic coasts.

The minimal area of sea ice extent in the northern hemisphere during the last 30 years changed from 6 to 3.5 millions square kilometers. In September, 2007, the area of sea ice achieved its historical minimum for the period of satellite observation (since 1978). Less extensive sea ice creates more open water, allowing stronger wave generation by winds, thus increasing wave-induced erosion along arctic shores. Therefore, the acceleration of erosion and thermo-abrasion of the coast can be caused by both increase of the air and water temperature and possible increasing of wind-wave activity.

For the key sites of Russian Arctic where the stationary observations for coastal dynamics are carried out we have



made the calculations of year to year variations of wave energy during the last 30 years. Based on a hindcast analysis it was revealed that warming events didn't always lead to the increase of wave energy or acceleration of coastal erosion. For example, in the Arctic regions we have studied in half of the cases warm periods were characterized on one side by reduce of ice cover and growth of open water area, on the other side – by sudden decreasing of wind-wave activity. As a result no acceleration in coastal retreat was observed. Furthermore, in West sector of Russian Arctic the wave fetch was limited by the presence of islands, and in the East one – by wave acceleration limit.

Thus, the prevailing at the moment scenarios of catastrophic acceleration of coastal erosion in Arctic are, in our opinion, strongly exaggerated.

## Optimal phenological development for spring wheat across Victoria under present and possible future climates

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The expected response of spring wheat to possible future climates in Australia range from positive (0 to +30%) to negative (-40 to 0%). Some studies have reported an expectation of little change in grain yield. Reasons for such diverse conclusions are varied but include spatial variance in soil types, agronomy and the climate itself. Of these, climate is probably the largest factor affecting the yield expectation in any locality in Australia. Two undisputed climatic factors that will have large effects on crop production are the rising global temperatures and atmospheric CO<sub>2</sub> concentrations. The extent to which these are moderated by rainfall in non-irrigated production systems is another source of uncertainty with greater response to elevated CO<sub>2</sub> under dry conditions reported in some locations, but not all. Under the present climate, the adaptation strategy of Australian crop scientists is to design crops that can be sown early enough to produce a large enough biomass by the time of flowering. Their aim is to set sufficiently large number of grains outside the period where winter and spring frosts destroy those grains. The problem, however, is not to delay flowering that the grain cannot fill before inevitable terminal drought. The aim is to maximise grain yield whilst minimising environmental stress to crops.

Under future climates how might our present wheat cultivars need to be altered to maximise grain yield? It appears that the present genetic variability is sufficient to cope with the climatic changes represented by the IPCC A1Fi scenario to about 2050. The most critical climatic factor is the increasing temperatures. Whilst mean temperature under A1Fi appears manageable, fluctuations above the normal coping range for crops is expected to induce more frequent catastrophic crop failures. Crops are most sensitive to high temperatures during pollen formation and fertilisation this occurring between September and October in Victoria. Currently, no contemporary crop models simulate the effect that increasing temperature has on the biophysical processes during grain set, due largely to the poor knowledge. Whilst our simulations do not explicitly account for such failures they should be considered the best case scenario rather than the worst case despite the simulated declining yields beyond 2050 for much of Victoria. We expect that if mean temperatures rise by about 3 degrees in western Victoria by 2100 as estimated by CSIRO's latest modelling (CSIRO Mark 3.5), then crop failures would be more the norm and there would be limited capacity for our wheat genetic resources to prevent such failure. In this context of a moderate temperature rise of about 2 degrees, we expect that wheat crop phenological development can be re-engineered to maximise grain yield under future climate scenarios across Victoria.

## Institutional Factors in Climate Change Adaptation: The Example of Flood Risk Management in Cape Town's Informal Settlements, South Africa

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In the policy debate on climate change there has been a growing need to address vulnerabilities to climate change through adaptation efforts, complementing mitigation efforts aimed at reducing the rate and magnitude of climate change. At present, this development has taken place largely in parallel to the increasing shift from disaster management to disaster risk management. Disasters are associated with extreme events. Climate change directly interacts with the exposure to climatic extremes. The challenge in the context of adaptation is to move from the understanding that climate change is occurring to concrete measures that reduce existing vulnerabilities of human and natural systems. Climate change is already aggravating urban flooding. When floods occur, residents of marginalised areas have only a limited set of options. This paper derives from an ongoing study funded by Global Change Systems for Analysis, Research and Training (START) under the African Climate Change Fellowship Programme (ACCFP) on climate change implications for flood risk management in the informal settlements of Cape Town, South Africa. The Cape Flats is an extensive wetland and home to unique strandveld vegetation that has come under extreme urbanisation pressure. In 1950 the area was practically uninhabited, but it's now heavily populated mostly by the large number of people living in the informal settlements. Many of Cape Town's informal settlements are particularly vulnerable, being on the Cape Flats, where a high water table and inadequate infrastructure render them vulnerable to flooding. Reducing the vulnerability of people to floods and enhancing their adaptive capacity to deal with floods are crucial governance issues. The study explores the challenging problem of how to effectively shape human institutional responses to the risk of natural disasters with a special focus on floods in Cape Town. The social risk management (SRM) and asset-based approaches provide a conceptual framework for understanding the sequential

links between risks; human exposure and sensitivity; the impacts of risky events; and risk management (or adaptation) strategies. The study relied heavily on the use of primary and secondary data. While primary data came mainly from the result of interviews with key informants at the community level, focus group discussions as well as visual observations were used to determine the physical vulnerability of the selected communities. Preliminary findings reveal that flood risk management plans are primarily focused on relocating the residents and restricting migration into these dangerous areas. The city's flood risk management plan thus addresses four broad domains to address a range of issues inhibiting faster progress, among which are ineffective communication between various stakeholders, the inadequacy of City resources, the absence of community involvement in the City's flood risk management scheme, and the nonexistence of a method to prioritise the areas most devastated by flooding. Given the present and predicted future vulnerability of Cape Town to climate change, it is anticipated that a case study like this will learn from best practices in good flood risk governance strategies for and by local communities and collaborations to enhance human security in the areas affected by floods.

## **Weather patterns and Lobar pneumonia occurrence in two eco-climatic zones in Nigeria**

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This study examined the temporal pattern of lobar pneumonia disease, and the influence of specific weather parameters on their morbidity in Rain-forest (Ile-Ife) and Guinea savanna (Ilorin) locations. Meteorological data including rainfall, maximum and minimum temperature, relative humidity and wind speed from 1992 to 2002 were collected from the Nigeria Meteorological Agency, Lagos. In addition, information on respiratory disease from 1992 to 2002 was extracted from the diagnostic card of patients at selected hospitals in Ile-Ife and Ilorin. These two categories of data were analyzed using descriptive and inferential statistics such as t-test, trend analysis, correlation and regression. Out of 372 and 627 cases of lobar pneumonia reported in Ile-Ife and Ilorin, highest occurrence of lobar pneumonia occurred in ages less than twenty years while patients aged 80 years and above accounted for 1.08% and 2.71% at Ile-Ife and Ilorin respectively. There is a significant ( $p$ Early Wet>Late Dry>Early Dry and at Ilorin: Late Dry>Early Dry>Late Wet>Early Wet. Both the annual trend and monthly pattern of lobar pneumonia at Ile-Ife and Ilorin vary significantly ( $p < 0.01$ ) within the study period. High occurrence of lobar pneumonia is associated with temperature between 30.0oC and 35.0oC in the months of January to March at Ile-Ife and 30.0oC to 32.0oC in the months of January to April at Ilorin. High occurrence of lobar pneumonia is associated with low relative humidity (67.0 to 77.0%) and wind speed between 3.0ms<sup>-1</sup> and 4.0ms<sup>-1</sup> in the months of January to March at Ile-Ife. Further analysis showed that temperature accounted for 43.8% of lobar pneumonia occurrence at Ilorin. Similarly, relative humidity in combination with wind speed, explained 82.1% of lobar pneumonia at Ile-Ife. The study recommends that continuous monitoring of weather parameters should be incorporated into environmental management system.

## **New York City's unwitting climate change adaptive technology**

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**Background:** Over the last three hundred years, known storm surges from hurricanes have caused infrastructure damage and casualties in not only low lying areas of New York City, but also higher elevated areas such as Canal Street (1821) and Central Park, Upper Manhattan and the Bronx (1938). But over the last one hundred years, City officials like Robert Moses unknowingly improved an adaptive technology against sea level rise and storm surge. It is well established that wave energy is easily dissipated by a beach's natural defense mechanisms and that beaches can play a major role in countering storm surge. Through public works projects, beaches were confiscated, built and improved along 17.96 miles of New York City's coast to give costal recreation access to all of the population. And although the City of New York through its Parks and Recreation Department only manages 14 miles of beaches of the New York City 578 mile coast, these beaches are strategically located along known hurricane corridors.

**Problem:** Climate change could create significant hazard for the New York City population and infrastructure. Mean annual temperatures are projected by global climate models to increase by 1.5° to 3°F by the 2020s and 3° to 5°F by the 2050s. Mean annual precipitation is projected by global climate models to increase by 0 to 5% by the 2020s and 0 to 10% by the 2050s. Mean sea level rise is projected by global climate models to increase by 2 to 5 inches by the 2020s and 7 to 12 inches by the 2050s. This does not suggest inundation on its own, but this data does not include historical ice-rate melts which suggest much higher figures under the "rapid ice-melt" approach. The combination of sea level rise and ocean surge due to increases in hurricanes and nor-easters subject a large portion of New York City infrastructure to flooding. From the above, the New York City Panel on Climate Change suggests that sea level rise-related impacts on New York City's critical infrastructure may include inundation of low-lying areas and wetlands.

**Methods:** By setting the model-based range of values for New York City and the surrounding region set by the New York City Panel on Climate Change, this research looked at what impact New York City's current beaches have in mitigating future storm surge and the inundation of City infrastructure. Data developed by the US Army Corps of Engineers was placed over climate change forecast to derive predictive analysis. Environmental economics was used to measure the cost benefit ratio of further beach investment under New York City Panel on Climate Change accepted range of values. The research also included interviews with New York City Officials in the Mayor's Office of Long-Term Planning and Sustainability and the Department of Parks and Recreation, and scientists at the US Army Corps of Engineers.

**Implications:** The research suggests that further nourishment of New York City beaches and the creation of more New York City

beaches offer the City of New York an efficient and cost effective mechanism to adapt to climate change with anticipated sea level rise and storm surge. The implications of this research extend beyond New York City. New York City is a combination of Islands and a small portion of the mainland New York. But the insured value of its infrastructure and massive population make it a focus of climate change. Because there are significant resources examining both climate changes implications on New York City infrastructure and climate adaptation through beach nourishment, the coupling of this research offers deliverables for other communities.

## Summary of a presentation of the work of HOPE in the area of community education on adaptation/mitigation to anthropogenic climate change

F Ondrus<sup>1</sup>

<sup>1</sup>Householders' Options to Protect the Environment (HOPE), QLD Australia

Introduction to the environmental and sustainability education work of HOPE, a small, under-funded, but effective community capacity building NGO - set in the context of its Darling Downs regional and Australian national constituency.

A SWOT framework consideration of the real world issues that drive and constrain HOPE's work in regard to community education and capacity building around climate change adaptation and mitigation in the Darling Downs /S.E. Regional Queensland context. And incorporating HOPE's direct organisational experience relating to some core themes of this Conference strand namely: how effective communication of information for adaptation can be provided to the right people, at the right time, in the most effective way – and how can fragmentation of the knowledge base be reduced through effective use of information to inform adaptation responses.

Telling the story of HOPE's work in 2010 to establish two projects that go to the heart of some of the communication and information themes relevant to this Conference strand. Firstly, the attempt to finance and produce a DVD video project entitled: "Right in my Backyard: local visions for climate change adaptation in the Darling Downs region." A project that would contribute to a public environmental education process that encourages the local community to engage, pro-actively, with the ecological and economic implications of an anticipated low-carbon future. Secondly, and in recognition of the mid-point of the UN Decade of Education for Sustainability 2005 – 2014, an application for Churchill Fellowship or other funding in 2010 to assist with a planned, international, fact-finding tour aimed to provide a fresh and contemporary understanding of 'what works best' in educating communities to effect environmentally positive behaviour change. And particularly in the area of responses to human induced climate change.

In summary, we believe that Conference would be interested in hearing such a story. And of the work that goes on in an organisation that perhaps typifies the NGO sector of civil society as it struggles with limited resources to bring about much needed community behavioural adaptation in response to anthropogenic climate change. In that regard, we certainly have direct experience of the "Examination of barriers and challenges for the communication of information for adaptation" as phrased in another Conference theme.

In conclusion we represent one of the key sectors that will be charged with the task of educating and building community capacity in response to climate change and yet much of our work goes unrecognised at the level of official policy making and strategy planning. We believe a presentation based around the points above could stimulate a stimulating and productive debate at Conference and we hope that our Climate Change Educator may be offered a further subsidy to attend Conference as a result.

## Defining and assessing maladaptation

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The concept of maladaptation is frequently used in diverse ways, but remains ill-defined. This presentation defines maladaptation as action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, and/or increases the vulnerability of other systems, sectors or social groups. Five types of maladaptation are identified, namely actions that, relative to alternatives: increase emissions of greenhouse gases, disproportionately burden the most vulnerable, have high opportunity costs, reduce incentives to adapt, and set paths that limit the choices available to future generations.

The five types of maladaptation identified can be used as criteria for evaluating decisions about adaptation. Each implies a question and a line of investigation that decision makers could ask and seek answers to before committing resources to adaptation decisions. In 2007, the Victorian State Premier announced plans for two large infrastructural schemes in response to water stress in Melbourne: the Wonthaggi desalination plant, and the Sugarloaf Pipeline Project. The above criteria were used to evaluate this decision, and the projects were found to exhibit all five types of maladaptation. These projects might have been avoided were the five criteria for identifying maladaptations applied.

## Exploring the distributional effects of adding carbon charges to the New Zealand household energy sector

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The introduction of carbon charges to the New Zealand energy sector has the potential to create inequalities. Most households in New Zealand use electricity as the main source of household energy. The New Zealand electricity market already contributes to inequalities, with low income households paying more as a percentage of income for electricity services, while using less electricity than their higher income counterparts. If the introduction of carbon charges to the electricity market is not considered carefully low-income households may be further marginalised, while the carbon costs of high-income high-emitting households are

cross-subsidised. As well as charging for carbon associated with electricity services, gas and other household energy services will contribute to energy hardship in some households, so carbon charges across all household energy services must be considered.

We explore different ways that charges can be applied, and the outcomes of using these different charging methods. We examine the implications of a flat tax, per unit charge, or progressive pricing on household energy purchases, grouped by income decile. Using data from the Household Economic Survey, routinely undertaken by Statistics New Zealand, we have applied carbon charges to household energy purchased across income deciles, under three different pricing scenarios to investigate the distributional effects of carbon charges.

We have identified vulnerable household types, under the three policy scenarios. Under any scenario it is important to be able to identify households, which would be left with significant deficits caused by the introduction of carbon charges and who are least likely to be able to pay for them. These households will be most vulnerable to the effects of extreme weather events such as heat waves or severe storms which may require increased use of household energy to maintain healthy and comfortable temperatures. Identification of vulnerable households can enable targeted policies to increase the resilience of these households in a carbon constrained economy.

## Food Security and Climate Change Adaptation in Africa

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Agriculture is the human enterprise that is most vulnerable to Climate Change, while African farmers are more vulnerable to it; this is because of the continent's heavy reliance on rain-feed agriculture, widespread of poverty and low levels of technical development. This also limit their climate change adaptation capability particularly in relation to food security.

Food Security will emerge as a core development concern in Africa as extreme Climate events will affect all four dimensions of food security: food production, food availability, food accessibility, food utilization and food systems stability which will bring uncertainty and volatility to food prices among others with disproportionate effect on the rural farming families of which majority are women and small scale farmers.

In Africa, Climate Change is likely to drive majority of the population into destitution as assets are lost and resources' are diverted to deal with emergencies, instead of being used for physical, social and economic infrastructure development. Frequency and intensity of extreme events (heat, waves, droughts and floods) are likely to increase, leading to reduced yield levels and disruptions in food production and distribution channels. Furthermore, temperature rise and changes in timing magnitude, and distribution of precipitation are likely to increase moisture and heat stress on crops and livestock which will make agricultural practices unpredictable.

There are considerable evidences that Climate Change is already affecting Africa's people and its environment creating strong negative impact, some areas are becoming too hot for certain crops or animals; it rain little or too mush to allow farming; the breakout of climate sensitive diseases, such as Rift Valley fever affect livestock production, drier areas to get even drier, producing food using irrigation may not be possible, as there will be no water. At the other extreme, flooding (rise in sea levels) could destroy the infrastructure used to store or transport food from production areas to markets, also raining season and time are now becoming very erratic. All these are serious indications which may serve as a disincentives for farmers who could produce more food, potentially contributing to even lower food production and threat to food security in which there will be reduction and loss of income (poverty), loss of crops and livestock's, high prices of food and other commodities which may lead to civil strife in Africa, there may be intensification of migration out of Agriculture, increased morbidity and mortality of human and livestock, loss of biodiversity, decline in the rate of economic growth (also increase of import), loss of traditional export markets, increased regional trade in agriculture commodities and reduced international trade on Agriculture or related products.

To achieve food security in Africa a holistic Climate Change adaptation strategy could be adopted.

- Promotion of conservation farming;
- Introduction of agro-pastoralism;
- Use of short season varieties and early maturing crops and livestock's;
- Promotion of drought resistant or tolerant crops and livestock's;
- Diversification and promotion of traditional crops and other indigenous crops;
- Promotion of multiple cropping;
- Promotion of community seed banks to enhance seed security and to maintain crop diversity;
- Introduction of Crop and livestock insurance to safeguard farmers' productive assets;
- Availability of both tangible and intangible credit facilities for farmers;
- Promoting irrigation and watershed management;
- Need for access to information (ICTs) on climate change and latest meteorological reports by farmers;
- Promotions of win- win trade policies;
- Promotion of regional drought early warning system;
- Harmonization of agriculture and natural resources policies;
- Conservation and Sustainable use of Biodiversity(protecting biodiversity);
- Encouragement and acceptance of Bio-carbon Market.

Major investments are needed to ensure that vulnerable farmers in Africa have the tools to build their resilience, adapt and contribute to food security, there should be new public investment in agriculture with emphases on agro-ecological approaches, it is also important to foster people – centered resilience in order to help vulnerable small scale farmers achieve food security. Finally, vulnerable farmers who are particularly women and small scale farmers should be treated as key partners in the struggle against climate change.

## **Modelling Scenarios of Future Adaptation using an Agent Based Simulation Framework**

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Future climate change will result in a range of increased risks, characterised by both complexity and high levels of uncertainty. Those with responsibility for planning and policy will need improved levels of information (and more importantly ‘usable knowledge’) to help strengthen community and organisational resilience, and better inform planning and response strategies. Promoting more effective adaptation (and importantly avoiding mal-adaptation) will require new learning processes which enable decision-makers to explore alternative responses, with opportunities for iterative reflection as new information becomes available.

This paper reports on an innovative way to support this agenda using agent based simulation. We describe how our approach to simulations of future scenarios, can improve understanding of climate-related risks, inform the development and implementation of more effective adaptive strategies, and be contributed to and used by a broad range of stakeholders. Agent based simulation is an analytical approach which is gaining in popularity internationally as a powerful tool for decision-makers and policy analysts to better understand complex interactions between different aspects of a given situation. It is especially useful for exploring complex scenarios, where standard mathematical approaches are not possible, and is perhaps the only experimental means for exploring complex social systems. Agent based simulation can thus play an important role in the exploration of adaptation strategies which – undoubtedly – must include consideration of human behaviour. The technique aims to capture the macro-level phenomena which emerges from the complex interactions of autonomous, decision-making entities at the micro-level, both with each other and their environment. By exploring social and institutional contexts (including the practices and behaviour of different actors, and important chains of influence between them) it is then possible to explore, through alternative simulated situations, how influential variables interact to result in different decision-making processes and outcomes. A range of future climate and non-climate scenarios can be considered.

The traditional approach to agent based simulation is to capture the entire scenario in a single model. The consequence is that the model itself quickly becomes nontransparent, and the process becomes too complex to capture all relevant aspects. To address this, drawing on the expertise of a multi-disciplinary research team, we are developing an interactive platform for integrating multiple, smaller agent-based modules into a single simulation. This will allow complex simulations to be built up incrementally by adding together independent modules created by members of a large distributed community, interested in the application area. Each module (a simulation in itself) will capture a different aspect of the environment, and could potentially be created independently by people with expertise relating only to that aspect. This distributed approach to agent based modelling and simulation is novel, and addresses the need for large, complex simulations which need to be transparent and reusable.

Ultimately, the vision for this ‘learning’ platform is that it will facilitate the iterative development of an open source, shared, resource where modules can be contributed by a variety of groups, building up an extendible framework or ‘family’ of resources which can be used to establish a range of complex simulations for exploration of a variety of climate change scenarios. The modelling and exploration of different scenarios will help identify the most effective strategies to ensure that individuals, governments and the private sector (acting at different spatial scales) are better prepared for a changing climate. Furthermore, the research program is intentionally designed to be ‘solutions oriented’, with close engagement with different stakeholder communities intended to promote ‘co-generation of knowledge’, as well as stimulating a process of mutual learning between scientists, policy-makers and wider stakeholder communities, leading to the enhancement of community and organisational resilience.

## **Formulating a Implementable Climate Change Adaptation Policy for Sri Lanka**

**C Panditharatne<sup>1</sup>**

<sup>1</sup>Griffith University, Australia

This paper addresses the main issues to be considered in formulating a climate change adaptation policy for developing countries in the South Asian region, with special emphasis on Sri Lanka. It outlines the links between enhancing adaptive capacity through achieving sustainability. The paper illustrates the importance of the social capital in formulating and implementing an adaptation policy, as well in taking a multi-faceted approach in this regard. The role to be played by national, regional and international communities in implementing an adaptation policy that would not lead to maladaptation is analysed.

Sri Lanka is situated in the South Asian Region, and countries in the region are severely threatened by climate change impacts (IPCC, 2007). With globalization and open economy, countries in the region need cohesion to withstand impacts of climate change, while they compete and coexist. As such, regional policies focusing on building long-term national adaptive capacities within the region are needed. Most countries in the region are dependent on activities that use ecosystem services; such as agriculture, herding and fishing for livelihood.

Small-scale farming is one of the predominant livelihoods, mostly dependent on rain fed agriculture and irrigation schemes. A number of irrigation schemes implemented in early 1960s in Sri Lanka are drying up and facing threats of desertification. The livelihoods of farmers in these schemes are no longer certain of their livelihoods, since changes in the monsoonal rain patterns are becoming more and more pronounced. The on-going land degradation including deforestation, soil erosion, landslides and desertification are already affecting large parts of countries. Already migration is taking place into urban areas in search of more stable livelihoods, thereby increasing the burden of these already hampered areas.

As such, in developing countries like Sri Lanka, adaptation to climate change mainly involves poverty eradication through sustainable development, and Sri Lanka needs an adaptation policy that will enable sustainability transition. Transition to sustainability could not be done through a top-down approach. The research attempts to formulate a framework climate change adaptation policy for Sri Lanka. Having a stand-alone adaptation policy for climate change will not suffice for Sri Lanka. Since environmental issues are cross cutting and since all economic sectors are to be strongly affected by climate change, sectoral policies and strategies need to be integrated. It is necessary to consider multi-stakeholder partnerships for formulation and implementation of integrated solutions, in order to prevent some communities from becoming more vulnerable.

It is necessary to determine how to integrate different vulnerable sectors through a multi-faceted, multi-level adaptation policy. Since adaptation is not a novel practice, it is assumed that the social capital traditionally has vast amounts of knowledge and skills, and it is an urgent necessity that these be harnessed effectively. Therefore, the research will attempt to determine the role that an enhanced social capital could play in improving the adaptive capacity of Sri Lanka. It is also necessary to investigate appropriateness of existing institutional mechanisms in enhancing and supporting the social capital.

A subsidiary objective of the research, which is extremely important in implementing the climate change adaptation policy of Sri Lanka is evaluating role played by the United Nations Framework Convention on Climate Change (UNFCCC, Germany). An important article with regard to adaptation in the Convention is Article 4.8, which states that “parties shall give full consideration to actions necessary under the Convention...to meet the specific needs and concerns of developing country parties arising from the adverse effects of climate change.” As such, it is clear that UNFCCC is intended to play a major role in the field of Adaptation. However, as at present, countries like Sri Lanka views its role in catalysing adaptation as marginal. Therefore, it is necessary to determine how UNFCCC could play a better role in implementing national and regional policies in the South Asian region.

## A framework for assessing and monitoring vulnerability and adaptive capacity

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Given the time-critical nature of the implementation of climate adaptation, the risk of maladaptation, and the limited resources available to undertaken response strategies, it is imperative that the most effective and appropriate tools and approaches are used to assess and monitor vulnerability and the capacity to adapt. A review of literature shows that a variety of approaches are currently used to assess vulnerability at a range of scales and in response to uniquely differing complements of drivers. It is therefore difficult to comparatively assess the efficacy of each approach and subsequently produce guidelines to aid the selection of assessment theories and tools that will deliver practical on-going adaptation.

In one commonly used conceptualization, impact is seen as a function of exposure (E) and sensitivity (S), with vulnerability (V) being a product of both potential impact and adaptive capacity (AC). This is captured by the simple equation  $V = (E \cdot S) - AC$ . Applying such a linear conceptualization to the quantification of vulnerability poses many challenges, not least of which is the choice of indicators used to capture and reflect adaptive capacity. More specifically, the question remains as to how well indicators selected in assessments actually reflect capacity to adapt to a range of drivers, including climate change. This is particularly important when considering how individual indicators contribute to (a) the perceived vulnerability status of a livelihood, community or nation, and (b) effective change. The answer to these questions will of course have implications for developing targeted policy response strategies aimed at reducing vulnerability.

Innovative methods need to be developed to identify indicators and effective ways of monitoring dynamic trends in adaptive capacity that result from activities such as substitution between capital assets and the development of emergent properties. One such approach includes working with local stakeholders to monitor the number of people sustained by farming activities in rural communities following a perturbation such as a natural disaster, economic recession or loss of labour through sickness, or following the implementation of an adaptation technology. This has the potential to elucidate ‘smart’ indicators that capture changes in adaptive capacity over time and avoid expending limited resources on extensive data collection.

There is also a need to evaluate the confidence that can be attributed to each of the indicators used in vulnerability assessment tools. This can be done by independently obtaining quantitative measures of each indicator and monitoring them over time in response to (a) the implementation of capacity building interventions, and (b) climate and non-climate related perturbations. Whilst the evaluation and collection of independent data sources can be scheduled relative to the implementation of capacity building technologies or other relevant capacity building interventions, a more opportunist response will be required for obtaining data following climate and non-climate related perturbations. Embedding the evaluation of adaptive capacity indicators within disaster risk management procedures and networks offers a potentially effective vehicle for data collection.

The above approach to monitoring adaptive capacity is embedded within a broader vulnerability and adaptation framework proposed in this study. This framework sets out to firstly identify the problem and issues associated with climate change, as a means to informing the selection of appropriate vulnerability and adaptation assessment tools. Similar to the vulnerability conceptual framework  $V = (E \times S) - AC$  mentioned above, we suggest the selection of tools to estimate the effect of exposure and sensitivity to climate change, as well as adaptive capacity. For example, mechanistic, biophysical models have been demonstrated to aptly quantify the sum of E and S to climate change in agricultural systems. As mentioned above, whilst tools for measuring AC have been promoted in the literature, none to date have provided an independent evaluation of the indicators being used to confer AC, and hence confidence in their use. We therefore seek to validate our proposed framework using case studies from the Indonesian islands of Lombok and Sumbawa, and a vulnerability and adaptation assessment undertaken for Pacific Island Countries, including East Timor and Papua New Guinea.

## Empowering communities to adapt fire management practices locally in a changing change

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It is now generally accepted that the world is undergoing a significant change in climate. By 2020 in south-east Australia, days of high or extreme fire danger are forecast to increase by 5 to 25 per cent if the effects of climate change are low, and by 15 to 65 per cent if they are high.

Warmer temperatures, hotter over all seasons and an increase in high fire danger days are projected to lead to a greater incident in the frequency and intensity of bushfires. The impact of this, on biodiversity conservation as well as the lifestyles and land uses we value, will be significant. In fact, for some parts of south-east Australia, climate associated changes in fire regimes may be one of the most significant drivers for ecosystem change.

Despite this reality, few resources have been invested in sustainable fire management policies and programs, and even less in engaging with landholders and land managers to help them adapt to changed fire regimes. The need for strategic, proactive and holistic approaches to fire management has never been so imperative.

The Hotspots Fire Project (Hotspots) is a community based training program which aims to address exactly this. Based on best available science and operational knowledge Hotspots has developed a training program which provides landholders and land managers with the skills and knowledge needed to actively and collectively participate in fire management for the protection of biodiversity conservation whilst preparing for the protection of life and property.

Through an integrated series of activities tailored to the needs of targeted communities, Hotspots gains community engagement and delivers a consensus building management approach among key stakeholders from all sectors (both public and private). The pragmatic approach to map-based planning and implementation used by Hotspots allows individual landholders and managers to develop management goals for biodiversity conservation, cultural values, rural production and risk management and importantly, to bring these together across their landscapes under changing local conditions.

Hotspots' partnership approach, with its nine agency and non Government partners, has overcome management challenges by bridging the gap between managing fire sustainably for Natural Resource Management and Emergency Management. The project has been in operation in NSW for over five years and has generated a remarkable amount of interest in the areas where it has worked.

This presentation looks to showcase that a locally adaptive, hands-on and community based shared approach is essential for meeting the challenges of sustainable fire management under a changing climate. This talk will outline why Governments must seek, invest in and adopt appropriate fire management policies and programs at a local, state and national level. The Hotspots approach and training package provides a working example of how sustainable fire management can enhance resilience, both of for human communities and ecosystems - hence making a valuable contribution to the adaptive process needed to manage fire within a changing climate.

## A modelling framework to project future pathogenic disease scenarios in wheat cropping systems under climate change.

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Relationships between a crop, pathogenic disease and a pest that vectors the pathogen can be complex. Rising atmospheric CO<sub>2</sub> and temperature may influence plant viruses through effects on hosts and disease vectors, both at the individual and the population scale. For example, nutrient balances within the plant are likely to be altered due to changes in photosynthesis or secondary metabolism. Insect vectors may increase their number of generations or number of flights with warmer temperatures. At the population scale, plant and/or insect species ranges may shift. Such changes may be influenced by other factors, such as adaptation to new environmental conditions. It is therefore highly likely that projected climatic changes will alter the dynamics of such crop-vector-disease systems, presenting us with new biosecurity challenges from existing pests.

Cereal Yellow Dwarf Virus (CYDV) is a widespread pest of wheat crops that is vectored by an aphid, *Rhopalosiphum padi*. *Rhopalosiphum Padi* is the most abundant species of aphid in Australia and the most important vector of CYDV: direct damage

by aphids in Australia is of less concern than their importance as disease vectors. CYDV is a highly significant disease of cereals in Australia with impacts on cereal yields, particularly in areas where the aphid can find refuge during the hot summer. A spatially-explicit process-based model is being developed using DYMEX to simulate the population dynamics of the aphid in several agricultural landscapes of Australia. This model responds to the influence of the environment, including weather, on: (1) the habitat of the species (incorporating a wheat growth model); (2) the species' population dynamics and phenology and (3) the dispersal of the aphid with subsequent CYDV disease spread. This tri-trophic model will enable us to project the outcomes of various future climate scenarios for the wheat-aphid-disease system in these regions.

The modelling benefits from knowledge gained at the free air CO<sub>2</sub> enrichment facility [The Australian Grains (AG) FACE] established in 2007 at Horsham, Victoria. This experiment has generated data on the response of wheat crops to elevated CO<sub>2</sub> under a range of temperature and water conditions. Additionally, the epidemiology of CYDV and physiology of its main vector, *Rhopalosiphum padi*, was also investigated in an associated set of experiments. The heuristic understanding gained from this modelling will inform adaptation options aimed at making robust future-oriented biosecurity decisions. We present the model development to date.

## Climate change impacts and adaptation strategies for the mixed crop-livestock farming systems of Tasmania

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As climate change is a reality for Australian farming systems, it is necessary to provide adaptation strategies and risk management options for farmers, at paddock and whole farm scales. The objective of this research project is to increase knowledge and awareness among farmers about the implications of climate change on broad-acre cropping in Tasmania, and to generate potential management strategies. A participatory research approach is being used to inform model development for crops (APSIM), pastures (SGS and GrassGro), and whole farms (AusFarm) for five contrasting crop-livestock agricultural areas across Tasmania; Deloraine, Cressy, Tunbridge, Bothwell, and the Coal River Valley. Paddock scale simulations of crop and pasture production for 2050 and 2085 were developed and are presented in this poster. Future climate data sets were used from two sources; downscaled GCM models from the Climate Futures Tasmania project; and, scaled historical data from the Queensland Climate Change Centre of Excellence (QCCCE). Future analyses will be at the whole farm level, including economic analyses of potential management changes.

## Climate Change Adaptation & Mitigation in Agricultural Societies – A case study in Bundala village, Hambantota, Sri Lanka

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Sri Lanka has experienced a number of tragic disasters including Tsunami, Floods, Landslides, Cyclones, Droughts, Wind storms and Coastal erosion in recent years and regarded as a multi hazard country. Bundala village is situated 300 km away from Colombo towards Southern province belongs to the DL 5 Agro-ecological regions of Sri Lanka, indicating the rainfall scarcity of the area. Total annual dependable rainfall is as low as 650 mm. These low rainfalls and more severe seasonal droughts collectively cause more evaporative demand resulting high salt accumulation on land surface. The major constraint to agriculture in this region is the low effective rainfall for a greater part of the year. Minor irrigation schemes go dry during long dry period due to lack of management of the limited water resource available in the area. Villages can recall their memories of droughts for last 100 years. The drought hit in 1914 caused scarcity of food and water, problem of dust and spread of diseases. Two year drought prevailed in 1956 and 1957 affected about 250 families with shortage of food and water and diseases. An extent of 70 – 80 acres of paddy and about 100 acres of rain fed crops was entirely destroyed in the village by this drought. Another drought with somewhat similar consequences prevailed in 1965 – 1966. many could remember the recent droughts occurred in 2001, 2004 and 2007. A research study carried out using the participatory action research methodology to assess villager's adaptability and mitigation practices in the prevailing condition took place. It was found that 90% of the village population has adapted alternative agricultural practices as a measurement of adaptation. There are several mitigation initiatives they have taken as a community. This paper analyses the finding of the study and gives conclusion and recommendations for further research.

## Challenges and issues in managing water resources with global climatic changes – “How vulnerable Sri Lanka as a small island country in the Southern Hemisphere”

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Sri Lanka has a tropical climate because of its location between 6 and 10 degrees north of equator. The island is exposed to moisture-laden winds from the southwest and the north –east but despite this favorable position, Sri Lanka has extensive areas of water deficit. A greater part of the country at times experiences dry spells extending over several months. Sri Lanka suffers almost annually from droughts and floods. These and occasional cyclones and landslides are problems directly related to water resources. Surface water from the high watersheds is transported by 103 distinct natural river basins that cover 90%



of the island; the remaining 94 small coastal basins contribute only marginally to water resources. Over 60% of the water that is discharged to the sea comes from the wet zone and often leads to floods and water-logged lowlands. Development of river basins in the dry zone has considerably reduced dry zone run off. Sri Lanka is a country which has an average annual rainfall of more than 2000 mm. However the problem is the rainfall variability in Sri Lanka is second highest among Asia-pacific countries. The country is finding it increasingly difficult to supply water to the growing urban centers. Sri Lanka's biggest challenge is to make use of high seasonal rainfall which even in the dry zone stand at 1000 mm and its extensive resource of inland water bodies. This paper presents the nature and extent of Sri Lanka's water resources, their present conditions, use, trends and issues and what we have learned from global climate variability and changes as a small island country.

## **Design flood estimation under Climate Change: the need for Continuous Simulation**

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Continuous simulation for design flood estimation is increasingly becoming a viable alternative to traditional event based methods, especially in light of our changing climate. It is likely that methods such as those that rely on Intensity-Frequency-Duration curves will not be suitable under a changed climate, due to non stationarity and their implicit flaws that may become enhanced with time. For instance, there is evidence to indicate that regional changes to precipitation may involve increases in extreme precipitation intensity as well as an increase in the number of dry days (CSIRO, 2007). Under these scenarios, event based methods are likely to be biased because they fail to account for the lengthy dry spells which affect antecedent moisture and thus the magnitude of the flood. This paper aims to determine the importance of antecedent conditions in design flood estimation by making use of continuous simulation methods. The lumped conceptual rainfall runoff model, Australian Water Balance Model (AWBM) was used on 45 catchments in the Murray Darling Basin. Daily rainfall and potential evapotranspiration records were used to investigate the importance of antecedent conditions for these 45 catchments of varying size and storage capacities using a bootstrap-with-replacement methodology. It was found that for 76% of catchments, the 1 in 100 yr flood was underestimated by more than 10% when antecedent conditions were not properly accounted for. This indicates the need to more accurately consider initial catchment wetness, which can be accomplished through continuous simulation modelling.

## **Opportunities for an Ecosystem-based Disaster Risk Reduction Framework: Lessons from a Doubly Exposed Coastal Social-ecological System in Orissa, India**

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Coastal social-ecological ecosystems, one of the most productive life-supporting ecosystems are albeit vulnerable ecosystems to climate-induced transformations and changes. Such changes have severely impacted the ecosystem services which support and strengthen the livelihood security of many coast-dependent communities. The coastal state of Orissa in India has become the ground-zero for natural and climate induced disasters, very often described as the 'disaster capital of India.' The Orissa Super Cyclone of 1999 brought in unprecedented ecological and socio-economic transformations. Post Super Cyclone has witnessed a systematic increase in the intensity and frequency of low pressures in the Bay of Bengal and many transforming to cyclonic storms. Many of the coastal villages are gradually vanishing under the sea because of coastal erosion. Vulnerabilities of such communities-at-risk are further compounded by the inequalities and uncertainties associated with economic globalization.

Economic liberalization policies of the state have heralded in huge financial and technological investments, both public and private. The government of Orissa has signed around 14 Memorandum of Understandings (MoUs) for development of ports along the coast, one of them being promoted with the highest Foreign Direct Investment (FDI) in India. The combined impacts of such global environmental changes and economic globalization have created situations of 'double exposures' and thereby severely undermining the adaptive capacity of the coastal-communities at risk. With gradual erosion of their traditional rights over the coastal resources including the sea, many traditional coastal communities have started migrating to distances near by and far off.

Orissa's coastal ecosystem is also biologically diverse, the Bhitarkanika mangrove ecosystem being the second largest mangrove forest in South Asia next to the Sunderbans. Ecosystem services from mangrove ecosystems are many, from being effective against low-intensity tidal waves to supporting a rich nursery of fishes and prawns. By building on the institutional mechanisms of mangrove resources conservation and triangulating this with the of disaster risk management approaches, an ecosystem-based disaster risk reduction framework has been developed in three selected communities around the Bhitarkanika mangroves in Orissa. Effective, equitable and sustainable institutional mechanisms have been identified and developed which are community-based. Aspects of livelihood security have been addressed through the design and development of mangrove-based enterprises with women self-help groups (SHGs) and cooperatives. Through the development of mangrove nursery and plantation many community members have been able to secure an additional income for themselves. The mangrove belts developed around these villages are effective eco-shields against cyclonic storms and tidal waves. Subsequent growth of the mangroves will further ensure the provisioning of the ecosystem services in terms of increase in fish catch and more scopes for eco-tourism.

By highlighting the emerging scopes for the design, development and delivery of an integrated ecosystem-based disaster risk reduction framework, this paper discusses the opportunities of such an approach for climate change adaptation.

## Carbon Footprint and Sustainability Analysis of Water Infrastructure Using Sustainability Intelligence Portal

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Scarce energy resources and global climate change have increased focus on energy use and greenhouse gas (GHG) emissions from water infrastructure during planning, design, construction, and operations. Three processes within the project life of water infrastructure need to be considered and evaluated: chemical usage, transportation, and operation of water plant.

CH2M HILL has developed a web based Sustainability Intelligence Portal (SI Port) which includes modules to estimate GHG emissions from Scope 1, 2, and 3 from a water infrastructure using Intergovernmental Panel on Climate Change emission factors. SI-Port can be customised to use local emission factors. SI-Port allows users to run alternatives during planning, design, construction, and operations, to minimise carbon footprint, from materials, energy, chemical and travel.

Three scenarios are case studied using SI Port for a 40 MLD brackish groundwater membrane desalting plant. They included baseline scenario in which all emissions were fully counted, a 10 percent energy reduction scenario by the use of high efficiency motors and finally, the green concrete usage scenario.

Three alternatives show significant reductions in GHG emissions are possible. The 10 percent power reduction scenario resulted in GHG emissions being lowered by 643 tons of CO<sub>2</sub>e each year. Optimising power consumption is crucial for membrane facilities because of their significant power consumption. The green concrete scenario resulted in 62 tons of CO<sub>2</sub>e reduction of GHG emissions. This saving is not as significant as the energy reduction scenario due to the relatively small physical footprint and quantity of concrete. However, coupling activities along with other minimisation strategies discussed above could achieve reductions that are even more significant.

This paper will case study the use of SI Port and discuss benefits of using innovative tools like this for water infrastructure development and minimising energy and carbon footprints.

## Developing citizen science as a communication and research tool for monitoring ecological change in the marine environment

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Engaging the community in the collection and monitoring of science is generically known as “citizen science”. Citizen science not only provides a mechanism for obtaining observations at a scale that is normally not possible at a scientific researcher scale but, importantly, it provides an opportunity for “citizens” to improve their knowledge. The latter is enhanced when a citizen science program requires the “citizen” to engage with a media interface which also provides information and updates about the science. In Tasmania we developed a web-based on-line database and mapping facility (REDMAP – Range Extension Database and Mapping project) where members of the public submit data on catches/observations of key species that may be impacted by climate change. Since the launch of the website in December 2009 we have had an overwhelming response from the marine community including commercial and recreational fishers, divers and boaters. In addition to engaging the Tasmanian marine community, the site has received over 29,000 page downloads from 64 countries in the eight weeks since its launch. We have also received positive feedback from schools that are using the site as an educational resource. The success of REDMAP has resulted in proposals to extend the concept nationwide. We believe that REDMAP demonstrates the potential of citizen science programs to be powerful communication tools that engage and inform the community.

## Building the Climate Change Response Capability of Local Governments Units in the Philippines

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In the Philippines, local government units (LGUs) have a significant role in climate risk management (CRM). However, many LGUs and their constituents have limited understanding of the climate change phenomenon as well as limited capacity to undertake appropriate climate change adaptation measures. While the existing disaster risk management framework specifies the “Preparedness-Prevention-Mitigation” pattern, strategies have been mainly reactive and rarely guided by science-based vulnerability assessment and adaptation planning.

Thus, it is important to enhance the LGUs’ capacity and strengthen their alliance with scientists to harness science-based climate change planning and policymaking. This paper presents the results of a participatory action research geared towards this objective. With five municipalities in four provinces as study sites, the paper discusses the capacity building processes and the LGU-scientist interface towards the formulation of the climate change adaptation plan (CCAP).

A team of LGU planners and scientists was organized in each municipality and based on the capability assessment results in each site; awareness raising and capacity building activities were undertaken. The training included members of the civil society and local legislative councils whose commitment is critical to the CCAP implementation. Learning and alliance building

opportunities were maximized through participatory research, coaching and interactive discussion about climate change issues.

Capacity building activities covered data collection and interpretation, situational analysis and understanding the various elements of adaptation programs and policies. Hands-on training on vulnerability assessment and CCAP preparation made use of local data as well as information provided by the community residents. The SCU partners further validated results of consultations with government records and led the preparation of the vulnerability assessment report. Team workshops were conducted to prepare their respective CCAP. The LGU staff appreciated the training, thus facilitating the integration of the CCAP into the local development plan.

Research findings revealed that: 1) the actual adaptive capacity of the LGUs was much lower than their perceived level due to their limited understanding of preparedness and adaptation principles; 2) the communities noted increasing frequency of intense typhoon, flooding and dry spell; 3) coastal residents noticed sea level rise, saline water intrusion and ground subsidence; and 4) the climate events affected the agriculture and fishery sectors, salt-making industry, general public and LGUs themselves.

The CCAP also pointed out socioeconomic and institutional constraints to adaptive capacity enhancement. Recommendation to overcome these include: 1) strengthening public information and education campaigns on CRM; 2) formulating national policy requiring LGUs to conduct vulnerability assessment, establish a knowledge management system and community-based risk monitoring and early warning system; 3) organizing the community for collective action; 4) establishing linkages with the private sector and non-government organizations; 5) livelihood diversification and appropriate agricultural technology options; and 6) integrating climate risk management in local development programs.

The project created a platform for sharing experiences, lessons learned, and “best practices” thereby enhancing LGUs’ respective capacity to appropriately respond to climate change issues. Results of this project were communicated to various stakeholders through forums and scientific conferences and circulation of adaptation planning guide.

## **Adapting to change – exploring the response of the GBR coral reef fin fish fishery to a major environmental event**

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Climate change models predict there will be an increase in the proportion of intense (category 3 to 5) tropical cyclones in northern Australia. Intense cyclones can have significant impacts on coral reef structure, associated reef fish, and the fisheries they support. It will be vital to understand how fisheries react to intense cyclones to explore how fishers and fisheries may adapt to these events, ensuring the sustainability and resilience of tropical fisheries in the future.

Tropical Cyclone Hamish (Category 5) traversed the southern Great Barrier Reef (GBR) in early March 2009, in an area where 70% of the commercial Coral Reef Finfish Fishery catch was previously harvested. While this cyclone did not cross the coast (and was therefore not considered a ‘natural disaster’ in legislative terms), commercial fishers reported substantial impacts to both the coral reef structure and the catch of important coral reef species. Fishers’ reactions and concerns prompted a tactical collaborative research project to investigate the reaction of fish and fishers to the cyclone. This poster focuses on the fishers, exploring the adaptability and vulnerability of fishers and the industry to major environmental events like Cyclone Hamish, and fishers’ opinions regarding the linkage of such events with climate change.

Most fishers working in the area directly affected by the cyclone reported extensive damage to reef structure and reduced catch rates, particularly of the main target species, coral trout, which are sold almost exclusively on the high value live fish market. The most common adaptive measure was for fishers to move, fishing more northern waters, although this was limited by boat size, among other factors. This reaction in turn affected more northern fishers, concentrating effort in limited areas. Fisheries managers, in an attempt to help fishers adapt to reduced catches of coral trout, adapted restrictive filleting regulations theoretically allowing fishers to increase profits made on other species. While this was initially seen as a positive step, few fishers found it helpful given the lack of markets for the ‘new’ product. Fishers suggested numerous other options to assist with adaptation in the future. In particular, fishers would like to see a management framework in place to respond to extreme events as there is for farmers impacted by natural disasters.

Fishers tended to be wary and concerned by cyclones but tend to accepted them as a natural phenomenon. Interestingly, fishers did not relate Cyclone Hamish to climate change. Further, they did not believe climate change will affect the ability of the GBR to support sustainable fisheries.

This project provided a real-time example of how fishers and fisheries adapt to major environmental events, and options for managers and the industry to improve or assist with adaptation when such events occur in the future.

## **Climate Change Adaptation and Disaster Risks Reduction - A Continuum: Philippine Case**

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The Philippines is most vulnerable to natural disaster risks for three reasons: The first reason is best explained by the country’s location, which is within the “ring of fire” and along “typhoon highway”, and its archipelagic structure. Approximately 20 tropical cyclones enter the Philippines Area of Responsibility (PAR) annually

with about 9 making landfall. May to December is considered the tropical cyclone season and the peak tropical cyclone activity occurs from July to September with an average of 3 or more cyclones.

Hazards create hazards. Storm-surges, interactions with monsoons and land subsidence enhance the flood potentials in low-lying places, islands and deltas. Rainfall induces landslides and mudslides from lahar-laden volcano slopes.

The third factors are socio-economic in nature such as growing population, poverty and lack of access to basic social services, which aggravate the hazard impacts.

Policies and actions for appropriate solutions must benefit from scientific understanding of the underlying natural and socio-economic issues. For example, without reference to land subsidence, the flooding of Metro Manila will not be solved, as much as also addressing poverty and proliferation of informal settlements in high risks areas. The scenario is confounded with accelerated sea level rise due to global warming.

Over the past 36 years, it was noted that disasters in the Philippines cost an average of Php15 billion a year (WB-NDCC, 2004). Typhoons alone cost the country an average of 0.5% of the GDP. The commitment to respond to disasters through the calamity fund appropriations is overwhelmed by the cost of damage brought by natural hazards. These losses do not affect the national economic status alone but increase the vulnerabilities of the Filipinos dependent on affected livelihood sectors further decreasing their capacity to cope. There is also a lack of risk transfer mechanisms such as micro-insurance/finance.

The effects of the 2009 Pacific typhoon season in the Philippines were considered some of the worst in decades, culminating in September and October from Typhoons Ketsana and Parma. The two storms killed over 600 people and cost about \$300 million in damages. They also exhibited very unusual characteristics: TS Ketsana brought extremely heavy rains (six hours amounted to almost twice the September 30-year average rainfall) while STY Parma went in and out of the country's land mass and made landfall three times. With climate change, extreme events are projected to be more intense, increasing flood and drought risks and could divert development funds to relief and rehabilitation.

Success story: the case of Albay Province

Of the 20 occurrences of tropical cyclones per year in the Philippines, 3-5 hit the Province of Albay in Bicol Region. This province is also under the threat of volcanic eruption, earthquake, tsunami and mudslides, its population are exposed to flooding since most of their settlements are in the low-lying coastal areas. With accelerated sea level rise and climate change, the risks are heightened.

The successful implementation of sustainable disaster management programs in the Provincial Government of Albay (PGA) is due to the presence of a permanent office overseeing disaster-management-related activities in the local level (Arguelles, 2007). The Provincial Disaster Operation Center (PDOC) was established in 1992 and was tasked to provide technical and administrative functions of emergency-related services. In July 1994, the Albay Public Safety and Emergency Management Office (APSEMO) was institutionalized by virtue of Sanguniang Panlalawigan Resolution (SPA) No. 155-94. It is a politically-independent department that serves as the technical and administrative arm of the Provincial Disaster Coordinating Council of Albay, created to empower the management of the PGA along public safety and disaster risk management through the use of cluster approach. The APSEMO believes that in order to save lives, an early evacuation is better than rescue, even if costs are not cheap. Disaster proofing approach and mainstreaming disaster risk reduction in the comprehensive landuse planning (CLUP) also pays.

Transitioning from these coping mechanisms on current disaster risks to climate change adaptation is seen as a matter of using scientific information and decision-support systems on the changing patterns of risks in order to enhance the DRR plans to a CCA framework.

## The Influence of Model Skill on Regional Projections of Extreme Temperatures over Australia

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Model evaluation by means of comparing 20th Century simulations to observations is readily undertaken to gain some level of confidence of model reliability. Many studies including Watterson (1996), Taylor (2001), Delworth et al. (2006), Knutti et al. (2006), and Shukla et al. (2006) have devised evaluation metrics however all have based their analysis on monthly, seasonal or annual data. Given that climate on time scales of days has a direct impact on human health (Trigo et al. 2005, Woodruff et al., 2006) and human activities (e.g., agriculture; Luo et al. 2005), an assessment of the capacity of models to simulate climate on time scales of days is clearly valuable.

Perkins et al. (2007) introduced a metric which evaluated the Coupled Model Intercomparison Project phase 3 (CMIP3) Global Climate Models (GCMs) on their ability to reproduce the observed probability density function (PDF) for daily minimum temperature (TMIN), maximum temperature (TMAX) and precipitation. The metric (Sscore) measures the amount of overlap between the observed and modelled PDFs by summing the minimum values across the common bins. Evaluation was performed for twelve regions across Australia, each representing one or more different climatic

types (Perkins et al., 2007). Perkins et al. (2007) demonstrated that the ensemble PDF closely resembled the observed PDF as models with lower Sscore values were omitted. Overall, it was concluded that while limited to one continent, some of the CMIP3 models show considerable skill at sub-continental scales, when assessed using daily data.

In order to investigate whether CMIP3 models with lower skill biased future projections of temperature extremes, Perkins et al. (2009) employed three measures of model evaluation calculated for daily TMIN and TMAX. The measures of skill included the difference between the observed and modelled mean, the Sscore proposed by Perkins et al. (2007) and a new metric (Tailskill) which focuses on the weighted difference between the top (bottom) 5% for TMAX (TMIN). The generalized extreme value (GEV) distribution was implemented (Kharin et al., 2007) to estimate and assess changes in the 20-year return value. Evaluation was performed for 1981-2000 and projections were considered for the SRES A2 scenario for 2081-2100. Models were chosen due to data availability for the 20c3m and A2 scenarios at the time data was obtained (6 models for TMAX and 9 models for TMIN). Once evaluation was performed, models were divided into “weaker” and “stronger” ensembles by ranking their score for each evaluation metric. Projections were based on either an average (continental) or a range (regional) of the ensembles, and were compared to the all-model ensemble. Regional analysis was performed for temperate, subtropical and tropical climates.

It was found that the all-model ensemble for each region showed a large range of projected temperatures. In each region, and irrespective of skill-score used, the projected TMAX is always lower in the stronger models than the weaker models, and the 90% confidence levels for the two ensembles do not overlap in two of the three regions. This suggests that the projected 20-year interval temperatures from the weak models are statistically significantly higher than those projected by the strong models, irrespective of whether “strong” is defined using the mean, PDF or tail skill measure. Results for TMIN inferred that the samples are not consistently significantly different at a 90% confidence level, but there is a systematic difference in that the weaker models always simulate larger amounts of increase in TMIN than the stronger models.

The use of an all-model ensemble therefore tends to over-predict the amount of increase in both TMAX and TMIN in the 20-year return levels over Australia, at least for the climates presented here. It is likely that such results can be extrapolated to other regions across the continent. Results highlight the need to begin to exclude a given model from regional projections where it shows weaker skill, and that projections are less affected by the chosen measure of skill, compared to not evaluating and simply averaging across all models.

To avoid any misinterpretation of results, it is emphasised that increases in the 20-year return levels in TMAX and TMIN projected by the strong models remains confronting. Results do not hint that increases in the 20-year returns from the strongest models are anything other than large.

## Sharing and Communicating Climate Change Adaptation Research in Victoria through an online collaborative platform

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Climate is a powerful driving force of change which effects our environment, society and economy now and in the future. The impacts of climate change need to be better understood so that society can develop both mitigation and adaptation strategies. Our research is focused on developing an eScience platform to support climate change adaptation in Victoria. A multi-disciplinary, cross-organisational approach is taken to developing adaptation strategies to deal with the ‘diabolical’ policy problem of climate change. In this paper we present a platform for collaboration as part of the Ecoinformatics Climate Change Demonstrator Project lead by the Department of Primary Industries (DPI) Victoria. The project partners include: the Victorian eResearch Strategic Initiative (VeRSI), University of Melbourne, Monash University and La-Trobe University. The platform initially focuses on the theme of climate change to support the DPI Victorian Climate Change Adaptation Program (VCCAP). The aim of the broader VCCAP research program is to increase the knowledge and capabilities of government, the agriculture sector and farming businesses to undertake sound and informed planning and policy decision that maximise the benefits and minimise the economic, social and environmental costs of climate change.

Ecoinformatics is defined as the science of information, data management and analysis within the fields of ecology and environmental science and falls within the scope of e-Science. The term e-Science (UK), synonymous with cyber-infrastructure (US), e-infrastructure (EU) and e-Research (Australia), refers to advances in information and communication technology (ICT) which have enabled the development of tools to access and share large datasets between organisations, promoting collaborative science on a global scale. The initial focus of our ecoinformatics platform is climate change as a subset of ecoinformatics, climate informatics.

To support the sharing of research across organisations and disciplines a platform for collaboration known as the e-Resource Centre (e-RC) has been established. The e-RC is a virtual organisation (VO) developed to support the DPI VCCAP and its research partners. The e-RC enables collaboration and the efficient exchange of information and knowledge between institutions, researchers, extension providers, the primary industries sector and policy-makers. The e-RC provides access to regional climate change scenarios, maps, models and model outputs, decisions support tools, research reports and communication material. This enables researchers working on a range of models including: downscaled climate models, hydrological models and land suitability analysis to share

data inputs and outputs. Online collaboration environments such as the e-RC for climate change adaptation research provide a powerful toolkit for researchers to collaborate across organisations and disciplines.

The ecoinformatics climate change demonstrator project also incorporates the application of a number of visualisation technologies such as digital globes, visual animations, computer game engines that can be accessed via an interactive touch table interface. Such a suite of tools enables the exploration and communication of climate and risk model outputs and scenarios to farmers, industry, communities and government. Geographical visualisation products such as virtual globes and photorealistic representations of climate change data and related biophysical modelling outputs to industry and farmers so they more clearly envisage the likely impacts and adaptation options at the regional and farm scale.

## **Adaptation with grace: Searching for stability in the non-linear Earth system**

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This paper argues that mitigation and adaptation approaches are linked, with effective mitigation a precondition for effective adaptation. We consider adaptation with grace as effective adaptation undertaken in an orderly and planned manner, embodying important principles of justice and equity, and with some expectation of longevity. Adaptation with grace is wholly dependent on relative Earth system stability provided by reflexive mitigation. Reflexive mitigation is an adaptive approach to mitigating climate change recognising: (i) atmospheric CO<sub>2e</sub> concentrations consistent with Earth system stability will vary over time in response to changes in the Earth system and the global economy, and in the relationship between them; and (ii) relationships between the Earth system, the economy and insurance systems are evolving, and therefore understanding of them is necessarily incomplete. The paper presents a complex adaptive systems approach to anthropogenic climate change and demonstrates the Earth system, the global economy and insurance systems are connected social-ecological systems. Earlier and current insurance system responses to anthropogenic climate change are generally adaptive and weakly mitigative rather than strongly mitigative.

The paper argues successful insurance system adaptation to anthropogenic climate change depends on returning the climate to a stable, familiar and relatively predictable state: effective mitigation is therefore a necessary precondition for successful longer-term insurance system adaptation. In the absence of familiar Earth system stability, potential adaptation efforts will be limited to ad hoc and reactive measures with reduced prospects for reflecting widely-shared ideas of fairness and equity, and with the term of benefits constrained by further changes in the Earth system. The paper focuses on insurance systems and raises implications of the adaptation-mitigation relationship for human societies more broadly.

## **Climate change adaptation and associated policy challenges: an international and national perspective**

**G Picker<sup>1</sup>**

<sup>1</sup>AECOM, Australia

As the science around climate change becomes clearer and more widely disseminated, there is an increasingly strong desire among those countries, sectors and communities that see themselves as particularly vulnerable to the impact of climate change to better understand – and to manage – their risk.

Adapting to the future impacts of climate change is a complex challenge for policy-makers at both an international and national level. Firstly, there is the challenge of evaluating climate change risk across and between diverse countries, communities and sectors where the nature and severity of the impact can only be assessed in a probabilistic fashion. Next, there are only rudimentary tools available to analyse the economic and social benefits of risk mitigation measures. Lastly, there remains uncertainty about whether – and where – the impacts of climate change will represent market failure and will require structural reform, and where the impacts while significant can be managed through current, albeit enhanced, policy approaches.

This presentation will provide an overview and analysis of recent developments in adaptation policy emerging out of the Copenhagen negotiations and through the next major negotiations in Cancun in December 2010. It will also provide an overview and assessment of developments in adaptation policy in leading countries worldwide including Australia, Canada and the United Kingdom, as well as adaptation activities supported by the World Bank and other multilateral funding institutions.

An analysis about the differences between national and international approaches on managing climate change impacts will be provided, and the causes for and implication of any discrepancies explored. Key differences in approach and proposed solutions will be examined, lessons learned identified, and examples of best practice highlighted. Challenges and barriers to the development of effective adaptation policy will also be detailed.

Lastly, the presentation will provide a scenario of the likely pattern of development for adaptation policy at both an international and national level. Finally, there will be a discussion about both the policy and practical consequences of how adaptation policy develops.

## Criteria for fair allocation of international adaptation finance

J Pickering<sup>1</sup>

<sup>1</sup>Centre for Applied Philosophy and Public Ethics, The Australian National University, Australia

The Copenhagen Accord contains new commitments to scale up international finance for adaptation in developing countries, but available resources are almost certain to fall short of countries' needs. As a result, priorities for the allocation of limited adaptation funding will need to be established. Vulnerability to the impacts of climate change is a widely accepted criterion for prioritising adaptation funding, as reflected in the UN Framework Convention on Climate Change, the Copenhagen Accord and the Kyoto Protocol Adaptation Fund. Distribution according to vulnerability or need is also consistent with a range of theories of distributive justice.

However, identifying consistent measures of climate vulnerability and obtaining sufficient data for them has proved difficult to date. A country's climate vulnerability is influenced by a number of factors, including both its biophysical exposure and sensitivity to climate impacts and also its social and institutional capacity to respond to those impacts. Vulnerability may also vary greatly within individual countries and over different time periods. Moreover, some research, drawing on experience from development assistance, has argued that factors such as a country's capacity to absorb adaptation finance (which could be inversely correlated with its degree of vulnerability) should also be taken into account in allocating adaptation finance.

This paper will survey a range of criteria that could be used to inform the allocation of international adaptation finance, including different measures of vulnerability and absorptive capacity. I will first sketch a brief conceptual framework for understanding the various principles that could inform the distribution of adaptation finance, drawing on recent literature from climate policy, climate ethics and international aid policy. I will then analyse several criteria-based approaches for allocating adaptation finance (including existing mechanisms such as the Kyoto Protocol Adaptation Fund and the Pilot Program for Climate Resilience), comparing them according to the relative emphasis they place on equity, efficiency and effectiveness. Finally, I will evaluate the feasibility of implementing these approaches under a range of possible institutional architectures for governing international adaptation finance. In doing so I will consider factors such as the interests of potential recipients and contributors of finance, and the practices of existing institutions through which adaptation finance could be channelled. I will argue that an approach to adaptation finance that places vulnerability at the centre of allocative decisions while making some adjustment for absorptive capacity is best equipped to meet concerns of both equity and efficiency, and that such an approach could feasibly be implemented under new or reformed institutional arrangements.

## Climate change adaptation and Australia's managed forests

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Forest management systems around the world have been largely developed on the assumption of climate being relatively stable both within and between rotations. There is strong evidence that this assumption no longer holds. In Australia, the increasing frequency of extreme climatic events over past decades (Steffen 2009) has resulted in drought mortality and storm damage with worrying economic and environmental consequences. Recent studies have illustrated that many plantation-growing regions will be vulnerable to the effects of climate change (Battaglia et al. 2009), with impacts on productivity particularly from reduced rainfall and the indirect effects of changes in pest activity, weeds and bushfires. Vulnerability can be moderated through adaptation, but to date adaptation has received scant attention in the forest sector.

In this paper we will discuss general principles of adaptation to climate change in the context of the Australian forest industry, including ways of dealing with uncertainty, barriers to adaptation and risks of maladaptation. We will provide examples of strategic and operational management options to reduce vulnerability, from establishment through to processing, and suggest ways in which adaptation can be embedded into the principles of sustainable forest management.

## Extreme events preparedness planning in indigenous communities in Canada

J Pittman<sup>1</sup>

<sup>1</sup>Projects and Partnerships, Saskatchewan Watershed Authority, Canada

This paper documents the process and discusses insights from an extreme events preparedness planning project undertaken in collaboration with three First Nations communities in Saskatchewan, Canada – the James Smith, Red Earth and Shoal Lake First Nation. This project builds upon previous research exploring vulnerability to climate change in these particular communities (Ermine et al., 2008; Ermine and Pittman, 2009; Pittman, 2009; 2010). It was found that droughts and floods have been problematic for the communities, which impact water supplies (both in terms of quality and quantity), homes and infrastructure. The communities rely on a suite of social, spiritual and technological coping strategies to deal with extremes, but considerable vulnerabilities still exist. As climate change is expected to increase the frequency and severity of droughts and floods in the study region, an extreme events preparedness project was proposed to facilitate climate change adaptation.

The project is being implemented in three phases: (1) bottom-up drought and flood vulnerability assessments; (2) Elders circles for guidance on values; and (3) planning session with local governments. The bottom-up vulnerability assessments engage community members through surveys designed to gather information on previous exposures and adaptive strategies related to droughts and floods and provide insights into future actions needed to reduce vulnerability

to these extreme events. The Elders circles will be used to obtain direction on the principles and values that should guide adaptation to climatic extremes in each community. Finally, the planning session with local governments will be a forum to identify preparedness strategies and adaptation action items as the communities move forward.

Timelines for completion of the phases are as follows: first phase completed by February 28, 2010; second phase by March 31, 2010; and third phase by June 30, 2010. Initial results from the first phase highlight the importance of social support networks in coping with extremes and the necessity for preparedness and action plans at the community level.

## **Linking institutional and agricultural adaptation to extreme dry conditions in the Canadian Prairies: The case of the South Saskatchewan River Basin**

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Of particular interest in the context of agricultural-based economies in semi-arid regions are vulnerabilities to drought and extended dry spells. Droughts often result in significant economic losses as well as environmental degradation and considerable social stresses. This situation is fairly evident in the South Saskatchewan River Basin (SSRB) of the Canadian Plains, where drought is a frequent and recurring feature of the natural climate. The majority of rural communities in this basin are heavily engaged in, and have economies largely centered on, agriculture. Many institutions have been created and subsequently evolved over time to address the challenges of coping with climate variability and drought in the basin. This paper discusses the ways in which institutions have facilitated and/or constrained adaptation in rural agricultural communities in the SSRB, Canada. This paper is based on the findings from a five year multidisciplinary project that focused on institutional adaptations to climate change and water stress in the SSRB through the lens of vulnerability.

Frequent exposure to droughts have facilitated the development of coping capacities to reduce the risks associated with these extreme events. The severe droughts of the 1930s sparked a wave of institutional adaptation that continues to influence vulnerability today. The Prairie Farm Rehabilitation Administration (PFRA) and the Prairie Provinces Water Board (PPWB) are among institutions created in response to the “Dirty Thirties”. The PFRA provided cutting-edge technical support to farmers allowing them to adapt their operations and practices to the Canadian Prairie climate. Agriculture was a relatively young industry at the time and was suffering from its reliance on techniques imported from Europe. The PPWB was another institutional reaction to water stress that sought to address inter-provincial governance concerns in multi-jurisdictional watersheds.

Producers in the basin manage climate and economic risks simultaneously. Producers have both proactively and reactively coped with climate variability, and have developed a suite of adaptive strategies from which they draw in times of stress. These strategies focus on maximizing economic returns while minimizing climate-related losses and ensuring the sustainability of their operations. Therefore they exhibit great resilience under the conditions that currently characterize the basin.

Notwithstanding these great achievements in vulnerability reduction, future climates may pose challenges to agriculture in the SSRB. Insights from the paleoclimate record indicate that the period of agricultural development in the basin occurred during a relatively wet period despite frequent dry conditions. Similarly, future climate scenarios project an increase in the frequency, severity and duration of dry spells. Current governance and management institutions have evolved in a time unrepresentative of both the natural and human-induced climate, and will need to adjust their approaches to accommodate future change, variability, and uncertainties.

Climate change and variability may produce conditions beyond the coping range of agricultural systems in the basin. Proactive drought-risk management could potentially alleviate some of the pressures from change and variability. It is likely that future adaptation will require an integration of institutional- and producer-driven strategies, while participatory planning and interdisciplinary perspectives will be key in guiding adaptation efforts into the future.

## **Disciplines and post-disciplinarity in climate change and coastal planning**

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Academic and policy responses to climate change require a cross-disciplinary focus. The form such a cross-disciplinary focus should take is subject to debate. This paper contributes to this debate through an examination of various approaches to coastal planning that seek to integrate development and climate change objectives; the value of post-disciplinary approaches in the development of improved culturally informed governance practices among researchers, policy-makers and local communities; and implications for the promotion of more socially and environmentally sustainable futures for coastal populations.

Part one examines the diverse contributions of disciplinary knowledges such as anthropology, psychology, politics, economics, environmental science, meteorology and law to climate change research in the context of coastal adaptation. In fact almost every discipline has a significant contribution to climate change research; few other phenomena have attracted



such catholic interest. This comprehensive attention is due to the urgency of the timeline, the inescapability and universality of the impacts, and to the consequent politicisation and availability of research funding. Such disciplinary research includes, inter alia, historical understandings and adaptations to weather and climate variability; debates over the social construction of climate change science; the relevance of local knowledge to natural resource management; environmental discourses; unequal ecological exchange and world systems theory; local responses to environmental globalisation; and the relationship between development planning and climate change. However, the very complexity and interrelatedness of climate change issues has meant that disciplinary research alone can never be adequate to the task. Part two critically examines examples of multidisciplinary studies of coastal adaptation to climate change: those in which specialists work together whilst maintaining their disciplinary boundaries and methods. Whilst this approach begins to address the need for multiple fields of research to be focused on climate change, it still does not generate a dynamic interface or genuine dialogue among contributing disciplines. Part three focuses on interdisciplinary knowledge forms such as sustainability. In such studies, areas of overlap or interaction among disciplines are investigated and new methods and synergies emerge in coastal adaptation. We begin to see a process in part four, we discuss the role of transdisciplinary approaches - which seek to transcend disciplinary boundaries using complex system analysis, adaptive learning across disciplines about climate change, in which not only are the substantive contents of disciplines shared, but so are methodological approaches such as community engagement and anticipatory action research. In part four, we discuss the role of transdisciplinary approaches which seek to transcend disciplinary boundaries and transition management – in framing current debates over the relationship between coastal development planning and climate change. In this type of research there needs to be a focus on integration as well as analysis in seeking ‘truth’, on incorporating non-scientific knowledges and qualitative values, and generating interparadigmatic dialogues. Thus we can generate socially robust and fully contextualised knowledge. Transdisciplinary approaches often use units of analysis which are strongly coupled, jointly determined, nonlinear, complex socio-ecological systems.

These kinds of post-normal interdisciplinary and transdisciplinary research pave the way for better links between research and policy, as the research generates the type of information that actually reflects the multi-faceted issues in the real world of climate adaptation on the coast. At this challenging level, some climate change anticipatory action research on the coast aims to treat new information and uncertainty explicitly with iterative and adaptive approaches across multiple scales. It can inform policy and planning in such a way as to enable a reflexive, responsive approach to governance. One example that could be usefully applied is the transition management approach. .

Bob Pokrant is Professor of Anthropology at Curtin University of Technology. His main research interests are fisheries and aquaculture in South Asia and coastal adaptation to climate change. His most recent publication, co-edited with Michael Gillan, is entitled: *Trade, Labour and the transformation of community in Asia*, Palgrave Macmillan, 2009.

Laura Stocker is Associate Professor of Sustainability at Curtin University Sustainability Policy Institute. Her research interests are in sustainability mapping, planning, policy and education. She is currently deputy leader of the new CSIRO Coastal Collaboration Cluster which focuses on enabling better dialog between knowledge-makers and decision-makers about climate change and other impacts on the coast, with a view to improving coastal management.

## **A Report Card of Marine Climate Change Impacts and Adaptation for Australia**

**E S Poloczanska<sup>1</sup>, A Hobday<sup>1</sup> and A J Richardson<sup>1</sup>**

<sup>1</sup>Climate Adaptation Flagship, CSIRO Marine and Atmospheric Research

Effective communication is a key issue in developing adaptation strategies. This presentation will describe the process undertaken in Australia to produce the first Marine Climate Change Report Card of Impacts and Adaptation for Australia in 2009 and supporting website [www.oceanclimatechange.org.au](http://www.oceanclimatechange.org.au). The Report Card was guided by the Moreton Bay Healthy Waterways Report Card (south-east Queensland) which is produced annually since 2000 and by the more recent UK Marine Climate Change Impacts Report Cards (2006 and 2007/08).

The first Report Card of Marine Climate Change for Australia reported on a number of key climate variables (e.g. temperature, sea level) and key biological taxa (e.g. mangroves, pelagic fish and sharks). To promote accurate, insightful information, we engaged the leading experts within each field to review and assess impacts and adaptation options. Over 77 authors and co-authors from 35 institutions and organisations contributed their time and efforts to this scientific assessment. The aim of the Marine Report Card is to connect science and policy, to communicate information in an efficient and user-friendly format, and to highlight adaptation key knowledge gaps and adaptation responses. The Report Card also served to concentrate fragmented knowledge on climate change in Australia, so benefitting the science community as well as policy and decision makers and the general public.

The biggest challenge in producing the first version was assigning confidence levels to statements and standardising expert perceptions of knowledge availability in their fields. For example, which fields are data-rich relative to others? How does this affect our confidence in statements? This aspect warrants further exploration. Confidence assessments are indicative only because of the problems with standardisation. Opportunities for discussion and interaction between the different experts were highlighted as vital for issues such as assigning confidence levels and we recommend adequate resources be made available for such projects.

The printed Report Card and website proved to be a highly successful communication tool with 210,000 hits on the website within the first week and extensive media coverage. It became clear that for biological systems, Australia is lacking in long-term baselines compared to other countries and our knowledge of many biological taxa such as zooplankton and macroalgae is poor. Our vision

is to elaborate on this first Report Card with biannual Report Cards. The National Report Card will be extended to include sectors, such as tourism and fishing, and to include greater investigation of adaptation options. Information at regional scales is urgently needed for adaptation planning. Producing versions for States and Territories will allow a focus on the key issues for each.

## Assessment of vulnerability and adaptation to climate change in Rio de la Plata artisanal fisheries through a participatory methodology

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The 'Rio de la Plata' is a river-estuary system located along the east Atlantic coast of South America that drains its the second largest hydrographic basin. The overall vulnerability of its estuarine waters, coastal zone, and ecosystem services is primarily associated with ENSO-related climate variability. In addition, human shifts within the basin and coastal zone (misuse of land, increase in coastal urbanization) are drivers of pressure at different spatial scales and timescales, which produce or trigger impacts and ecosystem responses. The case study is an artisanal fishermen community, located along the Rio de la Plata estuary coast, within the boundaries of the capital city of Uruguay. This particular livelihood is vulnerable to both environmental (ENSO variability) and non-climate constraints (macroeconomic crisis impacts, industrial overfishing). This exposed unit is based on the fishermen assets on which their livelihood is built: human, physical, financial, social and natural capitals. The climatic disruption to this coastal system is studied at the Estuarine Front (EF), a water column zone of the estuary defined by its specific salinity and turbidity, being its main ecological subsystem: ecological services such as primary production and coastal fisheries show peaks within the EF, so the artisanal fishery fleet exploits the resource within the EF. Both long-term river flow series of freshwater discharge and future climate scenarios for southeastern Southamerica suggest that a dramatic change in the location of fronts is occurring since 1970 and could continue over the next few decades. The location of the EF displaces seaward and riverward as a function of river flow into the estuary, and the mean yearly discharge has increased 35% in the last three decades, due to increased ENSO variability (LA NIÑA' EL NIÑO events); as a consequence, the EF is displaced. out of the fishermen reach most of the time. The overall aim of this research was to apply the Sustainable Livelihood Approach (SLA) in the assessment of the vulnerability and adaptation of this livelihood system to the effects of climate change and other global change stressors. Vulnerability and adaptation assessment focus on the dynamic interactions between natural and social dimensions of global change, so non-trivial results can only be achieved through an integrated approach treating both systems in the trans-disciplinary context of sustainability science, where successful research is measured by not only pure scientific merit but also by the utility of the resulting products. A relatively high degree of uncertainty will likely always exist regarding projections of climate and environmental change at the local management scale, so focus must be placed on the context of integrated vulnerability assessment that look at both environmental and human scenarios. The analysis of complex phenomena such as vulnerability and adaptation is difficult to capture in numerical terms and simple indices, so this research addressed a methodology based on participatory analysis (SLA), which is guided by the knowledge and experience of the community and helps to capture a realistic understanding of community's strengths and how they manage to convert them into positive livelihood outcomes. The data was gathered trough joint field work and through sample surveys using Likert scales. The information gathered was analyzed through multivariate statistical methods (Principal Component Analysis, NMDS) to obtain the perception of capital status and conditions, and then through a limited dependent variable model in order to identify key specific proxy variables for each capital. The main findings were that the natural assets (climatic conditions and fish stock conditions) are what fishermen perceive as the most relevant variable in order to achieve positive livelihood outcomes, as well as it is believed to have the worst conditions of the whole assets, either for the depletion of fish as well as the gradual worsening of the climatic conditions. These two statements were confirmed by the field measures taken. More in-depth analysis (ordered probit model) reveals specific proxy variables which highlight potential opportunities for rapid adaptation measures. A complete picture of vulnerability and adaptation measures requires consideration of the whole range of relevant assets; the opinions of vulnerable people are vital in the analysis for designing actions to improve their situation. The SLA constitutes an appropriate analytical tool for capturing the complexity of factors that generate vulnerability, providing a solid basis for policy interventions.

## Confronting Climate Change: An Early Analysis of U.S. Water and Wastewater Utility Adaptation Costs Through 2050

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<sup>1</sup>CH2M HILL, Australia

The Challenge: The effects of climate change are impacting U.S. water and wastewater utilities, driving the need to plan for adaptation so that utilities can continue to protect public health and the environment. Effective planning requires understanding the nature of the likely impacts to utilities, the types of adaptation measures to address the impacts, and early estimates of the costs of these adaptations. Climate change effects and the resulting impacts to water and wastewater systems are expected to include significant water cycle changes with increased water supply uncertainty; increased extreme precipitation events resulting in flooding; sea level rise and storm surge; and regulatory uncertainty. The National Association of Clean Water Agencies (NACWA) and the Association of Metropolitan Water Agencies (AMWA) teamed with CH2M HILL to conduct an early analysis of impacts, adaptations, and cost estimates for climate change impacts and adaptation to U.S. drinking water and wastewater services through 2050.

Goals and Objectives: The analysis has three objectives:

- Characterise the general impacts of climate change on drinking water and wastewater services based on recognised greenhouse gas emissions scenarios and projections of climate change effects

- Help the water and wastewater sectors understand the challenges of ensuring reliable water and wastewater services in the face of a changing climate
- Provide early U.S. adaptation cost estimates to guide policies and allow early 2planning.

Approach and Outcomes: The early analysis of climate change impacts, adaptations, and costs of implementation was based on available information from public documents, websites, databases, and projections software including the U.S. Global Change Research Program (2009), Climate Wizard (Zganjar, 2009), and CLIMSystem's SimCLIM (Warrick, 2009), and others. The analysis identified impacts and associated adaptations; costs were estimated based on 2009 technologies and cost assumptions for infrastructure, and operations and maintenance. The early analysis recognises that climate science and the technology of adaptations are evolving and that regulatory and technical innovation and associated costs are incompletely known at this time. The early analysis of wastewater system impacts, adaptations, and estimated costs assumed that:

- Extreme storm events and changing precipitation patterns will drive wet weather program enhancements
- Extreme precipitation events and earlier snow melt will drive flood protection measures for facilities, such as levees and siting considerations; and sea level rise and storm surge will drive effluent pumping and sea walls for low elevation coastal facilities.
- Effluent quality considerations will drive advanced treatment for environmental flows and drinking water supply related to wastewater reuse, with early estimates of U.S. costs for wastewater adaptation ranging from \$US123 billion to \$US252 billion.

The early analysis of drinking water system impacts, adaptations, and estimated costs assumed that:

- Changes in source water availability (quantity and timing) will increase the gap between supply and demand that will drive additional conservation and new source development through methods such as desalination, increased storage, and management changes.
- Changes in source water quality from increased temperatures and sediment are anticipated to increase toxicity and taste and odour problems, requiring additional treatment. Reuse and recycling for water supply augmentation will compel advanced treatment technologies and additional distribution systems.
- Flooding from increased extreme precipitation events and threats from sea level rise and storm surge will likely affect some intake, treatment, and distributions systems, driving the need for levees and sea walls.

The range of early costs estimates for U.S. drinking water adaptations was estimated to be from \$US396 billion to \$US692 billion.

Total early estimates for combined costs for U.S. wastewater and drinking water climate change adaptation through 2050 based on these impacts, adaptations, and cost assumptions are from \$US448 billion to \$US944 billion.

## Climate change adaptation and alternative water supply sources for industrial users in Australia

J Poon<sup>1</sup>, A Chris<sup>2</sup> and M M Muthu<sup>2</sup>

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Australia is facing a significant water management challenge as a result of prolonged drought, record breaking low rainfall and streamflows, continuing economic and population growth, and changing water quality characteristics. The future predictions for climate change and population growth in the Melbourne metropolitan area project an increasing demand for water, not only for drinking and domestic urban uses, but also for industrial and irrigation applications. This scenario has resulted in a new focus on finding alternative water sources to supplement and secure existing water supplies for urban users in Australia.

City West Water Limited, a Melbourne metropolitan retail water company commissioned CH2M HILL Australia to prepare an alternative water strategy for their Altona Industrial Precinct customers. The focus of this study was to investigate the replacement of drinking water with fit-for-purpose recycled water and stormwater for industrial users.

A decision making framework was developed to give a holistic and sustainable approach to finding the most appropriate alternative water supply option. CH2M HILL developed an integrated planning approach that utilised proprietary tools for multiple criteria analysis (MCA), rapid design and cost estimation, cost benefit analysis (CBA) and decision making science. A wide range of options for servicing, treatment and water sources were identified and compared using the integrated planning approach. The decision making framework considered non-monetary criteria such as water quantity and quality, technical feasibility, constructability, operability, greenhouse gas footprint, energy use, public acceptance and safety, chemical use and residuals generation. Monetary criteria such as capital, operational costs and net present value were also considered using a cost benefit analysis to provide a balanced and unbiased view during the decision making process.

Alternative water supply options were developed using a full range of potential water sources and treatment alternatives ranging from: natural treatment systems, groundwater, aquifer storage and recovery, stormwater harvesting and reuse, sewer mining and reuse and importation of recycled water from a nearby treatment plant as well as combinations of these sources. The options for alternative water supply were also developed by considering a range of delivery or servicing methods ranging from centralised systems to individual localised treatment systems.

The study found that the centralised options were superior in terms of ease of operation, consistency of supply and cost, while the importation of recycled water from a neighbouring treatment plant or from sewer mining were found to be more secure water sources that could yield more consistent product water quality.

This paper will discuss the options development and evaluation work, the results of the decision support modelling work, and the study findings in more detail, including the outcomes of the MCA and CBA comparisons of the alternative water supply options. The paper will also explore the use of dynamic simulation modelling tools to aid with the analysis and evaluation of alternative water supply systems such as the Altona Industrial Precinct, and how such tools could help with identifying optimal solutions that are sustainable and cost - effective.

## **Determining the impacts of climate change on water availability across south eastern Australia: the SEACI initiative**

**D A Post<sup>1</sup>**

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The South Eastern Australian Climate Initiative (SEACI) was launched in 2006 as a 3 year, \$7.5m program of research investigating the causes and impacts of climate change and climate variability across south eastern Australia. The first phase of the initiative wrapped up in 2009 and a synthesis report describing the major outcomes of this phase of the initiative has recently been released. This report and further details of SEACI can be found at <http://www.seaci.org/>.

Phase 2 of SEACI commenced in late 2009 and one of its core aims is to better understand the impacts of climate change and climate variability on water availability. The research program includes studies of climate variations on time scales from weeks to decades. This will assist operational management of water, which requires knowledge of climate variations with time scales of weeks to months, and planning and policy for water availability for which horizons extend to years and decades.

This new three-year \$9 million partnership covers the Murray-Darling Basin, the state of Victoria and southern South Australia including the Eyre Peninsula. Partners include the Australian Government Department of Climate Change and Energy Efficiency, CSIRO, through the Water for a Healthy Country Flagship, the Murray-Darling Basin Authority, Victorian Department of Sustainability and Environment, and Australian Government Bureau of Meteorology.

Research in SEACI falls into three themes:

### **Theme 1: Understanding past hydroclimate variability and change in south eastern Australia**

Research in this theme aims to better understand the factors that drive changes in both climate and streamflow within the region. Research in the first phase of SEACI showed reductions in autumn and winter rainfall can be accounted for by an increased intensity of the subtropical ridge. In phase 2 of SEACI, we aim to determine how an increase in global temperature influences the subtropical ridge, and the exact processes by which an intensification of the subtropical ridge leads to declines in rainfall in autumn and early winter.

### **Theme 2: Long-term hydroclimate projections in south eastern Australia**

Research in this theme will lead to improved long-term hydroclimate projections for south eastern Australia. Phase 2 of SEACI aims to extend climate and runoff projections out to 2100, as well as provide improved uncertainty estimates for these projections, based primarily on emission scenarios. Further, our research will examine the relationship between current climate and future climate by determining how much of the recent drying trend across the southern half of the SEACI region is due to climate change.

### **Theme 3: Seasonal hydroclimate prediction in south-eastern Australia**

Research in this theme will lead to improved seasonal climate and hydrologic predictions at lead times from several weeks out to nine months.

In this area of research we aim to improve climate forecast skills at longer lead times by examining the impacts of El Nino-Southern Oscillation on longer-term forecasts. We will also make use of a statistical modelling approach to improve the usefulness of streamflow forecasts.

## **Applying the farm scale system model APSFarm to explore adaptation options available to irrigated grain-cotton farming systems**

**B Power<sup>1</sup>, D Rodriguez<sup>2</sup> and P deVoil<sup>3</sup>**

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Static-equilibrium models have been used to model and explore the optimal allocation of limiting resources in farming systems. This approach however is limited in its applicability due to a reliance on assumptions about distributions made a priori on likely yields, prices, water allocations, etc.; and an inability to accommodate tactical and strategic responses to climate and markets.

Here we present an alternative dynamic framework that integrates multiple mechanistic bio-physical models that operate at differing scales i.e. the management unit, the farm and the catchment. Semi-structured interviews with farmers provide farm specific data, such as water sources and their annual allocations, water storage capacities, cropping areas, agronomy, irrigation management and paddock layout relative to storages. Plant, soil and agronomic interactions are simulated within homogeneous irrigation management units (described here as paddocks) using the point scale Agricultural Production System sIMulator (APSIM). Multiple paddocks within the farm are then represented in silico by various instances of APSIM using the farm scale bio-economic model APSFarm. Farm business constraints are included such as limits to the availability of resources, e.g. land, irrigation water, machinery and time. A farm manager is modelled using coded algorithms to specify field crop rotations and preference for the allocation of resources across alternative crop enterprises, risk attitude and cropping intensity.

To demonstrate the ability of this framework to explore adaptation options to climate change at the farm-level we applied it to a case study of an irrigated farm business near Dalby and provide metrics on the cost and benefits of alternative irrigation allocation strategies in response to scenarios of reduced farm water.

## Ecosystem-based Adaptation in the National Adaptation Programmes of Action (NAPAs)

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Societies that depend on natural resources for their livelihoods are likely to be adversely affected by climate change, unless they can adapt. There is growing evidence that ecosystem services play an important role in reducing these societies' vulnerability to climate change. Regulating services reduce communities' exposure to climate-related extreme events because, for example, they can act as natural protective buffers against wave and wind energy, and decrease temperatures during heat waves. Provisioning services can act as safety nets that lessen sensitivity to climate variability; for instance, in Africa, many rural communities use non-timber forest products for consumption or trading when agriculture and livestock are affected by climate events.

Ecosystem-based Adaptation (EbA) is an emerging concept both in science and in international discussions on climate change and biodiversity. Since the 14th Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC, Germany) held in Pozna in December 2008, several parties have submitted proposals related to EbA. Among others, G77/China, Costa Rica, Panama, Sri Lanka and the IUCN have all submitted such proposals. The Ad Hoc Technical Expert Group on Biodiversity and Climate Change (under the Convention on Biological Diversity) defined EbA as "the use of sustainable ecosystem management activities to support societal adaptation". Although EbA does formulate opportunities for sustainable adaptation, it also poses challenges related to the lack of awareness of ecosystems' role in adaptation among institutions, and the shortcomings of multi-sectoral planning, as EbA requires the involvement both of sectors that manage ecosystems and of sectors that benefit from ecosystem services.

Many Least-Developed Countries have developed their National Adaptation Programmes of Action (NAPAs) under the UNFCCC and have identified priority adaptation activities and projects, based on existing information and stakeholder consultation. Although the quality of the subsequent outcomes is sometimes questioned, the NAPAs constitute a starting point for realising adaptation and thus will need to be evaluated and improved as new knowledge emerges. The introduction of EbA could be one pathway for this further improvement. So far, the extent to which the NAPAs have integrated ecosystem services and EbA is relatively understudied.

Therefore, a content analysis study is conducted on the 44 submitted NAPAs (as of March 1, 2010) to answer the following questions: how are ecosystem services considered in priority adaptation activities? Are ecosystem services considered for the adaptation of local communities or broader society? Do the proposed adaptation activities involve multiple sectors? What approaches and instruments are proposed for conserving or restoring ecosystems (e.g., regulatory, economic and informational instruments)? What are the costs of the different adaptation activities (e.g., engineered infrastructure vs. green infrastructure)?

Although many of the NAPAs enclose "hard" engineering solutions, such as flood-control channels and seawall or dam reinforcement, a substantial number of projects emphasise ecosystems and their services. Such examples are found, for instance, in the NAPA projects of small island states or countries with large coastal zones, where rehabilitation techniques for dunes and mangroves are used to address erosion, provide protection against storm surges and enhance threatened livelihoods. These examples are explored in a comparative manner and are presented with a critical view on the various factors that influence the development of NAPA activities, such as stakeholder participation, existing development policies and trans-boundary dimensions.

## Conservation planning for adaptation to climate change: an operational framework

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In December 2009, we participated in a three-day, international workshop to review knowledge about designing, implementing and managing conservation areas to facilitate the adaptation of species to climate change. In this presentation we provide an overview of the seven sets of issues covered:

1. Anticipating species responses to climate change;
2. Objectives of planning and management under climate change;
3. Regional design of conservation areas;
4. Applying conservation actions on the ground;
5. Management of established conservation areas;
6. Planning and management under uncertainty;
7. Performance measures for planning and management under climate change.

We expand on some of these issues to give examples of the limitations of present knowledge and priorities for filling

gaps in knowledge and improving approaches to planning and management. We present a new approach to anticipating species responses to climate change, considering phenotypic plasticity, the potential for genetic adaptation, whether climatic refugia exist within or outside species' present ranges, and the kinds of constraints on range shifts if species are to reach external refugia. For regional design, we will consider issues such as planning to protect refugia, planning for climatic gradients, and ways of mapping spatial options for protecting and restoring gradients. We finish with recommendations about ways of planning under uncertainty and how to formulate performance measures of conservation prescriptions.

## Demography, Vulnerability and Climate Change Adaptation

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Demographic change is a core process underlying the interactions between humans and the environment and one that is therefore integral to climate change adaptation planning. While climate change risk assessments commonly conceptualise risk as a consequence of physical changes in the Earth system, demographic characteristics and trends of nations, regions and communities will have a significant influence on their social and economic vulnerability to climate change. It is therefore useful to explore how demographic change will influence human and ecological exposure, sensitivity and adaptive capacity to climate change.

The implications of demographic change for the exposure component of vulnerability are perhaps the most readily apparent. Prior studies have indicated that global population growth will expose millions of additional individuals to water scarcity, flooding and infectious disease. Australia's 'sea change' and 'tree change' phenomena are contributing to similar increases in exposure at national and regional scales. Nevertheless, the vulnerability arising from increased exposure is likely to be most acute in the least-developed nations, such as those of Sub-Saharan Africa, which are projected to experience the highest rate of population growth over the next half century.

Societal sensitivity to climate change will be particularly dependent upon changes in the age distribution of nations, regions and communities. There is a global trend toward population aging, a phenomenon that is particularly profound in Western Europe. As a consequence, heat-related mortality is likely to increase with rising populations of the aged as well as expanded heat islands due to urbanization. Similarly, mortality associated with infectious diseases such as dengue and malaria tends to be higher in those with significant comorbidities – conditions more common among the elderly.

The adaptive capacity of nations is also subject to demographic influence. The projected aging of Western Europe, for example, is anticipated to contribute to a decline in the working aged population. Such trends may reduce national revenue and financial resources for adaptation as well as the flow of assistance to developing nations. Emigration of talent from rural areas and developing nations may contribute to a 'brain drain' that reduces the human capital needed to facilitate effective adaptation responses. Meanwhile, increases in the consumption of natural resources associated with population growth will constrain the capacity of institutions to cope with climate-induced impacts to resource availability while reducing the resilience of natural systems and biodiversity. Yet, adaptive capacity may be enhanced through economic development oriented around sustainability principles.

Placing people at the forefront of adaptation planning will require a number of shifts in how institutions frame the climate change challenge. First, the capacity of institutions to understand current and future demographic trends at a scale relevant for adaptation planning needs to be greatly expanded. Second, institutions must ensure the continued development of robust systems for service delivery that keep pace with demographic change. Third, service delivery must proceed in a manner that reflects the changing nature of the climate and its inherent uncertainties. This will necessitate more holistic approaches to environmental management that avoid trade-offs between environmental protection and economic development.

## Partner or Perish: Regional Governance for Local Adaptation

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Adaptation is rapidly becoming a mainstream strategy for the management of climate risk, and formal adaptation planning is emerging at a range of geopolitical scales. Least-developed nations, for example, have completed National Adaptation Programmes of Action as part of the United Nations Framework Convention on Climate Change. Australia developed a National Climate Change Adaptation Framework in 2007; the UK is implementing a national adaptation program under the 2008 Climate Change Act; and the United States is laying the groundwork for its own national adaptation policy. Despite such developments at the national scale, it is recognized that climate adaptation is largely a local process.

Australia is an interesting case study of the proliferation of adaptation efforts at the local scale, with a particular emphasis on the role of Local Government. Local Government represents a key stakeholder in climate adaptation, as there is urgent need to address local concerns and Local Government is the most legitimate instrument of government at the community level. Support for Local Government adaptation has come in a variety of forms. In 2006, the Commonwealth Government funded five two-year integrated assessment projects in partnership with Local Government. In addition, the Commonwealth Department of Climate Change launched a Local Adaptation Pathways Program in 2008 that provides grants to Local Government to support climate change risk assessments and adaptation planning. The Commonwealth

has also published overview reports on adaptation options for Local Government across a range of sectors. Meanwhile, State Government is expanding its role in adaptation, including funding for adaptation research centres, investments in climate change projections and geospatial data sets and the development of adaptation planning manuals.

Despite such efforts, there are signs that institutional arrangements have yet to be implemented that empower Australian Local Government to take a leadership role in adaptation. In particular, constraints on financial resources and access to expertise interact with the policy constraints embodied in State legislation to limit the power of Local Government. As a response, there is a clear movement toward systems of regional governance and organizational partnerships to help address these constraints. Australia's regional organizations of councils (ROCs) are active in leveraging resources for climate change assessment activities, exchanging knowledge and experience, and developing a stronger lobbying foundation to communicate Local Government adaptation needs. In addition, ROCs are increasingly partnering with research institutions to enhance Local Government access to technical information regarding climate change, its impacts, and adaptation solutions.

Hence, despite ongoing attempts to advance adaptation through the formal three layers of government, ad hoc informal regional networks are proving to be highly effective political structures. Climate change assessment projects undertaken by ROCs have received national recognition for their ability to highlight climate impacts and adaptation challenges at relevant scales. Furthermore, there is evidence that the power wielded by such regional organizations has helped stimulate the emergence of adaptation policy guidance from State government. Examples include planning policies and guidance for sea-level rise in both New South Wales and Victoria.

## **Community Landcare Networks, Social Capital and Adaptation Strategies: Lesson Learned for Community Adaptation to Climate Change**

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Reviewing the literature, this paper asserts that regional communities (both urban and agricultural communities) with high levels of social capital will be better able to assess climate change impacts (risks and opportunities), and to identify, evaluate, extend and implement appropriate adaptive strategies. Social capital refers to the features of social organisation such as networks, norms, and trust, that increase a society's productive potential. Social capital is generally considered an attribute of communities, whereas human capital is considered an attribute of individuals. It is now broadly accepted that improvements to social capital contribute to poverty alleviation and sustainable development and to general community well-being.

In the context of community adaptation to climate change (CACC), the paper states that social capital would refer to those aspects of social organisation that contribute to, or enhance, community participation, community innovation, internal and external communication, community decision making, consensus building and conflict resolution. Citing the literature and the authors' experience, the paper states that, from the point of view of government or industry wishing to engage with regional communities or community sub-sets, those communities with low social capital are less likely to effectively participate, to innovate, to resolve conflict, to build consensus, and to make collaborative decisions and reach agreement. Communities with low levels of social capital are also more likely to feel threatened by change and to deny or resist it, than they will be to adapt to, manage and take advantage of change.

While building social capital is a longer-term and potentially complex process, a number of key lessons relevant to CACC can be distilled from the experience of community-based natural resource management (CBNRM) in general, and from the Australian Landcare experience in particular. In reviewing the Landcare experience, this paper identifies the following important aspects of social capital that may contribute to CACC: the building of community trust; local resource mobilisation; group learning and co-learning opportunities; the ability to extend knowledge, and influence the attitudes and behaviours, both within groups and between groups; landscape approaches to natural resource and environmental management; the ability to attract and utilise greater resources; within- and between-group reciprocity; and the ability to form horizontal and vertical linkages with other groups.

The Landcare experience highlights both opportunities and challenges for successful CACC. High social capital communities are likely to better enable community adaptation to climate change through:

- collectively assessing and accepting, impacts, risks and opportunities;
- identifying and adopting suitable adaptation mechanisms;
- testing, refining, and extending adaptive mechanisms throughout their community;
- developing links with researchers, government and industry organisations; and,
- enabling communities to better articulate their needs and negotiate with policy makers and resource providers.

However, there are several challenges posed by climate change adaptation for which the Landcare experience does not provide ready answers. The paper briefly discusses the following challenges, and suggests potential solutions.

- How do we deal with potential confusion and disagreement regarding climate change acceptance in regional communities?
- How do we identify, validate, modify and extend new technologies and approaches given that, in many jurisdictions, government-funded NRM and agricultural extension services have generally declined over the last decade?
- How do we learn from, and foster, urban groups that might target adaptation and sustainable livelihood strategies?

- How do we accommodate and resolve the greater degree of value diversity, interests and needs (and potential conflict) likely to be encountered in disparate urban Landcare groups when compared with more uniform rural Landcare groups?
- What are the roles of the three levels of government in building social capital for the purposes of CACC?

Finally, the paper makes recommendations relevant to government policy-makers who wish to build social capital for the purposes of CACC.

## **The Sustainable Livelihoods Approach: a useful conceptual framework for participatory community-driven processes for the identification of climate change impacts and community adaptation strategies**

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Communities themselves must actively participate in the assessment of likely climate change impacts (positive and negative), and in identifying potential adaptive strategies. Effective facilitation of community engagement requires a robust and functional conceptual framework for assessing impacts and identifying adaptive strategies that can be understood and utilised by participating communities.

This paper proposes that one such framework, increasingly used in community development initiatives over the last decade, the Sustainable Livelihoods Approach (SLA), with some modification, is well suited to developing community adaptation strategies involving participatory processes.

Climate change impact assessment and adaptation (CCIAA) is necessarily a holistic concept, encompassing biophysical, social, cultural, economic and political dimensions. The SLA is a useful holistic conceptual framework that can easily be adapted for CCIAA. Over the last decade, the SLA has gained increasing attention in community development interventions in developing countries.

According to the UK Department for International Development, the SLA incorporates:

“the capabilities, assets (including both material and social resources) for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.”

The SLA holds that community development must be holistic in its approach, whether it is related to health, environmental or economic outcomes. The SLA attempts to link an understanding of the development problems confronting the family, group or community, with the resources it owns or can access. It provides a conceptual framework that recognises that any group or community has seven capital assets. These capital assets are: natural, financial, human, social, physical, political and spiritual.

The SLA recognises that adaptation investments targeted at one capital area are more likely to be effective if the other capital assets are strong. Alternatively, investments in a particular asset area may be ineffective if one or more of the other capital assets are poor. For example, investments in natural resource management extension are less likely to be effective where groups or individuals are economically unviable. Similarly, investments in human capital (e.g. farmer training to increase agricultural production) are less likely to be effective when the natural resource base is poor. Livelihoods objectives are necessarily holistic. Thus, when taking a sustainable livelihoods approach, integrated natural resource management (NRM) strategies must also be explicitly concerned with social, political and economic perspectives. The SLA also assesses the differential vulnerability (to shocks or change) context of individuals, households and communities, and recognises that threats to one asset may also impact on other assets.

If utilised by community groups and their facilitators, the SLA is best employed in conjunction with an appropriate Participatory Monitoring and Evaluation system in order to help groups to reflect upon, assess, and build their own capital assets. One strength of such an approach is that the natural resource and environmental assets are seen as integrated into the livelihoods necessary for survival and for enhanced human well-being. Thus an SLA perspective explicitly addresses the concern that environmental or NRM activities may be seen as external to productive activities. The value of this perspective for CCIAA is that community support is more likely to be generated for what may initially appear to be peripheral issues (e.g. biodiversity conservation) when they are considered alone, than when they are viewed as interrelated to other issues or survival strategies within a livelihoods perspective.

This paper describes how the SLA may be used by communities within a CCIAA process using the following generalised steps.

1. Community-led identification and assessment of their seven capital assets (with the support of community facilitators).
2. Identification of climate change impacts (positive and negative) on capital assets (with support from relevant state and local government agencies or non-government organisations).
3. Identification of potential strategies to mitigate negative impacts and enhance positive with a view to enhancing the capital base of each of the assets.
4. Accessing resources (both community and external) to implement priority strategies.



5. Initiation of participatory monitoring and evaluation processes for ongoing assessment of the success of the adaptation strategies and the health of the capital assets.

Finally, the paper concludes by making recommendations as to how to replace conventional and limited community and government interactions with a more participatory, inclusive and holistic livelihoods approach.

## **Effective Community Engagement to Reach Agreement over Climate Adaptation: Utilising Consensus Building and Joint Fact-Finding Strategies**

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Community adaptation to climate change requires a participatory approach involving regional communities. This is because recent, more refined, regional climate modeling has indicated that there will be regional variations in climate changes and their impacts. Regional approaches will thus also be important to identify regionally- relevant and appropriate adaptation strategies.

Community perceptions and acceptance of impacts (risks and opportunities) will largely be socially mediated, and may involve disagreements. Thus regional communities must be engaged in a participatory manner for impact assessment, and to enable appropriate adaptation strategies to be identified and adopted.

Two techniques increasingly used in the field of environmental dispute resolution (EDR) may be relevant to this adaptation processes. These are consensus building and joint fact-finding strategies. This paper briefly describes the nature of these two approaches, and illustrates why and how they could be utilised in regional community engagement strategies for the purposes of climate change adaptation.

The US (and recent Australian) experience with consensus building in natural resource planning, policy negotiations, and EDR has been generally positive. 'Consensus building' can be defined as a process of seeking unanimous agreement. It involves a good-faith effort to meet the interests of all stakeholders. Consensus building has been reached when everyone agrees they can live with whatever is proposed, after every effort had been made to meet the interests of all stakeholding parties. Normally consensus-building processes require an independent facilitator, or where there is a greater degree of conflict, an environmental mediator.

Consensus building may involve an extensive range of steps, depending upon the complexity of the issue. The following steps are usually involved: convening, clarifying responsibilities, deliberating, deciding and implementing.

While these steps illustrate a general schema, consensus-building processes should be designed specifically for each situation. Commonly, consensus-building processes will involve scientific and technical information, and social, economic or cultural issues or information. Often there will be disagreement among stakeholders as to who can be trusted to collect, analyse, interpret and present this information. This will be particularly relevant to gaining community agreement on climate change impacts and adaptation. In these situations, joint fact-finding approaches may be used.

Many climate change adaptation issues will involve considerable uncertainty over outcomes. For example, differing stakeholder perceptions over the likely climate impacts on natural resources, and differing assessments of future risk, may mean that the accuracy and validity of scientific and technical information will be contested. Where each party to a disagreement presents their own carefully selected scientific information or scientific experts that support their own interests and claims, the resulting debate is sometimes referred to as 'adversarial science'. Adversarial science is evident in some aspects of the current climate change debate.

Scientific uncertainty, its complexity, and disagreement among scientific experts, and misunderstandings among lay (non-science trained) stakeholders about the nature of scientific debate, can all prolong conflicts, further damage poor relationships between parties, and postpone decision making.

One alternative to adversarial science gaining support is the 'joint fact-finding' approach. Joint fact-finding is a strategy normally used within consensus decision-making, and involves the negotiating parties working collaboratively to identify and collect trustworthy scientific information relevant to the conflict. Joint fact-finding commonly includes the following elements:

- parties to the negotiation pool relevant information, rather than withholding it from each other;
- there is a face-to-face dialogue between technical experts, decision makers, and other key stakeholders, with the dialogue often managed by an independent facilitator or mediator;
- technical information is normally translated into a form that is accessible to all participants;
- areas of scientific agreement and areas of scientific disagreement and uncertainty are mapped; and
- a single negotiating text records the results of the joint fact-finding process.

The claims made in the literature for joint fact-finding approaches are that, compared with other more adversarial approaches, they are more likely to mitigate or resolve intractable environmental disputes; they deal explicitly with differing assessments of environmental risk among the parties; and they are more likely to lead to higher levels of satisfaction among the parties in relation to the environmental assessment process.

Finally, the paper makes recommendations as to how community engagement for climate adaptation - utilising regional consensus-building and joint fact-finding approaches - may be designed and implemented.

## Feasibility Study for Combining Adaptation Aspect in to a Long Planning Project of the Rail Transportation Sector

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This is a five year project for establishing an End-of-Life treatment system of the rail vehicle. The ultimate goal is to enhance the scale of sustainability for rail transportation. The expected results of action are to reduce greenhouse gas emissions including minimize non renewable resource acquisition. All rail vehicles after used will send to this system. Indeed, this project closely relates to the Mitigation of the Climate Change which is on the political agendas for the most country. Within the framework of the Climate Change issue, one further significant form should perform. The complementary form of adaptation which mentioned about the unavoidable impact of Climate Change is that significant and has disclosed recently. The early preparation against those potential impacts is its addressing. Because this project is at the initial step, taking adaption aspect into account in planning will be necessary. The modification of system in a late stage can be very costly. The first year action of project is a scoping research determining the location of treatment infrastructure where less damage to facilities and infrastructure from the unpredictable weather conditions. Next task looks at designing of building, utility system and infrastructure, as well as analyzing transport system carrying products to treatment site. The project is the engagement of research institute, rail industry, technical infrastructure, and local authorities. Hence, the detailed assessment will be generated to facilitate the policy maker taking action to mitigate and adapt those risks.

## Adaptation Measures to Climate Change

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This paper presents findings from the assessment of adaptation measures to climate change in the Mongolia's livestock sector. Mongolia's development is highly dependent on pastoralism, and the sector already suffers from impacts of climate variability, particularly due to severe winters and summer droughts. The study recommends several adaptation measures for livestock herding and pasture carrying capacities in Mongolia. These measures focused on increasing livestock productivity, as well as the maintenance of pastures used by the livestock. The arid to semi-arid climate of Mongolia supports extensive grasslands that, while fragile, have sustained pastoral herding for centuries. Mongolia's pastures are the key natural resource input to livestock production. In recent decades the climate has become warmer and drier. Climate change threatens to reduce the production of forage grasses by this resource and may, in combination with heavy grazing pressures, degrade the land itself. Particularly, the productivity of Mongolia's pastures has declined 20 to 30 percent. Another observed trend is an increase in the frequency and intensity of climatic extremes such as drought and severe winters, or zud (severe winter). Drought and zud events have caused livestock deaths, hardship for herders and, in some instances, large rural to urban migrations, unemployment, deep poverty and economy wide losses of income. Projections of future climate change indicate that Mongolia will become warmer still, potentially drier in summer and wetter in winter. There is also a threat of even more frequent and intense droughts and zud in the future. Our study of projected climate change finds that the rangelands, livestock herders, and pastoral livelihoods of Mongolia would be strongly impacted. Technical and scientific experts and authorities from local, provincial and national levels, give priority to adaptation strategies that would generate near-term benefits by improving capabilities for managing the extremes of drought and zud and long-term benefits by improving and sustaining pasture yields. Specific measures identified as advancing these broad goals and warranting further consideration include (i) improving pastures by reviving traditional system of seasonal movement of herds, reforestation and increasing vegetation cover to restore degraded pasture, expanding and rehabilitating water supply, and developing cultivated pasture; (ii) strengthening animal biocapacity by modifying grazing schedules, increasing use of supplemental feeds, and increasing feed and pasture reserves; (iii) enhancing rural livelihoods by promoting collective communities to regulate access and use of pasture and water, developing and transferring new technologies, educating and training of herders, establishing rural enterprises, and providing access to credit and insurance; (iv) improving food security by improving and diversifying food production and distribution system; and (v) research and monitoring to develop and improve forecasting and warning systems. Different methods were used to identify adaptation options. These include household survey, focus group discussion, multi-stakeholder workshops, and adaptation screening matrix. Assessing the preference among these options in different sectors is a complicated task for policy/decision makers, since there are multiple problems and objectives to be solved and met. Therefore, a simple approach, or the Screening Matrix of adaptation was used to examine the priority of measures. Adaptation options are qualitatively ranked as high, medium and low against the criteria to indicate the preference. More than 700 herders' households from 19 aimags were interviewed in order to verify our research and to describe major risks perceived by pastoralist and how they cope with problems caused by climate induced phenomenon. The identified adaptation options have been discussed in three level multi-stakeholder workshops in order to select the potential adaptation options. More than 200 participants attended the workshops, including policy makers, central and local governors, and animal experts such as veterinarians, environmentalist, climatologists and herders.

## Estimating design floods for gauged urban catchments under climate change conditions

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Correct assessments of catchment response to extreme storm events has been a longstanding challenge for engineers who are obliged to recommend planning decisions based on simplified catchment studies. An additional hurdle with these decision making processes is encountered, with emerging evidence on Climate Change impacts on regional hydrology. Traditional hydrological analysis is pursued with statistical information formulated under the assumption that the climate remains stationary. The difficulty faced is attributable to the fact that catchment scale hydrology for flood forecasting require fine scale rainfall data, which is almost impossible to derive for future scenarios with any consequential degree of certainty, and as such, remains a controversial research topic. In the absence of scientific consensus on the most appropriate method for estimating future sub-daily rainfall, planning has centered on recommendations to undertake sensitivity testing for individual catchments by scaling peak rainfall by 10-30%. With this in mind, the ensuing analysis will involve extending an existing urban flood study to include future flood forecasts. Methodology will involve statistically downscaling various scenarios of GCM rainfall using Nested Bias Correction to correct the GCM modelled outputs to regionally observed climatology at a daily time step; and using the scaled rainfall to develop a continuous simulation via non-parametric disaggregation which maintains temporal dependence at sub-daily time steps. This process is expected to provide a relatively simple method which can be used as a more accurate tool to make predictions for gauged urban catchments as compared to the present methods of IFD scaling.

## Health sector challenges to climatic variability and change: A case study of the South East Queensland, Australia

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The Intergovernmental Panel on Climate Change (IPCC) has identified South East Queensland as one of the six hotspots highly vulnerable to climate change. The coastal topography and growing population have made SEQ vulnerable to climatic variability and change. Climatic events including heatwaves, increased storms, cyclones, floods and droughts, bushfires, coastal hazards and UV radiation are all expected to increase in frequency and intensity and have commensurate impacts on population health. Within this context the aim of this paper is to provide a broad analysis of the challenges facing the health sector as a result of the health threats posed by climate change. The first part of the paper will focus the broad issues associated with climate change and human health and will discuss climate variability and change with special focus on SEQ context. The final part of the paper will address health system capacity issues and in particular issues associated with manpower, surveillance, resources and infrastructure.

## Regional Climate Change Adaptation Knowledge Platform for Asia

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The science is clear: climate change is here and will be challenging us for the coming decades. It is therefore necessary to adapt not only to these specific changes, but also to the new uncertainty about our future climate.

To be able to take decisions on how best to adapt, it is essential to have access to reliable information on likely climate change impacts, the associated aspects, the choices, approaches and benefits of different adaptation options. Adaptation is dependent on customized solutions and formulation of effective adaptation solutions is possible only through effective management of knowledge from various domains (science, policy, financing, indigenous knowledge, experiences, etc.). There is a need for knowledge generation, assimilation, management and dissemination to support adaptation across all stakeholders.

The Regional Climate Change Adaptation Knowledge Platform for Asia (hereinafter, referred to as the Adaptation Knowledge Platform) aims to respond to demand for effective mechanisms for sharing information and knowledge on climate change adaptation and developing adaptive capacities in Asian countries, many of whom are the most vulnerable to the effects of climate change.

Adaptation Knowledge Platform focuses on three pillars:

- Establishing a regional system for sharing knowledge on climate change adaptation, making it easy to understand and available to those who need it;
- Generating new knowledge about adaptation that national and regional policymakers can use as they plan for climate change; and
- Promoting the application of new and existing knowledge about climate change in Asia.

Through its work, the Adaptation Knowledge Platform is working towards building bridges between existing knowledge on adaptation to climate change and the governments, agencies and communities that need this information and knowledge to make better informed decisions and responses.

In its first phase (2009-2011), the Adaptation Knowledge Platform will actively engage in 13 countries: Bangladesh, Bhutan, Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, the Philippines, Sri Lanka, Thailand and Viet Nam.

The Adaptation Knowledge Platform's approach towards enhancing and sustaining information and knowledge management for climate change adaptation at regional and national level aims to blend and bring synergy between people, processes and technology. The focus is on activities supporting three pillars: networking, developing knowledge products and capacity development.

The Adaptation Knowledge Platform is supported by the Swedish International Development Cooperation Agency (Sida). Initial partners are the Stockholm Environment Institute (SEI), the Swedish Environmental Secretariat for Asia (SENSA), the United Nations Environment Programme (UNEP) and the Asian Institute of Technology (AIT)/UNEP Regional Resource Centre for Asia and the Pacific (RRC.AP), which also hosts the Adaptation Knowledge Platform Secretariat.

The Adaptation Knowledge Platform collaborates with the Asia Pacific Adaptation Network, working closely in implementing activities in South and Southeast Asia. It also provides technical support on climate change adaptation knowledge to the South East Asia Network of Climate Change focal points.

The online portal, Climate Change Adaptation in Asia and the Pacific ([www.asiapacificadapt.net](http://www.asiapacificadapt.net)) is supported by the Adaptation Knowledge Platform and the Asia Pacific Adaptation Network. The online portal uses the weADAPT Platform to share knowledge and experiences. This includes a Google Earth function where information on climate change adaptation is geo-referenced and can be visualised on a globe. The poster presentation will highlight strategies, approaches, activities undertaken for effective creation, capturing, sharing, and managing knowledge in climate change adaptation.

Invitations will be extended to the Asia-Pacific Climate Change Adaptation Forum, 21-22 October 2010, Bangkok, Thailand. The Adaptation Forum 2010 will provide opportunity to share practices, knowledge and experiences on mainstreaming adaptation to climate change into development planning in Asia and the Pacific.

## Assessing and managing extinction risk under climate change

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Climate change is recognized as a major threat to biodiversity with expectations that many plant and animal species are unlikely to survive. Appropriately assessing species' risk of extinction under climate change is crucial for devising suitable mitigation and adaptation strategies. Unfortunately the potential effects of climate change on species' extinctions and ecosystem changes are poorly understood. A common approach for predicting species' responses to climate change uses habitat suitability models or bioclimatic envelopes. These models use present-day species climate relationships to project the potential distribution of species under future climates. Inferring extinction risk based on bioclimatic shift alone becomes problematic as it is unclear how a shift in distribution relates to extinction risk. Species responses to climate change will also depend on landscape, population and dispersal dynamics, species interactions, and existing stressors such as habitat loss, predation and disease. Predictions of species responses based solely on projected bioclimatic changes are incomplete as they fail to account for these important processes and interactions that may influence extinction outcomes.

We apply an integrated modelling framework to assess species extinction risk under a changing climate that incorporates interactions between population dynamics and landscape level processes in a changing climate. We couple time series of habitat suitability models with spatially explicit stochastic population models to explore factors that influence extinction risk under a stable and changing climate. We illustrate this integrated framework through two case study species with very different life history traits; *Callitris verrucosa*, a mallee pine potentially affected by an altered fire regime and grazing of seedlings on agricultural land, and *Xanthorrhoea resinosa*, a grass tree in coastal heath threatened by disease and an altered fire regime. Results indicate that complex interactions between life history, landscape dynamics and disturbance regimes may compensate species extinction risk under climate change. This highlights the need to have methods that link population and landscape dynamics as it can highlight the processes and interactions that influence extinction risk greatest and can lead to development of more effective conservation strategies that mitigate biodiversity losses due to climate change.

## Scenarios vs probabilistic futures: towards a risk-based understanding of climate change and adaptation priorities

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Risk-based approaches to adaptation generally benefit from probabilistic descriptions of future changes in climate and their associated impacts. Probabilistic descriptions are particularly useful for engineering-type adaptation responses where infrastructure is designed to withstand extreme events (such as floods or high sea levels) that occur with a given probability. By contrast, guidance material provided or supported by governments on climate change commonly describes future climate change not through a single probability distribution of future changes but through a range of alternative scenarios associated with alternative global emissions pathways. This approach recognises that some drivers of future climate change, particularly global socio-economic developments that influence future greenhouse gas emissions, are not predictable in an objective way.

We discuss how and under what conditions the use of a set of alternative scenarios can best support informed adaptation decisions, and where a single cumulative probability density function across a range of alternative emissions pathways might better assist risk-based approaches to adaptation decision-making.

We argue that providing a set of alternative scenarios for adaptation assessments could result in under-adaptation if the use of such scenarios at the local decision-making level is not coupled with a risk-based understanding of potential climate change impacts. In situations where damages increase non-linearly with the amount of climate change, we show that from within the range of plausible futures, high-end scenarios are much more important to guide adaptation decisions than low-end scenarios even if they are considered less likely than mid or low-end scenarios.

Our analysis suggests that the main benefit of alternative climate change scenarios based on alternative emissions pathways is that they can enable a consistent treatment of the potential flow-on effects of global and regional socio-economic changes as well as the global and regional climate changes and the responses to those changes in local economies and societies. For countries that are intimately connected with the rest of the world through trade, migration, technologies, aid and security, such flow-on effects could be critical for fully appreciating the impacts of climate change on specific locations, systems and sectors, but these aspects remain significantly under-explored. A greater understanding of the interdependency of socio-economic changes and local climate changes may also support a more strategic understanding of key vulnerabilities and critical adaptation decision-points, as well as provide input to local and national positions on desirable future emissions targets in international agreements.

## **Climate change impacts on energy consumption and GHG emissions in Australian housing**

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The Australian households' energy consumption contribute about 13% to the total national greenhouse gas (GHG) emissions, and thus, to the global potential for climate change. This is a 'coupled' problem in that certain climate change scenarios will, in turn, increase the total energy consumption - and the resulting GHG emissions - of Australian residential buildings. When this happens, the resulting adverse impacts from this vicious cycle would accelerate. This paper investigates the extent and degree of this coupled problem in the Australian setting. In particular, the impacts of several climate scenarios on the energy consumption and GHG emissions on three variations of a house in Melbourne, Sydney and Brisbane are assessed. In response to the changing climate, and depending on climate zones and fuel resources, the vulnerability of these houses (average, low-emission and zero-emission house) to increased GHG emissions is analysed. Then to maintain low-emission and zero-emission house performance even in the face of climate change, adaptation options in the design and operation of a house, which decouples or breaks this vicious cycle, are identified.

## **Psychological adaptation and psychologically significant responses to climate change**

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Psychological perspectives on climate change adaptation highlight a number of crucial but currently neglected aspects of adaptation and the 'Human Dimensions of Global Change'. These include multi-levelled approaches and analytic frameworks that encompass individual and experience-focused levels of analysis, social psychological process responses to the threat and unfolding impacts of climate change, and models, constructs, and indicators relevant to assessing the psychosocial impacts of climate change. Psychological research on human response to global environmental change spans four decades, providing particularly helpful perspectives and insights on human adaptation and adjustment to environmental threat, natural and technological disasters, and extreme and stressful environmental changes. But this very relevant and extensive body of theoretical approaches, research findings, and evidence-based applications continues to be a relatively unfamiliar disciplinary landscape in the environmental sciences. Of particular importance is the conceptual framing and theoretical elaboration of psychological adaptation processes across many different areas of psychology, which are seen to be important mediators of public risk perceptions and understandings, effective coping responses and resilience, overt behavioural adjustment and change, and psychological and social impacts. This historical and continuing focus on psychological adaptation within psychology and many health perspectives also highlights and demonstrates the multiple and important psychological consequences and benefits of taking what is seen to be meaningful action in the face of a clear threat to either human communities or the natural environment and/or with respect to human-caused adverse environmental impacts. A very important aspect of such psychologically significant behaviours (PSBs) is that they powerfully mediate and motivate those environmentally significant behaviours (ESBs) which are integral to both climate change adaptation and mitigation and human health and well being. This psychological window on climate change adaptation is arguably indispensable to genuinely multidisciplinary and interdisciplinary research and policy initiatives addressing the impacts of climate change. It perhaps also provides the best disciplinary vantage point we have on important interlinkages between climate change adaptation and mitigation. Interdisciplinary collaboration, and the transdisciplinarity mandated by the challenge of global climate change, require a more effective and informed cross-disciplinary language and discourse, and a substantial broadening of our understanding of adaptation processes and models, and discipline-based assumptive worlds and favoured levels of analysis.

## Understanding climate change impacts and adaption for ecosystems using qualitative models

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Over the past few decades, substantial progress has been made in understanding and predicting climate change due to human activities. However, we have far less understanding of the consequences of climate change for ecosystems. This is despite the fact that this understanding is critical if we are to develop successful adaptation strategies to preserve biological diversity and human well being. One of the difficulties for predicting climate change impacts on ecosystems is that the components of ecosystems (e.g., species) interact through complex direct and indirect feedback loops and these interactions are difficult to quantify. Although we commonly do have information on the direct links between the individual components of ecosystems (e.g., what species eats what), we rarely have information on the strengths of those linkages. We also rarely have direct information on the strength of dynamic feedbacks between ecosystem components. Nonetheless, these quantities can have important implications for the response of ecosystems to climate change and therefore effective adaptation responses. However, we can often learn a great deal about the likely response of ecosystems to climate change based on their structure alone. To demonstrate this, we undertook a qualitative analysis of the likely effects of climate change on marine ecosystems and the human communities that rely on those ecosystems in the South West Marine Region, Australia. We used an approach known as loop analysis that enables predictions to be made about changes in ecosystem components resulting from sustained perturbations to one, or more, of those components. Predictions are based on graphical models (known as digraphs) that specify the directions and causal relationships between ecosystem components. Based on these relationships, the effect of a perturbation on any component can be calculated. A very useful aspect of loop analysis is that no assumptions are required about the magnitude, or functional form, of the relationships between components, only the direction. It also allows for the identification of which critical components of a system we require quantitative information for to fully understand the impact of perturbations such as climate change. We applied this approach to two systems in the South West Marine Region: (1) a pelagic system and associated fisheries; and (2) the western rock lobster fishery. We identified the likely impact of climate change on the ecological and social components of these systems and possible adaptation responses. In general, climate change impacts were predicted to be negative for both ecological and social ecosystem components. Many uncertainties remain, but it was possible to show which interactions it is most important that we have quantitative information for to reduce this uncertainty. We therefore suggest some research priorities for these systems. In addition we identified a number of potential climate change adaptation strategies for these systems. We suggest that loop analysis provides a general framework for qualitatively predicting the effect of climate change on ecosystems and identifying potential adaptation strategies. Importantly, it also provides a method for identifying future research priorities.

## The value of improved weather forecasts and socioeconomic information for preventing meningitis outbreaks in sub-Saharan Africa: A decision analytic tool to allocate meningitis vaccine in the face of uncertainty

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Meningitis epidemics in sub-Saharan Africa are observed to occur in the dust season and end with the onset of the rains. Uncertainty about weather patterns and socioeconomic factors that increase meningitis risk complicate the allocation of scarce vaccine. This project is a first step toward Google.org's vision of an Earth-gauging network, which seeks to integrate environmental, social, and economic data to help communities respond to emerging environmental forcing. This project's activities include: 1) developing a model of the vaccination allocation decision problem at the regional, national, and international levels, 2) developing an information system combining epidemiological and weather data to support vaccination decisions integrated with Google Earth, 3) developing improved 1-14 day weather forecasts, 4) examining other factors (i.e., socioeconomic/cultural) that influence meningitis outbreaks, and 5) evaluating the benefit of improved weather prediction. The presentation will report on an influence diagram model of the vaccination decision problem and the project progress to date.

## International Co-operation on Adaptation to Global Environmental Change: Earth System Science Partnership (ESSP) and Earth System Analysis

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Sound science in support of adaptation activities is challenging. Human interaction with and adaptation to a changing environment (including mitigation) can take many forms, and can have both positive and negative environmental impacts (bioenergy is a good example). The need, therefore, to understand how individual aspects of and processes in the natural and social domains underpins the answers to questions of adaptation. The basic science research needed to support decisions about adaptation clearly needs a tightly coupled natural-social science support structure. At the same time, scientists, resource managers and policy makers also require a common understanding in order for their interactions to be mutually beneficial.

As a result of the first Global Environmental Change (GEC) open science meeting, the Amsterdam Declaration ([www.gecopen.org](http://www.gecopen.org)).

[igbp.net/documents/amsterdam-declaration.pdf](http://igbp.net/documents/amsterdam-declaration.pdf)) was articulated in 2001, whereby the scientific communities of four trans-national environmental research programmes – an international programme of biodiversity science (DIVERSITAS), the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Environmental Change (IHDP), and the World Climate Research Programme (WCRP) – recognised that the immediate threat of significant climate change and growing concern over the ever-increasing human modification of other aspects of the global environment combine into massively destructive impacts on human well-being. Basic goods and services supplied by the planetary life support system, such as food, water, clean air and an environment conducive to people's health, are being affected increasingly by global environmental degradation. The Amsterdam Declaration set out the international research programmes' Earth System Science Partnership (ESSP). The ESSP facilitates the study of the Earth's environment as an integrated system in order to understand how and why it is changing, and to explore the implications of these changes for global and regional sustainability, including adaptation to climate change.

In this paper we review the increasing demand for trans-national GEC research to contribute towards adaptive solutions as the stresses imposed by human activities on the life-support systems of planet Earth become more pressing. Today, the climate and indeed the GEC research community generally faces an increasing challenge to present research results in more accessible and informative ways to stakeholders, especially to policy makers. This demands that inter- and trans-national research builds into political and economic decisions (i.e. that research improves societal outcomes) with an understanding of the kind of information that decision-makers need.

In response, GEC research, under the auspices of the ESSP, has delivered valuable knowledge products: for example, the ESSP-Global Carbon Project's annual global carbon budgets ([www.globalcarbonproject.org/carbonbudget](http://www.globalcarbonproject.org/carbonbudget)) and the ESSP-Global Water System Project (GWSP) digital water atlas (<http://atlas.gwsp.org>).

ESSP and its partners help facilitate international co-operation and contribute to science in support of adaptation. This paper presents salient examples from the GEC research community, with particular emphasis on the ESSP bioenergy study led by the Global Carbon Project ([www.globalcarbonproject.org/meetings/Bioenergy.html](http://www.globalcarbonproject.org/meetings/Bioenergy.html)). This ESSP bioenergy study is driven by the need to adapt to global environmental change and serves as an important benchmark for Earth system analysis. Time lags between research and policy and the frenetic pace of change also highlight the need to develop new analysis tools to tackle increasingly complex challenges facing humanity and planet Earth. The range of dimensions and scales in GEC research (tends to be systemic and covering the whole globe or large regions or systems) and applications such as adaptation that involves local communities poses a real challenge. Disciplinary research will continue to underpin climate and GEC science in general but addressing GEC problems also requires greater integration across disciplines, nations and all the other different dimensions and scales of the problems. Additionally, improved stakeholder engagement and community-wide understanding are essential to effectively tackle the adaptation challenges of today and tomorrow.

## Bayesian Networks as a novel tool for identifying barriers to community-based adaptive capacity

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Enhancing adaptive capacity in the context of climate change and at multiple scales (individual, local, regional, national and international) and across multiple communities is a priority management challenge. Fundamental to this is identifying the barriers that restrict a 'system', at whatever scale, from being better able to cope with the real or perceived threats and consequences of climate change. However, identifying these barriers is problematic given that there is great uncertainty and variability associated with the nature and impact of climate change even for perennial physical indicators such as sea-level rise and temperature. This problem is further amplified when viewed in the context of highly subjective relationships such as associated with more tacit variables (e.g. social dynamics and cultural capital).

Bayesian Network (BN) modelling is recognised as a well-suited methodology to representing the causal relationships of a system in the context of variability, uncertainty and subjectivity. They combine intuitive visual representation of cause-effect between variables, however subjective, underpinned by a robust mathematical framework. They have a demonstrated utility for combining subjective expert opinion with quantified data (measured and/or modelled data) and can infer these causal relationships even when there is incomplete evidence (data). BNs, however, have not been widely-used to explicitly model social dynamics even though they have recognised utility in modelling these types of unstructured systems. Rather, BNs have typically incorporated only a few (often one) social variables as an endpoint and which is often set to a quantitative scale such as 'willingness to pay'. The few examples of where BNs have been used to explicitly model social dynamics, however, have shown strong utility and practicality for enhancing adaptive management in the context of common-pool resource management.

We present here our work on using BNs to help identify and evaluate stakeholder perceptions to climate change adaptation as part of the South East Queensland Climate Adaptation Research Initiative (SEQ-CARI) project. Specifically, BNs are used to quantify causal relationships (and the uncertainty of these relationships) for a range of priority 'issues' as a means of identifying community-specific and generic barriers to enhancing adaptive capacity in the South East Queensland region. The BNs are developed through participatory modelling whereby key stakeholders fully participate in all development stages of these

models including identifying model variables and model structure and helping to populate the model (parameterisation) through expert opinion. This participatory process facilitates a common understanding amongst the stakeholders regarding the causal relationships of each model as well as informing them of the underlying assumptions, limitations and application (of the model), thereby effectively de-centralising ownership of the model away from the modeller and to the stakeholders themselves.

## Marine climate change impacts: Out of sight but not out of mind

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Climate change is impacting our global biodiversity. The IPCC 4th Assessment Report reported 28,671 significant biological changes globally, of which 90% were consistent with climate change. However, <0.3% of these changes were from marine systems and few were from tropical systems. This dearth of documented changes from marine systems is a consequence of a number of reasons, including the distribution of global science funding, the difficulty of disentangling multiple stressors from relatively poorly sampled systems, the way marine ecologists report their research, and the lack of a global synthesis on marine biological impacts. This fundamental information, about what organisms and systems are most vulnerable, is critical for developing integrated management strategies to protect marine environments and conserve fisheries. This presentation describes preliminary findings from a National Center for Ecological Analysis and Synthesis (NCEAS) Working Group to address a number of these key questions concerning the vulnerability of marine systems to climate change. 1. Which marine species, groups and systems are most sensitive? 2. What are the similarities and differences in types and rates of responses in tropical, temperate and polar seas? 3. To what extent do human stressors increase vulnerability to climate change? To answer these, we have built a database summarising the observed impact of climate change on all marine habitats and organisms. The database is based upon field observations of climate change in the peer-reviewed and the grey literature where many valuable fisheries studies are found. Preliminary results from the database will be presented. We encourage researchers to submit their papers and reports on biological impacts of climate change for inclusion in the database. Findings from the Working Group will be produced in time to inform the IPCC 5th Assessment Report and the database will be publicly-accessible through the NCEAS website at the end of the Working Group.

## Does 'drought' exist anymore in Australia? The challenge of adapting to a normalised climate extreme

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Predictions of climate change impacts in southern Australia include two parallel changes: hotter and drier average conditions; and more frequent and severe droughts (periods of extreme dryness). The first of these changes has led to claims that drought is no longer an appropriate term in the Australian context and that a focus on droughts as short-term, cyclical 'disasters' is an impediment to adaptation to longer-term climate change. Using the federal government's predicted redefinition of 'exceptional drought' through the ongoing review of the National Drought Policy, and drawing on empirical research with the farming community, this paper examines the conceptual and practical challenges associated with understanding and adapting to drought in the context of climate change.

Drought is an important climate extreme to understand for six main reasons. First, not only is it predicted to become more common in southern Australia in the future, it is – or has been until very recently - an immediate and threatening reality for many communities in the area, particularly rural ones, where it is indeed being experienced as a disaster. As such, the current drought makes it difficult for these groups to even think about climate change, not only because it 'competes' conceptually with climate change, but because it is eroding the physical, economic and mental reserves they need for adaptation. Insights from an in-depth and long-term social research project with farming families in the Wimmera Mallee region of north west Victoria are presented to illustrate the challenge such families face in adapting to climate change while in the midst of drought.

Second, drought highlights the way 'natural' disasters are co-constructed by humans, being as much about water demand as water supply, which reminds us of the need to take sensitivity to a threat into account as well as exposure. Water supply is also a 'more than natural' phenomenon, being strongly shaped by social, economic and political factors as well as environmental. The 'triple' drought being experienced by irrigators is used to illustrate this point. Third, related to this, declarations of 'official' drought or meteorological drought often sit uncomfortably alongside personal experiences



of drought, not only temporally but in terms of how drought is understood, communicated and responded to. The role of water restrictions as communication tool as much as behaviour change tool is discussed in relation to this point.

Fourth, the increasing ‘commonness’ of drought under climate change raises the question of whether increasing familiarity with a threat such as drought increases or decreases our perception of its risk. Literature on this point presents mixed findings. Fifth, the current debate about the definition of drought in Australia illustrates how natural disasters are also socially constructed at a more profound level through language. Recent changes to the national fire danger index are another example of this process. Finally, drought provides an example of how this construction process can be manipulated and used for ideological ends, such as a neo-liberal agenda to privatise risk, which has implications for the vulnerability of different groups. All of these elements of drought help us to better understand the challenges we face in understanding and adapting to the more frequent and severe climate extremes that are emerging under climate change.

## Adaptation of the Australian electricity sector

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ROAM Consulting is a leading provider of expert services in energy market systems for participants in the Australian National Electricity Market and in other energy markets around the world. With a focus on detail, ROAM provides modelling services for a wide range of clients including the Australian Energy Market Operator, the Department of Climate Change, generators, transmission companies and renewable energy developers.

The electricity sector is now investigating how to mitigate climate change, but the necessity of adaptation is rarely considered. Due to the long timeframes over which electricity infrastructure is relevant, consideration of adaptation needs is essential. ROAM has therefore conducted a holistic analysis of the impacts of climate change on the electricity sector in Australia, determining the system elements that are likely to be most strongly affected.

Maintaining security of supply is found to be an increasing challenge, with bushfires, lightning, very hot days and extreme winds causing increased transmission and generation forced outages. Double contingencies may become credible events, which will significantly reduce the flexibility in operating the grid. The potential of decentralised energy as a adaptation response is considered.

The increased number of very hot days is also likely to make it increasingly difficult to provide sufficient capacity at the time of peak demand, due to decreased transmission and generator ratings (both significantly reduced on very hot days) combined with rising peak demand (from air conditioner loads). This will be exacerbated by drought conditions, causing reduced output from hydro generators and possible shut-down of wet-cooled thermal power stations due to lack of water. Despite lower efficiencies (and hence higher greenhouse emissions) it may be preferable for all new thermal generation to be dry-cooled to avoid this eventuality.

Possible adaptation responses to the various issues are suggested, including the increased importance of demand side management as not only an aid to mitigation, but a technology necessary for adaptation.

## Urban Water Supply in an Energy Constrained Australia: the water-energy nexus

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Increasing population pressure, natural climate variability and susceptibility to projected climate change impacts are placing ever-increasing strain on existing water infrastructure in Australia. Historically, water infrastructure has focused on meeting urban water demand via a range of ‘low-energy’ approaches predominantly based on the capture and storage of surface runoff; however, this approach is proving to be no longer sufficient to satisfy the increasing urban water demand.

Water service providers have been seeking to minimise supply risk through the implementation of a diverse range of energy-intensive climate-independent solutions. To date, water service providers have investigated numerous options and implemented a range of alternative water sources, such as desalination, groundwater extraction, pipeline distributions and recycling schemes. These water sources, however, rely on technologies that are significantly more advanced and/or have much higher operational energy costs, and to date, many attempts to address emerging water supply problems in Australia have come at an increased economic and environmental cost.

Detailed assessments and understanding of the ‘water–energy nexus’—the interactive relationship between water and energy—are crucial precursors to enable the water sector to reduce its operational energy costs and facilitate the design of water and energy systems capable of realising any synergistic benefits. Under the current acclimate, in which energy supply and pricing issues are becoming increasingly important in the public sphere, having an improved understanding of this linkage will allow water service providers to be more aware of the energy impacts of key water infrastructure and be more responsive to future changes in the cost of their energy supplies.

This literature review addresses the water–energy nexus in the context of urban water supply by assessing the current energy requirements and associated operational energy costs for a number of important water and wastewater treatment technologies. Additionally, a critical review of various water supply options either currently implemented or being investigated by water service providers is presented from an energy perspective. Finally, system management approaches as well as other alternative low-energy water supply or savings options are discussed.

## Modelling coastal saltmarsh response to sea-level rise to predict vulnerability and resilience

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Coastal saltmarsh is an endangered ecological community in New South Wales and sea-level rise has been listed as a key threatening process. Over the previous five decades moderate rates of sea-level rise have coincided with the invasion of saltmarsh by mangrove. Surface elevation tables (SETs) were installed in 12 coastal wetlands in southeastern Australia to establish elevation and accretion trajectories for comparison with mangrove encroachment of saltmarsh and sea-level rise. SETs confirmed that the elevational response of wetlands is more complex than accretion alone and elevation changes may also be attributed to below-ground processes that alter the soil volume such as subsidence/compaction, groundwater volume fluctuations, and below-ground biomass changes. A simple modelling approach was employed to establish a relationship between the observed rate of mangrove encroachment of saltmarsh and relative sea-level rise, which incorporates the eustatic component of sea-level rise and changes in the marsh elevation. Increasing access to high resolution digital elevation models has enhanced our capacity to model the response of coastal wetlands to sea-level. Preliminary modelling of the projected distribution of saltmarsh by 2100 on the Hunter River estuary, NSW, has been undertaken using high resolution digital elevation models and elevation trajectories. Long-term datasets of elevation dynamics and improved understanding of the feedback mechanisms influencing marsh elevations will further enhance our modelling capacity. Site-specific models of coastal saltmarsh response to sea-level rise predict saltmarsh vulnerability and resilience and are an important tool for management of coastal habitats.

## Planning for climate change in New South Wales: do planning laws and climate change litigation hinder or help?

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Climate change is a global problem which poses risks at the local level. In Australia, although the Commonwealth government has recently conducted an inquiry into climate change and environmental impacts on coastal communities, there is a general dearth of Commonwealth legislation on climate change adaptation. In contrast, commentators have acknowledged the innovative approaches of many local Councils in pioneering strategies in climate change adaptation. However, local government planners must balance the ongoing pressure for coastal development with the urgent requirement for adaptation measures; there can be conflict between councils and property owners over the appropriate use of vulnerable coastal land. Furthermore, local government planners must work within the restrictive parameters of the current legislative framework.

In this paper, I discuss the research outcomes of a qualitative research project undertaken in November and December 2009 and January 2010. In the course of this project, I conducted interviews with senior planners at the thirteen New South Wales coastal councils responsible for the nineteen 'hotspots' identified by the New South Wales government. My intention was to investigate local government planners' perceptions of the effectiveness (or otherwise) of existing NSW planning legislation, in the context of planning for climate change impacts along the NSW coastline.

In addition, I wanted to discover what local government planners thought about the expanding body of climate change litigation against councils, and to ascertain whether such litigation played a positive role in encouraging more effective climate change adaptation strategies on the part of local government. The inclusion of effective climate change adaptation measures in land use planning is not only a necessary response to reduce the vulnerability of coastal communities to climate impacts; it is also a necessary response to reduce future exposure to legal liability. I was interested not only in legislative reform but also in the impact of the so-called 'adaptation cases' on local governments, which increasingly find themselves targeted in such litigation.

Commentators tend to portray such litigation as a positive development because it serves to highlight the need for legislative reform but few have considered possible negative impacts of such litigation on local governments and their employees. At the 'coalface', in the planning departments of local Councils, it is unclear whether such litigation encourages effective planning strategies. For instance, ongoing costly litigation over the Byron Shire Council's implementation of the policy of planned retreat at Belongil Beach, where apparently more than 25 properties are at risk of demolition, might well discourage other Councils from adopting a similar approach; this is despite the fact that the New South Wales Land and Environment Court has thus far supported the Council's application of this policy.

In seeking the perspectives of those involved in the practical operation and application of existing legislation and planning instruments, my intention was to 'study the law in action'. However, during the interviews the research project took on a broader focus, as planners discussed the many obstacles which inhibit effective planning for climate change impacts on the part of councils.

In my paper, I will set out my findings and discuss the nature of these obstacles and possible ways of overcoming them.

## How the combination of adaptation strategies and mitigation options, leading to a net CO<sub>2</sub> - sink, enhances the regeneration of the Peat Colonies, the Netherlands

R Roggema<sup>1</sup>

<sup>1</sup>Wageningen University and Research Centre, Netherlands

The Peat Colonies is a region where decline can be distinguished in population, service level, job availability, income and education level. At the same time the area is suffering from droughts in summer, agriculture and nature are vulnerable and people tend to become less proud on their environment. The starting point for this area is not too bright. The central question discussed in the paper is how adaptation strategies and mitigation options together can turn the development around. Thematic research on how agriculture, nature, living and water management can adapt to climate change and how agriculture (by using biochar), traffic (by introducing electric mobility) and living (by clearing the conditions for inhabitants to shift towards own production of sustainable energy) can contribute to reach a CO<sub>2</sub> neutral or better region, are integrated and designed in a spatial structure vision. The aim is that people regain their confidence, become proud on their environment again and communicate the competitive advantages of a well-adapted and CO<sub>2</sub> neutral region, where daily life is cheaper. The ultimate effect of this is that people from outside the region are attracted and cause a stagnation in decline.

## Anticipative planning for future circumstances: The Groningen experience and the development of the swarm planning concept

R Roggema<sup>1</sup>

<sup>1</sup>Wageningen University and Research Centre, Netherlands

Current planning practice is limited to a short term period of maximum ten years. Climate change adaptation needs to start now, but has a longer period, in which the measures need to be executed. Moreover, as time goes by the type of measures can and will change due to new insights in required adaptation strategies. The climate adaptation plan for Groningen province illustrates how anticipative planning solves the problem of uncertainty and complexity, which develop on the long term. A new planning concept is developed to do so: swarm planning. In this concept blueprint planning is replaced by the implementation of interventions at key locations in the region, where strategic adaptive processes need to start. The results show that, using this planning concept, the region is better prepared and functions in advance of time and future circumstances.

## Socio-economic trends and implications for community based adaptive capacity

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Past approaches to assessing adaptive capacity and vulnerability to climate change are usually isolated to one particular place and point in time. However, the effectiveness of climate change responses is influenced by the adaptive capacity of all sectors of society over various spatial and temporal scales. Socio-economic characteristics have often been used to help determine a community's capacity to adapt to climate change related risks. However, other factors including cultural, institutional and technological characteristics interact to influence adaptive capacity. Moreover, these factors influence the vulnerability and adaptive capacity of various economic and social sectors differently. Much of the literature discusses adaptation through determinants in a particular space and time, with little reference to the temporal and spatial dynamics of adaptive capacity. Drawing examples from the socio-economic trends (current and projected to 2030 and 2070) of the South East Queensland (SEQ) region, this paper explores the dynamic relationships between socio-economic characteristics and potential vulnerability to climate change over time and space, and points to implications for those investigating sectoral impacts of climate change and adaptation responses. Gaps and limitations inherent within routinely available socio-economic data are also highlighted along with the challenges that these present.

Systems-based approaches to investigating the determinants of adaptive capacity within regional communities that utilize both pre-existing secondary data on socio-economic profiles and primary data collected through a variety of means are introduced. The paper will also examine the interplay of different socio-economic characteristics including population, age structure, education, employment, income, community disadvantaged groups, household structure and housing; and their implications to community vulnerability and the likely implications on adaptive capacity. The factors discussed are not meant to provide the whole range of determinants of adaptive capacity but examples relating to SEQ contextual influences to enhance a deeper conceptualization of the relationship between socio-economic characteristics. The paper will therefore not only highlight the important foundational aspects of adaptation research that account for the temporal and spatial dynamics of adaptive capacity and its relationship to climate change risk, but also advance the debate on climate change adaptation in general.

## A problem-oriented approach to adaptation in a business community: insights and lessons learnt from Alpine Shire, Victoria Australia

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Climate change is gaining attention as a significant strategic issue for localities that rely on their business sectors for economic viability. For businesses in the tourism sector, considerable research effort has sought to characterise the vulnerability to the likely impacts of future climate change through scenarios or 'end-point' approaches. Whilst useful, there

are few demonstrable case studies that complement such work with a 'start-point' approach that seeks to explore contextual vulnerability. This broader approach is inclusive of climate change as a process operating within a biophysical system and allows recognition of the complex interactions that occur in the coupled human-environmental system.

A problem-oriented and interdisciplinary approach was employed at Alpine Shire, in northeast Victoria Australia, to explore the concept of contextual vulnerability and adaptability to stressors that include, but are not limited to climatic change. Using a policy sciences approach, the objective was to identify factors that influence existing vulnerabilities and that might consequently act as barriers to effective adaptation for the Shire's business community involved in the tourism sector. Through mapping of the social context, particular attention was placed upon the role of embedded values – those of the researcher and participants alike - and how these influence the way in which problems are defined and constructed.

Analyses of results suggest that many threats, including the effects climate change, compete for the resources, strategy and direction of local tourism management bodies. Further analysis of conditioning factors, such as climatic variability and extremes, showed how these played a role in highlighting the dynamics of this contextual vulnerability. It also highlighted the extent of adaptive capacity of the Shire's tourism sector to the challenges of broader global change, which collectively have more immediate implications for policy and planning than long-term future climate change scenarios. An approximation of the common interest, i.e. enhancing capacity in business acumen amongst tourism operators, was recognised as a means for facilitating adaptability and sustainability in their pursuit towards achieving tourism sector goals.

### **'Ground-truthing' adaptation research – a collective reflection on contextual adaptation issues**

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In the same way ground-truthing is used in remote sensing to calibrate image data to real features, we reflect collectively on our experiences to 'calibrate' our understanding of adaptation. Despite diverse theoretical and methodological approaches, our work exposes contextual adaptation issues beyond climate change. Such issues represent immediate concerns for those who are directly impacted by policies and measures for adaptation and sustainability.

Three themes emerge:

Research approaches. Within climate change, adaptation has received considerable attention. However, many studies have relied upon 'end-point' methodologies to ascertain likely impacts. Whilst useful in highlighting likely impacts, this invariably restricts adaptation strategies. Adaptation encompasses many interacting drivers of change that includes but is not restricted to climate change. A variety of conceptual frameworks are used in adaptation research, which incorporate broader impacts including climate change. As researchers in this field, we have our own preferred theories and methodologies that are based on unique and distinct standpoints. But despite these differences in means, our end results demonstrate evidence for contextual adaptation issues.

Defining who is vulnerable and why? In line with other research, we have found vast inter- and intra-variability in communities who would otherwise be homogeneously labelled as vulnerable (or not). Variables often attributed to characteristics of vulnerability, did not necessarily reflect contextual reality. For example, a vulnerability assessment undertaken in the Thai coastal tourism destination of Khao Lak following the 2004 tsunami revealed that small and medium tourism businesses were largely overlooked by aid providers because of mandates that favoured 'traditional livelihoods'. Two of our studies were conducted in different communities within Australia, yet elements of adaptability were quite divergent. In West Arnhemland, cultural institutions appear to have built-in capacities to cope with environmental change. However, infrastructural adaptation is hampered at the municipal and Territory levels where other issues take precedence. Conversely, issues of social capital and a lack of formal and informal networks for regional support were found to be a constraint to adaptation in Alpine Shire, Victoria. Commonalities and differences identified in these independent studies have helped us uncover limits to adaptation, adding empirical depth and theoretical clarity.

Scale and relevance – Interactions between the local, regional and global scales are relational and exhibit non-linearities that need to be addressed in order to facilitate meaningful and relevant local adaptation. Global scale impacts are generally understood at coarse resolution, but locally may exhibit non-linear impacts unaccounted for in broader scale predictions. Similarly, adaptation occurs locally while decision-making, legislation and funding are generally controlled at State/Territory levels. We outline a series of conditions in which actors and processes move across preconceived scalar interactions to produce local expressions of impacts and adaptation.

Through collective reflection, we facilitated a fruitful blending of perspectives and a shared understanding of issues pertaining to human security. Reporting on the collective reflection of our research and on our own involvement as researchers serve as vital input for innovation and advancement of knowledge as we continue to 'ground-truth' this evolving field of research.

## CARAVAN: A tool for visualizing vulnerability to climate change in the Nordic region

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With their commitment to universal, tax-funded public services, the Nordic countries are often perceived as relatively “safe” from climate change. However, high national levels of adaptive capacity can mask potential barriers and constraints to adaptation at local scales. For instance, rural areas are gradually becoming depopulated, creating an ageing population that is increasingly vulnerable to extreme weather events as rural services are run down. The Nordic countries therefore provide an interesting example of how adaptation to climate change is likely to take on different significance at regional, national, and local scales. CARAVAN (Climate change: a regional assessment of vulnerability and adaptive capacity for the Nordic countries) is a two-year collaborative project (2008-2010) funded from national sources in the Nordic-Call of the EU CIRCLE (Climate Impact Research Coordination for a Larger Europe) project. CARAVAN aims to explore alternative approaches for estimating and mapping vulnerability to climate change at the municipal scale across the Nordic region. The project has developed a tool for visualizing vulnerability to climate change by incorporating approaches used in Norway, Sweden and Finland for assessing climate vulnerability in social and environmental contexts. The basic premise of the tool is that the vulnerability of a system or population can be described as a function of its exposure to climate change, its sensitivity to the impacts of that climate change, and its adaptive capacity to cope with the impacts. To map the vulnerability to climate change across the Nordic region, methods were developed to describe exposure to climate change based on a consistent set of climate observations and scenarios from a range of sources, including gridded climatologies, global and regional climate model projections, and statistically downscaled data. Impact models and indices were then used to evaluate sensitivity to climate change, and indicators of adaptive capacity were analyzed, based on statistical data at the municipal scale. Each of these elements are represented spatially in a web-based system and combined to visualize climate vulnerability at the present and for 2030. Rather than the research team making academic choices about how to combine the indicators into an index of vulnerability, the interface is designed to allow end-users to make informed choices about those combinations themselves. The tool is intended for high-level planners wishing to identify focal points (regions, sectors or communities) that may have difficulties in meeting the challenge of climate change through high exposure, enhanced sensitivity, limited adaptive capacity, or a combination thereof. Once identified, these focal points can then be analyzed in more detail to assess the need for policy interventions to enhance their adaptive capacity and to examine the possible barriers in implementing such measures. Two cases studies will be presented: agriculture and human health.

## Heat Stress, Urban Health and Labour Productivity: Adaptation Strategy for a megacity in India

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Climate projections for India indicate an increase in the temperature (maximum and minimum) to the order of 2-4°C by 2050 (Govt. of India 2004). It is important to note that Climate change induced heat stress is going to impose an extra layer of threat to already stressed sustainable development agenda in India with relatively poor performance in health sector. Case study of Kolkata (megacity with second highest population density in the world and highest population density in India) shows that heat stress is going to affect human well being adversely directly due to loss in labour productivity. With large informal economy in urban areas adds a new dimension to the problem. Impact of heat stress in terms of productivity of working force will pull down the national performance enormously in megacities unless adaptation strategies are adopted. The WBGT index shows that sometimes the loss of productivity is 100% of the working day for some occupation category without additional adaptation strategy. The paper tries to capture the impact of heat stress on human health with a major focus on the loss of labour productivity in terms of WBGT index. It is also shown that labour productivity can be enhanced with proper adaptation strategy. But adaptation is not without cost. So what is needed is comparison of costs against benefits.

## Me & My Community

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Providing leadership training for women and youth involved in rural-oriented businesses in Queensland by developing social and emotional well-being networks through focusing on the individual, families and communities.

The Centre for Rural and Remote Mental Health Queensland (the Centre) developed a three-day training program that combined elements of rural leadership with mental health literacy programs. This training was provided in the Queensland rural communities of Mt Isa, Longreach, Roma and Kingaroy.

The theoretical basis to the development of the training was that individuals who increased their knowledge about mental health and who were involved in a network or community have a greater capacity to develop personal resilience and adaptability. It was proposed that if the ability for a person to analyse new information could be improved and if they could learn strategies for managing change, they would respond more effectively and confidently to the changing and demanding environments.

The participants, who live and work in rural and remote Queensland, are continually confronted with situations over which they have very little or no control. These situations most commonly are environmental adversities such as drought, floods, bushfires etc. Some of the participants in this initiative have faced one or more of the following challenging situations: up to 10 years of unrelenting drought; severe flooding in the Gulf; recent adjustment and/or removal of Exceptional Circumstance declarations and associated payments in various areas; vegetation management legislation; high Australia dollar against the US dollar and wild rivers legislation.

The first day of the three separate training days focussed on the individual and included strategies for facing change, problem solving and networking. The second day focused on the role of the participant in their household and/or the workplace. The participants determined the content of the third day of training. In two locations, they requested the two-day Mental Health First Aid course. In the other two locations, a local mapping of the network of mental health services and the identification of the referral pathway was requested. Throughout the training the participants were introduced to and encouraged to adopt the learning process of the Active Learning Cycle to improve themselves and the environment in which they live and work.

The evaluation of the project has received ethics approval and consisted of pre, during and post training questionnaires as well as telephone interviews with participants.

Current indications suggest that training has been well received and that the leadership skills the participants have acquired has enabled them to pass on their knowledge about adapting to climate change. It is anticipated that as a consequence of the networking opportunities this initiative has provided, the participants will be able to confidently contribute to their respective community's capacity to adapt to change, build resilience and reduce the stressors which can lead to mental illness.

A National Workshop is being held in Cairns on the 24th September 2010 where the design, methods and outcomes of the training will be shared with interested organisations.

## **Dynamic Assessment of Coastal Vulnerability to Sea-level Rise: When and Where to Adapt?**

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Most infrastructure, settlements and facilities are located near the coast and are highly vulnerable to sea-level rise (SLR), coastal erosion and storms. Continued population growth in low-lying coastal areas will increase vulnerability to these hazards.

At the projected rates, SLR may not pose an immediate threat to coastal areas; nevertheless, a higher sea level will provide a higher base for storm surges to build upon and diminish the draining rate of low-lying areas, thereby increasing the risk of flooding from rainstorms.

Due to uncertainty in climate change predictions, coastal vulnerability assessments (VA) and most town planning activities are based on an assumption that sea level will remain constant in the future. However, climate change is undeniable and the resulting SLR is a reality that coastal communities will face in the coming decades. Thus, it is essential to consider coastal dynamics in assessing the impacts of SLR under various scenarios when preparing our cities for the future.

Currently, the number of regional-scale VA studies is limited. They are, however, required by local stakeholders to design adaptation strategies at a local level. Therefore, the knowledge gaps with respect to how coastal areas can adapt to climate change must be filled. The dilemmas confronting decision makers are: when and where to adapt to SLR.

By considering the complex and dynamic nature of coastal systems interacting and changing over time and addressing these dilemmas, this research intends to provide a dynamic model for a VA of coastal areas to assist decision makers to identify and evaluate effective adaptation alternatives for reducing climate change impacts.

The research models coastal inundation to make predictions about what might happen with different actions addressing a range of SLR scenarios. Under these scenarios, the extent and timing of coastal inundation and its impacts will be assessed in terms of a range of indicators; for example, impacted population numbers, impacted properties and socio-economic characteristics of impacted regions. The research examines natural and socio-economic systems already vulnerable to current climate variability by firstly analysing their current conditions, to provide a reference map to compare future conditions. It then analyses the systems under various scenarios to identify how climate change affects the already troubled systems over time.

Traditional modelling approaches focus on either temporal or spatial variations, but not both. However, it is the space-time integration that provides the explanatory power to understand and predict reality. Accordingly, they must be examined together for modelling the environment. Therefore, the research concentrates on the concurrent modelling of temporal and spatial variations of coastal processes. To achieve this outcome, two modelling techniques are combined: (1) System Dynamics, and (2) Geographical Information Systems.

A combination of these approaches would provide the potential to address temporal and spatial problems concurrently. Owing to the model's flexible structure, any other elements such as population growth and economic scenarios effecting coastal systems, can be integrated as needed. Users can change values of the model variables during the simulation process to test impacts of various scenarios.

## Adapting coastal policies and instruments to climate change: a case study from South East Queensland, Australia

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Coastal areas are highly dynamic systems, which are predicted to be adversely affected by climate change. This has a special resonance in Australia where over 90% of the national population reside in the coastal zone (Hennessy et al. 2007). It comes therefore as no surprise that climate change adaptation as a policy issue is currently gaining more prominence across all three levels of government in Australia. South East Queensland (SEQ) is one of the most developed and fastest growing coastal regions in Australia, and is considered a priority area for climate adaptation research by the Australian Government. Coastal areas of SEQ are extremely vulnerable to the effect of sea level rise, changing wave climate and extreme storms, considering that most of the population, which is expected to grow by 60% in the next 20 years, is concentrated in proximity to the beach front, canals, estuaries and tidal entrances, or within a coastal floodplain.

The coastal management framework applicable to the SEQ region includes a range of policies, plans and schemes issued by the three tiers of government. While the federal government offers informal guidance to the States in the implementation of their coastal policies, the Queensland Government is responsible for natural resource management, including coastal zone management. Local councils are then responsible of integrating the state coastal policies into local government instruments including corporate strategies, planning schemes and shoreline management plans.

This has implications for both the development and discharge of coastal management policies and plans, which now also require sea level rise and the possibility of increased natural hazards to be addressed (e.g. Government of New South Wales, 2009; Government of Queensland, 2009a, 2009b; Victorian Coastal Council, 2008).

Anticipatory adaptation is especially deemed effective as a means to respond to the unavoidable impacts (Carter 2007, Hallegatte, 2009) and this requires a clear understanding where liabilities and responsibilities lie in adaptation (Tomlinson and Helman 2006). To date there has been limited discussion about what kind of adaptation and adaptation strategies the different levels of government are proposing and what the synergies and possible differences are in practice. The federal government does not have jurisdiction in most coastal areas, so the options available for to them are either financial (funding adaptation schemes) or informative (funding scientific studies), but not likely regulatory action. This is different for State and local government who have increased regulatory responsibility and diminishing financial capacity.

This research therefore provides a critical approach in examining the current coastal governance instruments in Australia and to identify the synergies, differences and responsibilities between the adopted approaches at multiple scales. The focus lies on examining the coastal policy instruments at national, state, regional and local levels, while trying to understand the practical implications of the policies for specific local areas with high vulnerability such as Palm Beach on the Gold Coast in SEQ (Lazarow et al. 2008). Integrated coastal management is also discussed in terms of how climate change adaptation could be mainstreamed into current practices.

The study will be advanced using a multi-method approach (Norgaard, 1989) with a focus on identifying the nature of suggested adaptation strategies (anticipatory in particular) within policies. These are then compared with local level findings addressing place-specific vulnerability and the possible conflicts between public vs. private adaptation strategies to the unavoidable climate change impacts in coastal areas, as coastal changes are already issues of social justice (Cooper and McKenna, 2008). The research also draws on on-going discussions occurring in Australia regarding local government responsibility in providing public protection of private properties in terms of sea level rise and increased coastal erosion and the nature of different adaptation strategies being discussed.

## Adaptive Capacity of a Flood Vulnerable Community in Rural Bangladesh

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Bangladesh is highly vulnerable to flooding due to its geographical location in the Ganges, Brahmaputra and Meghna river basins. Every year at least 21% of the country is flooded and in an extreme case, the magnitude of inundation could be as high as 70%. Floods cause significant damage to the socio-economic sectors of the country. In the last few decades many adaptation measures have been implemented in Bangladesh; however, vulnerability to flooding still remains high. The affected people try to cope with the flood hazard and disasters with various coping mechanisms. The major objective of the project is to understand the local knowledge for their adaptation process to flood hazards in Bangladesh. This understanding will help crafting future adaptation strategies to tackle increased flood hazards under a climate change regime.

Pre-designed questionnaires with 40 questions have been used to conduct survey in the study area close to the Kaliganga River basin. Questionnaires have been designed around the six determinants of adaptive capacity- economic resources, technology, information and skills, infrastructure, institutions and equity identified by the Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report. Door to door interviews have been conducted in one hundred households/families comprised of different age groups and professions in four selected villages.

According to the most of the respondents, river overflows due to the drainage congestion is the prime cause of the flood in the study area. The result of the survey shows that almost all respondents (90%) own house and most of them are not protected from floods. Farming is the predominant profession of the study area but is gradually declining due mainly to recurrent crop damage from floods. Extreme floods damage crops especially Aman paddy in the rainy season. This natural event usually forces farmers to cultivate two crops in a crop-calendar instead of three. Earnings from two crops in a year are not enough to support their families. Many of them engage in alternative professions like boating and fishing during an extreme flood.

In the adaptation process, micro-credit is playing an important role. Private bank (59%) and other NGOs (38%) are the leaders for distributing micro credit loan in the case study area. Even through, 92% women do household work, 97% respondents have acknowledged women's active participation for managing flood. Study also shows that many of the respondents are illiterate (53%) or have elementary education (27%) irrespective of their gender, but they are familiar with information technology like cell phone and television. Television is the most effective information media among the rural people for receiving flood forecasting and warning. Most of the people have general knowledge on flood related health hazard management techniques like water purification and treatment methods for diarrhoeal diseases. None of the villages has regular flood shelters. During an extreme flood, some people go to makeshift shelters like roads, bridges and schools and many of them make elevated platform, locally called tong inside their homes during a flood.

## **Towards enabling mitigation of climate change through green technology investment and innovation: an empirical investigation into the Australian offshore oil and gas industry**

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As business managers scramble to compete in the global economy, they must do so within societal constraints characterised by ever-increasing environmental accountability. This accountability includes heightened public scrutiny of both the firm's environmental performance and its strategies to invest in green technology and innovation. Over the past decade, the concept of green investment has expanded to include the simultaneous consideration of economic growth, environmental protection, and social equity in business planning and investment decision-making. Green investment has a role to play in promoting the compatibility of a firm's good environmental and financial performance, thereby encouraging greater corporate environmental transparency and contributing to changing investment behaviour.

This study examines the influence of a firm's regulatory environment on business managers' decisions to invest in green technology and innovation in a risk-averse, experimental setting. While arguments exist that regulatory factors can influence business managers to adopt environmentally friendly production and processes that require investment in low-carbon technologies, no empirical study has been presented to examine the interrelationships to do so. From a sample of 95 managers employed in the Australian offshore oil and gas industry, we show that regulatory environment has a significant influence on managers' decisions to make investments in a firm's pollution prevention strategies. In particular, the findings revealed that regulatory environment has a significant influence on business managers' decisions to make investments in the use and development of low-carbon technologies that can enable the mitigation of climate change. The experimental case material included a between-subjects manipulation to examine the relative influence of mandatory versus voluntary regulatory environments on managers' intention to undertake investments in low-carbon technologies. As expected, in all circumstances, the managers' were more willing to undertake investment in low-carbon technologies in a voluntary industry self-regulatory environment rather than in a mandatory government regulatory environment. This is consistent with the findings of previous studies, which have suggested that regulatory pressures caused significant variability in a firm's pollution prevention strategies that were adopted by business managers. The findings of this study will be important to regulators and government policy-makers, business, industry organisations and policy analysts because it provides useful empirical evidence of the relative efficacy of mandatory government regulation and voluntary industry self-regulation in influencing a firm's climate change mitigation and pollution prevention strategies.

## **Perverse Adaptation Strategies: Four Scenarios**

**E Saxon<sup>1</sup>**

<sup>1</sup>Independent consultant

Caron (1990) introduced the concept that strategies that make it easier to manage current problems could aggravate the problems they were meant to solve, once climate changes significantly. Not only will they fail to serve the purposes for which they were originally designed, but trying to prevent their failure will reduce the capacity of future generations to meet other needs; their sustainability is negative. Such perverse adaptation strategies may result from unanticipated impacts of climate change. For example, toxic waste dumps situated in coastal, flood-prone areas below 1m above mean sea level may have been designed to survive one 500 year flood event, but not several that occur at short intervals, even before they become permanently inundated. Perverse strategies may also result from non-climate sources of stress (e.g. social reluctance to invest in aging infrastructure) and sources of stress indirectly related to climate change (e.g. the increased cost of electricity needed for pumping water). Interactions among these two factors generate four future scenarios in which adaptation strategies may be implemented.



## Climate-adaptive National Conservation Planning in Papua New Guinea

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At the request of the Papua New Guinea (PNG) Department of Environment and Conservation (DEC), the authors developed a climate-adaptive National Conservation Plan (NCP) in the form of a spatially explicit decision-support tool implemented in a geographic information system. Conventionally, biodiversity conservation plans identify a fixed set of protected area proposals for implementation as circumstances permit. They have proven ineffective, even counter-productive in the dynamic and shared decision making context of PNG's national, provincial and community land-holder decision making processes. We have developed a data base and a set of software applications that allow decision makers in PNG to consider a range of conservation planning scenarios and possible selection criteria including: projected climate refugia; climate-invariant land systems, climate-dependent forest types under various current land uses; existing protected areas; and, the observed occurrences of restricted range endemic species, those most vulnerable to climate change. The planning tool generates portfolios of conservation reference areas by the application of specific criteria to relevant data— a transparent process in which all stakeholders and decision makers can participate. The portfolios then serve multiple purposes. On the one hand, they provide a ready-reference to sites of potential concern under any Environmental Impact Assessment process. On the other, they allow authorities to respond quickly to opportunities to enhance the conservation potential of areas. Taken together, the planning tool allows decision makers to explore options for minimizing adverse impacts on the nation's biodiversity and offset those that remain.

## Determination of the Effectiveness of Chemical Film Monolayers under Wind and Wave Conditions

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Numerous complex large scale systems have been used in recent history to reduce evaporative loss from critical water catchments such as shade cloth coverings, static buoys and destratification units. The application of thin layer chemical films (monolayers) has also been tested. Monolayers are long chain molecules with one hydrophilic end and one hydrophobic end, which means that they have the ability block escaping vapour at the water surface. Unfortunately, up to this point most monolayers that have been trialled have failed to prevent substantial amounts of water loss primarily due their physical inability to withstand various forms of physical and chemical degradation such as that caused by surface wind and wave action and microbial interference at the monolayer to water surface interface. The application of monolayers once completely developed and quantified, may help to reduce the need to extend current water supply infrastructure by reducing the requirement for the building of new dams and desalination plants and also possibly assist in limiting the amount of processed recycled water entering town and city drinking water supplies. In turn, this could result in the saving of large amounts of money for governments and ultimately tax payers over both the short and long term. Water surfaces in both natural and artificial water bodies are susceptible to wave motion generated by either wind or gravitational effects. The influence of waves on the overall effectiveness of monolayers and their ability to reduce evaporation rates has not been adequately quantified. It is hypothesised that waves can break up and stretch out a monolayer film. This has a greatly negative impact by reducing their effective thickness and hence their water trapping value. Water surface winds are also predicted to work as a breaking and stretching mechanism upon monolayers. In addition to this the combination of both wind and wave action on the applicability and effectiveness of monolayers has not been analysed. As a result it is necessary to derive relationships connecting varying wind and wave conditions to monolayer performance. This research project is solving these complex research questions by implementing a two phase experimental methodology. The first phase of this project has involved the collection of wave and wind pattern measurements over several months at Logan's Dam in Gatton, Queensland. Daily wave patterns have been recorded using three wave pressure sensors positioned at different sections within the dam and daily wind speed data has been collected by using a series digital anemometers working in conjunction with automated data loggers. The second and most important phase of the project has commenced with the development and implementation of laboratory experiments to develop mathematical relationships between changing wave and wind conditions and the effectiveness of a basic standard monolayer currently used in agriculture. These experiments have been carried out in a wave tank located at the Griffith University Gold Coast Campus. A controllable wave paddle and wind blower system has been fixed to the wave tank so that the wind and wave pattern data obtained from the first research phase can be used to simulate real-world conditions. The wave tank is completely enclosed by a custom built air-conditioned housing structure that allows for temperature and humidity levels to be kept at near constant values. During trials, evaporation rates are monitored over regular time intervals by using a Vernier scale point gauge in collaboration with a pulse distance sensor. Water temperature, air temperature, humidity, wind speed and wave pattern data are also all continuously monitored. This presentation will deliver sample results from both the field and laboratory phases of this research and will detail several future directions this work will take on in the near future.

## Ecosystem Services for Adaptation to Climate Change: Case Studies from Semi-Arid Botswana, Africa

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Ecosystem services as benefits that people derive from ecosystems have remained key to livelihoods for rural populations particularly in arid and semi-arid areas such as found in Botswana. While arable and livestock production systems are practiced, the drier climatic and highly variable rainfall at annual and decadal scale have constrained reliability on these systems without supplementation from natural resources such as food and other products from the wild to sell for income. Frequent crop failure and livestock mortality due to drought have seen communities resort to harvesting natural products for food and other needs and for income generation to secure other necessities. In some areas of Botswana, farmers have increasingly maintained the harvesting, processing and sale of natural products in addition to conventional agriculture. Studies have shown increasing preference for this adaptation, leading to the development of trade in natural products and in some cases rural industries based on these products have emerged.

These adaptation strategies are generally rooted in the indigenous knowledge systems that are linked to ecosystem services that have supported the livelihoods for millennia. Notable ecosystem services that are mostly known in terms of direct value include supply of natural products for human use and feed for their animals, habitat, water, soil media and other services that may be identified from time to time depending on human needs. Other ecosystem services that are not readily apparent to communities include mainly soil erosion control, pest control, cycling of nutrients and water, primary production and cultural services such as recreation and ecotourism. However, communities have benefited from the totality of these services that enable the various choices that need to be explored and mapped to assess their potential for sustainable adaptation strategies to climate change.

This paper looks at the production cycle and influential factors of some natural products such the lucrative phane caterpillar (*Imbrasia belina*), silkworm (*Gonometa* sp), some oil plants and their use together with potential for industrial development. It highlights how these natural products could provide better options for adapting to increasing unfavourable climatic conditions to normal crops, if supporting ecosystem services are maintained. For instance, anecdotal evidence indicate that increased runoff and less infiltration due to overgrazing could be affecting the timing of phenology in the host plant and its natural synchrony with the biological cycles of phane caterpillar and silkworm. Hence the need to understand the interaction nature of land use, ecosystem processes and services. The paper also shows how the diversity of the products (and/or services) have been exploited to cushion households against food and other stresses, including the emerging trade and rural industries based on these products.

The increasing opportunities offered by efforts to lower emissions of green house gases such as the REDD programme and bioenergy from oil plants are also explored for diversification of options for adaptation to climate change. The paper concludes by highlighting supporting or conducive policy initiatives that could enhance the adaptation based on the ecosystem services identified.

## Vulnerability, impact and adaption assessment of health threats from infectious diseases

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Climate change has far-reaching implications for public health such as the emergence and re-emergence of communicable diseases including Lyme disease, hantavirus pulmonary syndrome, tick-borne encephalitis (TBE), or cryptosporidiosis. While climate change is expected to shift their distribution and transmission patterns, health impacts will vary across European countries depending on climatic regions as well as differences in the capacity of the public health infrastructure to adapt and respond to these changes. The European Commission released a White Paper in April 2009 on adaptation measures and policies to minimize the European Union's vulnerability to the impacts of climate change. This policy paper was accompanied by a Staff Working Document entitled "Human, Animal and Plant Health Impacts of Climate Change" that describes possible key problems, the means that are currently in place, and the key steps that the Community and the Member States will have to implement in order to tackle these challenges in the most effective way possible, with the tools and financial resources available. In response to this call to action, the European Centers for Disease Prevention and Control (ECDC) has developed a decision-making tool to help EU Member States assess their potential vulnerabilities to climate change, evaluate the impact and consider adaptation options. A set of decision-making algorithms based upon clear criteria and principles were developed. These included assessment not only of anticipated climatic changes and the links with communicable disease transmission, but also multi-disciplinary assessment of the relevant infrastructures in the country, such as water supplies, animal husbandry, vector abatement, and disease surveillance. It also involves thorough assessment of specific options for each climate-sensitive disease and criteria for evaluating of health and economic variables, and options for monitoring and evaluation. This assessment will have to be done for different parts of the respective country, with an identification of needed adaptive and preventive policies and measures to address these risks. However, not only direct impacts of climate change should be considered but also secondary and tertiary health consequences caused by the effect of a changing climate on for example ecosystems, water flows and sources, and impacts on vital infrastructure. Thus,

trans-disciplinary approaches and cross-sectoral collaboration are therefore needed when assessing the impacts of climate change on infectious disease risk in an area. Sectors other than the health sector, and existing collaborations between the sectors, often need to be included in the assessment as well. They include water management, food industry, veterinary medicine, nature conservation and management, housing and urban planning, transport, energy sectors, etc. The handbook will be launched at the 5th WHO Ministerial Conference of Environment and Health in Parma, Italy, complemented by a targeted communication campaign. Twelve European countries have already conducted vulnerability, impact and adaptation assessments that included health. ECDC will work with selected European Member States to conduct thorough national vulnerability assessments during 2010 and 2011. A set of climate change monitoring indicators will be established to track the impacts of climate change on communicable disease transmission, and to guide prioritisation of adaptation strategies.

## Cooling Energy Impact of Climate Change in Southeast Queensland (SEQ)

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This paper investigates the historical and likely future cooling electricity use of residential housing in Southeast Queensland (SEQ), the fastest growing region in the last decade in Australia. The cooling energy consumption is analysed based on a number of key parameters: air temperature, number of households, cooling system penetration rate, energy efficiency of air conditioners and building insulation.

The cooling energy consumption in SEQ (base case) was 318GWh in 2005, 80% of which was consumed by the four major cities: Brisbane, Gold Coast, Moreton Bay and Sunshine Coast. It is projected to increase to 438 GWh and 472 GWh by 2020 and 2030, respectively (i.e. 1.4 and 1.5 times 2005 consumption). The City of Brisbane has the largest cooling energy consumption in SEQ — it was 119GWh in 2005 and will be 134GWh by 2030. However, the proportion of total cooling energy consumed in SEQ by Brisbane City will decrease from 37% in 2005 to 28% by 2030. On the other hand, the proportion for Ipswich and Scenic Rim show significant increases in residential cooling energy consumption by 2030 (2.71 times higher for Ipswich, 2.47 higher for Scenic Rim compared to 2005 levels). The proportion of the residential cooling energy for both Cities will rise to about 13% of total SEQ consumption by 2030. This is due to future housing growth variation for local governments in SEQ. For example, Brisbane City housing is expected to increase by 25% from 2005 to 2030, Ipswich and Scenic Rim housing is expected to increase by 202% and 103% respectively in the same period.

Considering climate change in the SEQ region, residential cooling energy is projected to increase to 633 GWh by 2030, which represents an increased of 99% above 2005 levels. This proportion (%) is twice more than base case (increased 48% more than 2005 in the base case described above). While an average temperature increases of 1°C is projected for SEQ by 2030, residential cooling energy consumption is projected to grow by 15% by 2020 and 34% by 2030 comparing to the base case.

With a projected 10% energy efficiency improvement (EER rating) for air conditioners by 2030, residential cooling energy consumption in SEQ should decrease by 6.2% (29GWh), leading to a total residential cooling energy demand of 442 GWh by 2030. If energy efficiency improvement increase 30% by 2030 then the total residential cooling energy in SEQ decreases by 16.6% (78GWh). Also, by increasing ceiling insulation rates by 9% compared to current levels, residential cooling energy consumption could be reduced by 71GWh in SEQ, which is 15% less than base case. Particularly by increasing dwelling insulation to 90% by 2030, residential cooling energy consumption in 2030 could be similar to 2005 levels. This study provides us with an adaptation strategy for climate change impacts on electricity consumption due to temperature change in SEQ.

This study is part of the South East Queensland Climate Change Adaptation Research Initiative.

## Scenario Planning for Climate Change Adaptation

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Planning is the deliberate act of attempting to manage change – natural and/or human induced. In this sense, strategic planning deals with the management of change over long time frames – typically in the order of twenty plus years.

Increasingly, the planning policies that constitute these plans and strategies are becoming much more reliant on a scientific foundation. To this end, modelling has been seen as a way to consider future circumstances that may require policy intervention in contemporary plans and strategies in order to avoid, minimise or enhance future outcomes as modelled. However, modelling requires the input of robust data to produce reliable forecasts of the future. While the accuracy and reliability of climate science is still improving, there is currently a lack of precise scientific data for many regions that could readily support a modelling approach sufficient for strategic planning purposes. This is particularly problematic given the growing importance and role of statutory regional land use planning in many rapidly growing regions. Until the science is refined and defensible, how can credible climate change adaptation policies be reliably formulated to assist strategic planners manage change over long time horizons?

This then raises the question of whether, under the lack of future certainties surrounding the projections elaborated by the current climate change science, are there alternative tools to modelling that might assist strategic planners to develop plans and strategies that deal with temporal horizons of 25 plus years?

Scenario planning is a strategic tool that was developed during World War 2 and then pioneered by the Royal Dutch

Shell Company. This technique is now widely used to consider the future by the public and private sectors worldwide. Scenario planning provides a systematic approach for the development and testing of plans and strategies in an uncertain environment through the creation of possible futures to test them in. These possible futures can be useful to inform present decision-making especially as they can deal with the high degree of uncertainty surrounding the future whilst making no attempt to actually predict a particular future. Scenario planning also does not involve forecasting or modelling which normally deal with the short term and are based on predetermined elements particularly from the past and the present.

This paper outlines the strengths and weaknesses of scenario planning to inform strategic planning in the context of climate change adaptation.

## Adapting Rainfed Agriculture to Impacts of the Climate Change in the Semi-Arid Tropics of India

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India ranks first among the countries that practice rainfed agriculture both in terms of extent (86 M ha) and the value of produce. Yield gap analysis for major rainfed crops, even under existing conditions; find that farmers' yields are about one-half to one-quarter of achievable yields, mainly due to aberrant rains at critical stages. Rainfall is a random input and its variation and intensity are high in areas of low rainfall. Findings suggest that a decrease of one standard deviation from the mean annual rainfall often lead to a complete loss of the crop. Adverse meteorological conditions resulting in long dry spells, unseasonal rains and extended moisture stress periods, with no mechanisms for storing or conserving the surplus rain to use during the scarcity/ deficit periods comprise the major cause of low yields and heightened distress in rainfed regions. Unfortunately, the available climate change models for the semi-arid tropics predict a further decrease in number of rainy days, more intense rains in fewer events and frequent occurrence of long rainless periods causing meteorological and agricultural droughts with decreased crop and livestock productivity and constrained livelihood options. Providing a dispersed mechanism for storage and smart application of water to tide over the critical periods was found to be the most potential adaptation to the existing and future scenarios. A detailed district and agro-ecological level study comprising 604 districts of India showed that total water availability may not be the major problem in the dominant rainfed areas- which was limited to about 225 districts. For each crop, there are a few dominant districts which contribute most (~ 85 %) to the total rainfed production and these need to be targeted in the first instance. A climatic water balance analysis of 225 dominant rainfed districts provided information on the possible surface runoff during the year and the cropping season. On a potential rainfed cropped area of 28.5 M ha, a surplus rainfall of 114 billion m<sup>3</sup> was available for harvesting. Of this available runoff, about 28 billion m<sup>3</sup> are needed for providing one supplemental irrigation to an area of 25 M ha during normal monsoon year, leaving about 81% to meet river/ environment flow and other requirements. Even during extreme drought years (50% deficiency), 31 billion m<sup>3</sup> are still available after providing one supplemental irrigation for 20.6 M ha. Water used in supplemental irrigation had the highest marginal productivity and with an improved agronomic management an average increase of 50% in total production (+ 12.8 m ton) can be achieved with a single supplemental irrigation. Economics of water harvesting through dispersed small structures was favourable even at the regional scale. With the adoption of improved practices, in conjunction with supplemental irrigation, net benefits become positive for all crops, except the pearl millet. Analysis showed that net benefits improve by about three times for rice, four times for pulses and six times for oilseeds. Droughts appear to have a mild impact when farmers in the semi-arid tropics are equipped with supplemental irrigation and the net benefits remain stable even when climate change impacts are strong. Dispersed and well planned rainwater harvesting and storage in small reservoirs on the surface or efficiently used for augmenting groundwater banks shall be a potential adaptation mechanism for the semi-arid regions of India and elsewhere. This might become important component of new development schemes aimed at adaptation of impact of climate change in the poor rural rainfed landscapes of semi-arid tropics.

## Present-day variability in Great Barrier Reef carbonate chemistry and implications for future ocean acidification

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The ocean has absorbed approximately half of the anthropogenic carbon dioxide emissions from fossil fuel burning and cement manufacture. When carbon dioxide dissolves in water it forms carbonic acid, leading to ocean acidification, where the acidity of the surface ocean has increased by 30% since industrialization. The chemical changes associated with ocean acidification have been shown to reduce the ability of calcifying marine organisms to produce calcium carbonate. Coral reef ecosystems are therefore predicted to be particularly vulnerable to ocean acidification as a result of decreased calcification and increased dissolution, where reef erosion could dominate in future high CO<sub>2</sub> conditions.

Coral reef ecosystems are incredibly important in terms of both their high biodiversity and ecological value, as well their socio-economic values. Given that ocean acidification is already underway and that the only way to control it is through limiting CO<sub>2</sub> levels, then marine ecosystems and the communities that rely on these ecosystems will need to adapt to the changes that result from ocean acidification. In order to predict and understand how ecosystems will respond to ocean acidification we need to understand the underlying natural variability in marine carbonate chemistry. Despite the importance of coral reefs, there is currently very limited data on the variability of carbonate chemistry in reef ecosystems. In particular, for the Great Barrier Reef (GBR), which is the world's largest coral reef, there is virtually no data from prior studies that show the seasonal variation in carbonate chemistry that these ecosystems are already adapted to.

In this study we have characterised the short-term (diurnal to seasonal) carbonate variability of the coral reef at Lady Elliot Island in the southern GBR. We show that corals and other organisms on the reef flat are already exposed to large underlying variation in pH and calcium carbonate saturation state. We relate the variability in carbonate chemistry to the net community calcification and provide insights into how future ocean acidification may alter the chemistry and affect calcification. Understanding the links between carbonate chemistry and calcification will enhance our ability to predict how coral reef ecosystems will respond to ocean acidification and assist in determining threshold values for when coral reefs will shift from net calcification (growth) to net dissolution (erosion).

## Development of high resolution integrated climatologies for Marine Protected Areas

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Although a great deal of attention has been focused on assessments of how future climate states may impact marine and coastal ecosystems, there has generally been a lack of historical context against which to compare these potential impacts. In particular, few historical climatologies are available at spatial resolutions that would differentiate localized climate variations of importance to sensitive marine ecosystems that may vary significantly over distances of just a few kilometers. This deficiency limits the ability of ecosystem stewards, such as those charged with managing marine protected areas (MPAs), to fully understand the potential impacts of climate variability and change and to develop optimal adaptation strategies. This paper discusses efforts by the United States National Oceanic and Atmospheric Administration (NOAA) to bring together available in situ and remotely sensed atmospheric, oceanic and biological data to develop integrated reference climatologies for its National Marine Sanctuaries (NMS). Starting with a pilot project in the Florida Keys NMS, the climatology is a combined effort by climatologists, oceanographers, satellite remote sensing experts, ecologists, and sanctuary managers to not only distill and rescale disparate data sources into meaningful comparisons between climatic parameters and ecosystem responses at a sub-regional scale, but also to foster improved communication and knowledge transfer between science and stewardship. The climate information produced by this project is designed to permit managers, many of whom have no formal training in climatology, to easily recognize significant climate-ecosystem linkages, reveal localized variations in impact potential and, through the use of probabilistic data confidence maps, identify informational uncertainty. In addition, this information will serve to place future climate scenarios into a more appropriate context, allowing managers to determine more precisely how potential changes in conditions will affect their managed region. As a follow on, such information will also help to determine critical observation gaps, as well as form the basis for a climate impact tool that would combine historical information with real-time monitoring to alert managers and stakeholders to developing climatic stressors on the ecosystem.

## Assessment of the challenges in adapting water resources and water infrastructure to climate change—a review

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There is now widespread agreement amongst the international scientific community that climate change is occurring, that it is largely manmade and that it will have significant implications for humanity (IPCC, 2007). Australia in particular has been described as one of the most vulnerable developed nations with respect to climate change (Garnaut, 2008). Australia experiences a high degree of climate variability, including exposure to a range of climate extremes such as extreme rainfall, winds, tropical cyclones and drought (Preston et al., 2008) and the largely arid nature of the continent already creates significant challenges for securing reliable water resources. Australia is already experiencing impacts from recent climate change with increasing stresses on water supply and agriculture, and is expected to face more extreme events with more intense and frequent heatwaves, droughts, floods and storm surges (Hennessy et al., 2007).

Just as the reality of climate change has been acknowledged, it is also generally acknowledged that some of the impacts of climate change are now either present or are inevitable and that they will become more severe if we do not take action to modify our behaviour. Of the suite of possible active responses to climate change, human actions generally fall into two broad categories: mitigation; and adaptation. Mitigation involves actions aimed at reducing the magnitude of our contribution to climate change (e.g., reducing greenhouse gas emissions) to offset or reverse its effects. Adaptation, on the other hand, consists of actions aimed at reducing the severity of (or risks associated with) adverse climate change impacts that are seen as highly likely or inevitable, as well as actions seeking to harness any beneficial opportunities that may arise under a changed climate system. Adaptation, therefore, represents a planned and active response to combat the future effects of climate change rather than a reactive post-adjustment to climate change impacts.

Whereas considerable effort has been directed toward climate change mitigation during the past two decades, comparatively little research effort has gone into climate change adaptation, and as such, implementations of adaptation measures are currently very limited (Parry et al., 2007). This applies for all adaptation areas and includes the field of water resource management. Traditionally, water management was the art of matching the limited water resources with the present and projected water needs of people, food, economies and environment. This water resources 'balancing act' was performed on the assumptions of historically stationary variability in climate and water availability and a defined forecast of water demand; however, this assumption is proving to be too simple and may no longer be valid, with the ongoing persistence of climate 'stationarity' now being seriously challenged (Milly et al., 2008).

Climate change poses a major conceptual challenge to water managers; this is in addition to the future challenges relating to population and land-use changes. Predicted future climate changes are expected to lead to a general intensification of the global water cycle, with a consequent increase in the risk of flooding (Kundzewicz et al., 2007). Changes to current water supply and demand chains, changes to water resource quality and impacts on water infrastructure are just a few of the many projected climate change-related challenges facing water managers in the future. Recognising the urgency of the adaptation challenge, and the wide range of information needs required to meet this challenge, the Council of Australian Governments endorsed a National Climate Change Adaptation Framework early in 2007. The Framework identified a need for the establishment of a facility to coordinate Australia's research resources and to deliver supporting information climate change decision-makers, leading to the establishment of the National Climate Change Adaptation Research Facility (NCCARF) in 2008. One of the initial tasks of the NCCARF was to develop a suite of National Adaptation Research Plans across a range of priority areas: one of which was Settlements and Infrastructure. The current review paper forms part of the water infrastructure and water resources component of the Settlements and Infrastructure research node, with the key purpose of the review being to identify the critical information needs and research gaps in the context of ongoing water security under climate change.

This review paper will provide an up-to-date state of the art assessment of the climate change adaptation challenges facing the water industry at large, with a particular focus on water security issues in an Australian context. A review of past and current international adaptation activities and research agendas in relation to water infrastructure and water resources management will be provided, as well as a critique of the key knowledge gaps and research needs identified within the global literature. Among the range of priority adaptation research agendas presented, there will be a discussion of:

- Critical data and information needs for water managers;
- Water efficiency, demand management and water market measures;
- The 'water-energy' nexus;
- Water quality issues and supply bio-security research needs;
- Water infrastructure and asset performance research needs;
- Collaboration, communication and education needs for the water sector; and
- Sustainable adaptation directives for the water industry.

## **Climate Change and Indigenous Peoples: Community Adaptation and Sustainability of Biocultural Diversity in Eastern Himalaya, Arunachal Pradesh**

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Throughout the world concern has been expressed about the measurable changes in global climate. The climate change has threatened sustainability of biocultural diversity and livelihoods of Indigenous peoples. India is highly diverse both in its biosphere and ethnosphere both. Within India, the State of Arunachal Pradesh-lies in eastern Himalayas, is the abode of megabiodiversity and rich ethnic cultures. The subsistence economy of state tribal communities depends largely on its native forests. The tribal peoples of Arunachal Pradesh- represented by 26 major tribes, have developed unique bonds with the nature expressed through 'biocultural diversity'. Though, now the tribal communities of State are facing threats from the climate change as experienced by them. Present paper is based on the six years of participatory action led field research with Adi tribe on climate change and community based biodiversity conservation in East Siang district of Arunachal Pradesh.

Forest located villages were selected randomly and data pertaining to study were recorded using survey, village workshop and participatory rural appraisal (PRA) methods. Results indicate that climate change has been readily experienced and noted largely by the tribal communities and is increasingly recognized by the state's formal agencies. Changes in climatic events affect on biocultural diversity of traditional foods (e.g. in the production of fermented foods of the Adi community), in collecting food resources, wildlife, medicines, weaving arts of women and water availability. Climate has been shown to affect microbial population of foods and, to pre-poned flowering and fruiting times of plant species (for example flowering of *Gymnocladus burmanicus* from the middle to the last week of May to middle to end of the April) and to influence the abundance of plant and animal species. Tribal people have experienced about an increased frequency of unpredictable rains and drought- resulting in poor productivity of jhum cultivation, and cultural practices relating to food gatherings and hunting, knowledge and institutions.

Unpredictable climate changes have led an overall threat to agrobiodiversity, and to the availability of indigenous aquatic biodiversity- essential in nutrition, ethnomedicinal practices and subsistence economies. 'We are facing now the frequent and unpredictable drought, flood and increasing temperature. If the climate changes continues at the present rate & trend then what will be the future of ethnicity and culture of Adi community, food habits, agricultural and hunting practices, food gathering, knowledge nurturing institutions and our close proximity with the native forests? ... Our culture, food habit and native forests are at stake' - Mr. Kaling Borang, cultural leader, Pasighat.

The Adi tribes have a rich body of knowledge about plants, animals, water bodies and indicators used in weather prediction. Adi communities have learned how to live in harsh climatic weathers and still to acquire their food, medicines, and livelihoods with nature. Adis use location specific adaptation strategies- such as forming informal groups and working festivals for managing river banks, controlling land slides, conservation and plantations of critically endangered biodiversity, developing alternatives to ensure food security and minimize pressure on plants and wild animals' resources. Despite their rich ecological knowledge held by Adis, government policies are re-missing in joining hands with them

to sustain the biocultural diversity in changing climate. Depending on local wisdom and knowledge of environmental susceptibility, environmental knowledge of communities and sociocultural adaptive capacity will further require combination of large-scale protection of ecosystems and social-ecological systems in culturally appropriate ways, and building the capacity of communities coupled with appropriate government policies to mitigate with climate change.

## Climate change and multiple impact assessment for marine management in Melanesia

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Communities and managers of marine systems face immense challenges in developing effective responses to future climate change and other pressures such as natural resource use, and population increase (at global, national and local scales). Ecological systems are complex, interconnected, and the interaction of various impacts is difficult to predict and visualise. Also, management and community response mechanisms are limited by a broad suite of human governance, cultural, infrastructure and natural parameters. We have developed a cost-effective, multiple impacts assessment and scenario building approach that will provide information for managers, at all levels, to plan for the possible impacts of climate change and other pressures on ecosystem assets and the services they provide to humans and other connected ecological systems. Information products from the approach, such as ecosystem conceptual models and impact scenarios, can then be used in participatory frameworks being implemented by a variety of government and non-government agencies across the South Pacific for natural resource planning that achieves a balance between sustainable production, livelihoods and effective conservation. The models and concepts are based on qualitative approaches and expert knowledge, as well as widely available mapping data. The formulation of these generic methods and the participatory frameworks that they will feed into are part of a long term process that will ultimately build the capacity of local government planners and managers in Melanesia.

## Socio-Agrarian Adaptation to Restore and Conserve Tropical Forest Carbon Sinks

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In tropical countries, changes in agriculture and underlying socio-economic conditions are integral to deforestation and reforestation and, thus, terrestrial carbon budgets. As climate change advances, agricultural and economic conditions are subject to adaptation but also purposeful intervention by governments seeking to protect and enhance forest sinks, e.g., REDD. Clearly, agricultural adaptation and intervention may overlap, which may prove strategic. Yet the history of land-use change in the global tropics suggests that adaptation and intervention may prove oppositional. As it is, we are ignorant of what conditions encourage reforestation over deforestation, and how amenable intervention and adaptation are to reforestation and forest conservation. We therefore cannot confidently integrate adaptation with intervention policy with respect to tropical forest-cover change.

I respond by providing the most comprehensive analysis of agricultural, social and forest-cover change in a tropical country to date. Using Panama as a case study, I define the major socio-agrarian trends and conditions giving rise to reforestation and deforestation over 1980-2008. To do so, I draw on ~18 million respondent-level records from Panama's agricultural, social and housing censuses of 1980, 1990 and 2000, which I combined with satellite-derived maps of forest cover for 1990, 2000 and 2008. Using this dataset, I defined 60 variables describing socio-agrarian and forest-cover change for 400 counties over 1980-2008. A principal components analysis then determined the socio-agrarian trends resulting in reforestation, deforestation over this period.

Results suggest that reforestation aligns strongly with improved economic conditions and a transition out of agricultural activity. The shift away from agriculture is defined by the rise of a female work force (perhaps farmers' wives) alongside rising rural wages and declining (or 'transitioning') agricultural employment in deforested agricultural areas. However, rural impoverishment causing farmers to seek 'off-farm' livelihoods also had a strong positive effect on reforestation. Agricultural change, such as intensification, mechanization, expansion etc., had no particular alignment with reforestation. Thus, policy to encourage reforestation and forest conservation would be wise to prioritise socio-economic development and shifts away from agriculture, rather than (exclusively) agricultural development and increased agricultural resilience.

## Enabling climate adaptation: moving from information provision to knowledge integration

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The rapidly expanding volume of guidance, advice, methods and tools for adaptation represents both an opportunity and a challenge for communicating information on adaptation. The problem is often not a lack of information, but navigating and assessing the quality of sometimes-conflicting information to distil useful lessons and source information most appropriate to the context in question. We review lessons learned through our efforts to develop and share information and knowledge relevant to climate adaptation, and focus on exciting developments to overcome the obstacles we have encountered.

An increasing number of Internet based adaptation 'platforms' or 'portals' exist which aim to help users find relevant information on adaptation and share their practices and experiences. While some have the potential to provide an empowering space to articulate local needs, exchange advice and engage with a wide community of people working on adaptation, experience has shown that there are significant barriers to be overcome if they are to fulfil such a role. Since early 2007, SEI

Oxford has led the development of one such platform - weADAPT - aimed at fostering communication and collaboration on climate change adaptation by building a set of socio-institutional relationships, developing a suite of computer-based tools, and using innovative technologies, to support the generation and exchange of relevant data, information and knowledge.

Initially, the main focus was on using a wiki to facilitate collaborative writing and try to encourage communication and partnership between users – rather than simply providing information in a top-down way. This worked to an extent, however we encountered both technological constraints (the difficulty of editing and engaging with other users) and also social problems as we found that while inter-organisational collaboration is an aspiration held by many in the adaptation field, in practice it is not always a priority, falling victim to busy schedules and institutional barriers.

We have also learnt that there strong and pervasive desire for ‘easy answers’ or ‘simple solutions’ to adaptation. It is not easy to communicate complex, nuanced messages, for example the confidence or uncertainty associated with climate projections in data-sparse regions, in ways that allow users to move forward in their understanding and work. Failure to do so can encourage people to look for simpler (and in most cases scientifically less credible and defensible) sources of information and answers, which may lead to mal-adaptation.

Based on experience from the initial phases of weADAPT, and feedback from several practitioner communities, we are now using innovative technologies coupled with an intensified focus on building partnerships in order to generate, store and communicate data, information and knowledge relevant to climate adaptation. Semantic technology allows intelligent links to be made between each piece of information in weADAPT. This increases the efficiency of a search, presenting users with additional resources they may need to make sense of and apply newly acquired information – thereby facilitating knowledge integration and ultimately learning. For example a search on ‘water Lesotho’ might return case studies of water management in Lesotho, tools for water planning and users working in Lesotho. In an attempt to reduce fragmentation of the broader knowledge base, the site has the potential to provide dynamic links to other web resources relevant to the topic being displayed – harnessing the power of the semantic web.

Responding to a commonly expressed need to know who is doing what type of work on adaptation, we have developed a system for users to browse and add project descriptions, videos, data animations and images to Google Earth in order to be able to quickly access locally relevant information. This visual tool for sharing information has found immediate appeal and we are working with a number of new Knowledge Partners to increase the content and integrate the use of the tool into existing activities.

Technology helps, but we have found that the only reliable way to provide effective information to support adaptation is through an intense and iterative process of direct communication with partners involving understanding needs, establishing common goals and working out how to bring relevant information into existing frameworks and protocols. We have found that collaboration between organisations working in different fields leads to the most innovative and useful means to support climate change adaptation.

## Climate change and human health in the Northern Territory: The road to adaptation

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The Northern Territory Department of Health and Families (DHF) formed a departmental Climate Change Committee in late 2009 tasked with developing a DHF Climate Change Policy and accompanying Action Plan. A number of factors influenced the development of these documents including: Council Of Australian Governments (COAG) assigning responsibility to the Australian Health Ministers’ Conference for the development and implementation of a National Climate Change Action Plan for Human Health; the identification of a series of actions relating to human health in the overarching Northern Territory (NT) Government Climate Change Policy released in December 2009; and a commitment to addressing climate change impacts on health and wellbeing as a key priority within the DHF Corporate Plan 2009-2012. A key consideration in developing the DHF Climate Change Policy and Action Plan has been to identify and support departmental adaptation responses within the unique context of the NT, which focus on activities that promote good health and ensure equitable health outcomes, particularly for Aboriginal people. These responses include representing NT interests in national discussions relating to climate change adaptation and human health; advocating and influencing key stakeholders on increased action on adaptation; as well as seeking funding to implement specific NT adaptation projects. This paper will describe the key adaptation strategies outlined in the DHF Climate Change Policy and discuss how they have been used to develop a series of specific actions relevant to the NT.

## Climate Change, Coastal Change, and Adaptation on a Low-Lying Coral Cay: A Case Study from Masig, Torres Strait, Australia

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Masig is a low-lying coral cay located in central Torres Strait that is home to approximately 350 people. Together with Poruma and Warraber – two nearby coral cays, and Iama – a granitic island where the village lies over low-lying coastal sediments, Masig has been the focus of a detailed study examining past coastal change and potential vulnerability to projected future sea-level rise. The villages on these islands are located over mainly unconsolidated



accumulations of reefal sediment with maximum elevations that are generally very close to the present high tide level. The shorelines are dynamic at event, seasonal and decadal timescales, and the islands are already vulnerable to seawater inundation and flooding during the highest spring tides, particularly when they occur simultaneously with surge events. Here we report on the outcomes of this research using Masig as a case study.

The study was undertaken at the request of the Masig community to assist them to:

- a. document shoreline change (and responsible processes) to improve access to resources to mitigate coastal erosion; and to
- b. help inform decision-making by the community on acceptable and realistic adaptation strategies to cope with projected future climate and sea level changes.

The research identified decadal and seasonal changes in shoreline position, with much of the island shoreline fluctuating by as much as 30-40 m during the period since 1974. Patterns of shoreline change established from historical aerial photographs and shoreline mapping were in accord with those remembered by community elders, but overall there has been little net change in island area since 1974. Detailed topographic survey identified sites that were more and less vulnerable to coastal flooding under a range of sea-level rise scenarios, with 40-50% of the island elevated above a projected 0.59 m higher sea level. Frequent dialogue between the community and the research team was a cornerstone of the project, with the community making the decisions using their own knowledge augmented by the information presented by the research team.

The community at Masig understands that the island, especially around the current village, is low and that flooding events may become more significant and frequent as sea levels increase. They also understand that these events will be occasional – on the highest tides and during poor weather only – well into this century. The community expressed a willingness to participate in a process of adaptation to future sea level and coastal changes including such actions as incorporating sea-flooding and erosion hazards into planning for infrastructure planning (including replacement), staged movement of village infrastructure to higher parts of the island, improved berm management, and allowing some parts of the island to erode where that erosion is not threatening people, infrastructure or cultural sites, while monitoring the situation and recognising that usually, comparable accretion is occurring elsewhere on the island.

Significantly, the community recognises that adaptation will raise issues of land tenure and traditional rights that must and will be worked through by the community. The community recognises that changes in their island environment will require changes to present and traditional community practices. However, they also feel that the vulnerability of their island to climate change and sea level rise is not, at present, fully appreciated by policy makers and governments. They feel that they have invested considerable effort and resources into research to enable informed decisions on adaptation strategies, and have indicated that where coastal protection works are required they are willing to test innovative solutions, but are frustrated that to date they have not been successful at securing funding to address identified priorities. The community has re-affirmed a wish to remain on the island, and do not consider relocation off island as an option.

## Scenarios, stakeholders and systemic regional adaptation planning

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Agriculturally dependent regional communities comprise intricate, highly interdependent systems. While primary producers focus on milk, grains or meat, the undergirding systems involve land-use zoning, infrastructure provision and institutional arrangements. Processing facilities and service industries contribute to employment and regional economic activity. Employees and their families need schools, hospitals and other community services. What happens when these complex, interdependent systems are perturbed by climate and non-climate induced change? Are some elements of that system more vulnerable than others? How should regional actors respond to uncontrolled changes in the contextual operating environment? What policy frameworks and instruments might governments implement to facilitate effective, systemic, regional-scale adaptation? These questions are not trivial, and their nature suggests that we require a systemic approach to regional adaptation planning.

We present a methodology for on-going collaborative engagement with selected stakeholders aimed at eliciting their tacit and explicit knowledge to assess the likely systemic regional consequences produced by scenarios of climate and non-climate change. We discuss some of the insights into systemic regional response to perturbation gained by participants, and present their recommendations for integrated regional-scale adaptation. Finally, we outline how those systemic insights and recommendations are being transferred into the policy arena. The methodology has the potential to make a contribution in the area of integrated assessment, and is put forward for further consideration and development.

The work was undertaken under the Department of Primary Industries (DPI) component of the Victorian Climate Change Adaptation Program (VCCAP). VCCAP aims to increase the knowledge and capability of government, agri-business and rural communities to make informed, holistic decisions with respect to climate change adaptation in the agricultural sector. DPI VCCAP has piloted a number of research themes in south west Victoria including modelling, institutional adaptation, policy response frameworks, visualisation and the use of scenarios.

Our work shows that change processes in complex agri-community systems often ripple across a number of scales and institutional boundaries. Assessment by in-house governmental staff may not always pick up the subtleties of system interdependence, or problems hidden at the boundaries of jurisdictional responsibility. Stakeholder engagement at the inform, consult, involve levels may not provide decision makers with sufficient understanding of system behaviour for effective policy design. Our work illustrates that on-going collaborative engagement with carefully selected stakeholders can provide insightful contributions to understanding systemic regional behaviour. We therefore propose that one component of robust systemic adaptation planning in the face of uncertainty is targeted on-going collaborative engagement between government and selected stakeholders. This complements modelling information, enables policy makers and stakeholders to better understand the nature of the problem, engage in mutual learning, build trust and respect, consider multiple perspectives and formulate shared visions and plans for the future. The end result is likely to be smoother introduction and greater end-user support for policy. Such an approach will require commitment by government to the development of new paradigms and processes for engagement. Without it, government is likely to be hampered by an imperfect knowledge of system operation and sub-optimal regional adaptation planning and implementation.

## **Spatial Information Technologies for Climate Change Impact on Ecosystems: Detecting and Mapping Invasive Weeds in the Rio Grande River System of South Texas**

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Global warming is projected to have immense effects on freshwater and wetland ecosystems. Wetlands and aquatic ecosystems are quite vulnerable to climate change. Exotic invasive weeds are a serious problem in the Rio Grande River system of Texas. The Rio Grande is one of the longest river systems in the United States. The river extends 3,040 km from its source in the San Juan Mountains of Colorado to the mouth at the Gulf of Mexico on the United States-Mexico border in extreme south Texas. The Rio Grande River system of Texas has serious problems due to exotic invasive weeds such as waterhyacinth [*Eichhornia crassipes* (Mort.) Solms.], [*Hydrilla verticillata* (L. F.) Royle], saltcedar (*Tamarix chinensis* Lour.), giant reed (*Arundo donax* L.), Eurasian watermilfoil (*Myriophyllum spicatum* L.), and wild taro [*Colocasia esculenta* (L.) Schott]. These invasive plant species have displaced much of the original native vegetation. Water shortages in the Rio Grande have been exacerbated by the invasion and spread of the above-mentioned weeds. Remote sensing techniques offer potentially timely, cost-effective means of obtaining reliable data for these areas. The scientists at the USDA ARS Laboratory in Weslaco, Texas, in cooperation with the senior author at Virginia State University, have been conducting research on the utilization of aerial photography and videography integrated with global positioning system (GPS) and geographic information system (GIS) technologies for detecting and mapping exotic invasive weeds in the Rio Grande system from the mouth of the river the near Boca Chica in extreme south Texas to El Paso in west Texas. This paper describes the results of several aerial remote sensing studies conducted from 2002 to 2006 on the Rio Grande River from its mouth near Brownsville in south Texas to El Paso in west Texas. Aerial photography and videography were used to detect plant species. Aerial imagery was obtained under sunny conditions with photographic and videographic systems mounted vertically in either a Cessna 206 or Cessna 404 Titan aircraft. Video imagery was integrated with GPS and GIS technologies to develop distribution maps denoting infested locations of the invasive weeds. Our findings indicated that approximately 1,285 river-km of the Rio Grande was plagued by infestations of waterhyacinth, hydrilla, saltcedar, giant reed, Eurasian watermilfoil, and wild taro. The aquatic species, waterhyacinth and hydrilla infested approximately 225 river-km in the extreme southern portion of the Lower Rio Grande Valley of Texas. The wetland species saltcedar infested approximately 460 river-km from Lajitatas to near El Paso in west Texas. Giant reed infested approximately 600 river-km along the Rio Grande from near Laredo in south Texas to near Presidio in west Texas. Eurasian watermilfoil occurred along a 66 river-km area from below Amistad Reservoir near Del Rio to north of Eagle pass in southwest Texas. The joint use of these technologies provides valuable information on the distribution of invasive weeds in the Rio Grande system along the Texas-Mexico border. It is anticipated that these technologies can be used for a variety of natural resource management of ecosystems, wetlands, coasts, and deltas.

## **Securing the city in a climate-constrained future**

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Within the major Australian coastal cities - where the majority of people live - the immediacy and potentially catastrophic nature of climate risk (i.e. storm surge, fire, heatwave, drought) poses considerable challenges to contemporary democratic models of metropolitan governance (Gleeson, 2008). In response to climate change conditions that Spratt and Sutton (2008) describe as having entered the realm of a 'code red' emergency, this poster highlights the utility of critical securitisation theory as a lens for better understanding and ultimately re-framing the response to climate change adaptation within Australian metropolitan settlements. Drawing on analogies with the 'war on terror', the poster maps out both the Orwellian dilemmas and democratic potentialities of the securitization approach to the very real agenda of a climate constrained future for Australian cities.

## Building Resilience to Climate Change through Community Based Development Planning: Lessons from Addressing Climate Impacts in a Rural Coastal Community in Hawaii

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Community based development planning as practiced in the County of Hawaii (U.S.) provides an ideal opportunity for community scale climate adaptation. The government sponsored planning process engages all sectors of the community in developing long-term strategies to guide development in a way which reflects community values and addresses community needs. The plan, once adopted, carries the weight of law and thus provides the community with a strong voice in future conversations regarding development. The multi-stage planning process includes local, state, and federal government representatives, community leaders, private consultants, subject matter experts, and the general public and addresses thirteen standard planning elements. Over the course of two years the National Oceanic and Atmospheric Administration (NOAA) has provided scientific and planning technical assistance to the County of Hawaii for two community planning efforts. NOAA's interest, beyond supporting Hawaii County, was to gain practical experience in integrating natural hazard and climate risk information in community based development planning to inform future products and services for building community resilience. Throughout the process effective communication was paramount, from initial engagement with local government representatives in articulating the benefits of risk-based approaches to engaging community members in determining what community assets could be at risk now or in the future. As with any dynamic stakeholder driven process there were ample opportunities to learn about effectiveness of communication strategies. These experiences are informing NOAA products and services so they can be tailored to ensure they effectively reach their intended audience and provide value to local decisions. Furthermore, the experience is providing Hawaii County and NOAA with critical information on current and future communication strategies for delivering climate and hazard related data and information for community scale climate adaptation in other communities and may have value for other jurisdictions in the Pacific and elsewhere. Outcomes of this work include the development of draft guidance on integrating risk information into community based planning efforts as well as the adoption of numerous community scale climate adaptation strategies in the County of Hawaii.

## A Micro-Foundation of Direct and Indirect Damage of Extreme Weather

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Understanding the effect of disaster on production is crucial for quantifying economic damage related to climate change, since the frequency and intensity of several extreme weather events may increase. Also for developing adaptation strategies it is essential to comprehend parameters that determine damage. Our paper provides an economic micro-foundation of direct and indirect damage costs of extreme weather events that disturb productive capital. By considering the optimum reconstruction path after an extreme event, we determine direct reconstruction costs and the indirect losses from foregone production. Based on that analysis we discuss whether adaptation measures that reduce the frequency of damages, or others that reduce the amount of disturbed capital from a single extreme event should be preferred.

In Gaddis (2007) it is broadly discussed, that the reported damage costs from disasters often only include the direct costs. These are generally defined by the replacement costs of the damaged assets, or the insurance value. Thus, substantial indirect costs are usually disregarded. As Albala-Bertrand (1993), they list very different categories of indirect costs that are partially very difficult to estimate. In our contribution we solely focus on the indirect costs due to loss of production in the affected industry and direct costs, caused by the reconstruction of damaged productive capital. A review on the economics of disasters by Okuyama (2003) collects empirical evidence for a broad variety of economic effects that appear in association with extreme events. It concludes that there are, among other problems, still important theory gaps. In particular, it discusses the dynamics in the direct aftermath of extremes, for example changes of market equilibrium, capital replacement and the speed of recovery. Already Dacy and Kunrether (1969) discuss possible market failure due to, e.g., rigidities of factor allocation; a thread of the discussion we will take up as well. Hallegatte et al. (2007) develop a model where an extreme event affects all production facilities of an economy equally. He shows that just reducing the capital stock strongly underestimates damage, as for diminishing returns from capital, this formulation of damage implies that only the least efficient production facilities are damaged.

Our model considers a single industry that is affected by an extreme weather event. As consequence parts of a capital stock, that is assumed to be decomposed into production facilities with individual production functions, including labor as further input, are damaged. For a fixed supply, labor is optimally allocated to the facilities to maximize output. Since the loss of production depends on how easily labor can be reallocated after an extreme event, two polar cases are derived. Based on that the optimum reconstruction path, resulting in minimum total damage costs, is determined.

We show that both, the direct reconstruction costs and the indirect losses from foregone production, increase convexly, if more capital is initially damaged. Further, indirect costs then become larger compared to direct costs, in this case. This gives rise to a consideration that we call "impact aversion": The average damage costs of a "weak" and a "strong" impact by an extreme event are higher than the total damage costs of one event with the "mean" impact. Thus, when there are measures available (at the same cost) that reduce the initially damaged capital, or others alternatively reducing the frequency of extreme events, the former would be preferable. As an example, consider sea surges that

damage a coastal industry. There are different ways to cope with such risks, e.g. building or raising levees, or relocating industry from areas that may be flooded. The former reduces the frequency of surges that affect the industry. Yet, only those floods that are higher than the levee damage industry, but in a similar way as if there were no levee. In contrast, relocation does not reduce the frequency of floods reaching the inland, but decreases the amount of capital that can be damaged. In the light of the “impact aversion” argument, relocation may thus be preferable to structural coastal protection. A micro-foundation of damages thus gives valuable hints for adaptation to climate change.

## Developing a typology of adaptive learning strategies within coastal institutions affected by extreme events related to climate change

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This paper reviews the literature on adaptive learning applicable to climate change extreme event management to develop a typology of adaptive learning that has the potential to inform decision-making within coastal institutions. Testing and evaluating this typology within a range of coastal organisations will assist improved understanding of how coastal institutions learn, adapt and respond to extreme events related to climate change. This paper draws from research linked to the Enabling Science Uptake in Coastal Zone Management Cluster, based in the CSIRO Wealth from Oceans Flagship and closely associated with the Climate Adaptation Flagship.

Adaptive learning is an emerging area of enquiry and increasingly considered important in the general field of sustainable resource management, and specifically coastal management. Yet, there is limited understanding of the particular elements and processes for successfully embedding this type of learning within organisational structures to achieve effective responses to priority socio-ecological issues.

Nevertheless, coastal organisations responsible for the adaptive management of current and anticipated climate events require the competencies and capacity to deal with dynamic, complex and transitional social-ecological systems, characterised by either incremental and/or rapid rates of change. In contrast to incremental climatic events, the nature of extreme climatic event management suggests that adaptive learning will be characterised by different spatial and temporal factors. For example, the requirements for learning are likely to be rapid and experiential in nature.

By reviewing the adaptive learning literature and associated areas of social, sustainability and experiential learning, this paper develops a typology of adaptive learning specifically focussed on institutional response to extreme events in coastal areas affected by climate change. The application of this typology has the potential to contribute to a more rapid response to scientific knowledge and other forms of learning and knowledge in climate change extreme event management and decision making. While this research is focused primarily on coastal systems in an Australian context, the outcomes are likely to hold relevance to scientists and decision makers at an international level across a range of contexts wherever rapid responses to extreme events are required.

## Adaption Strategies arising from Clarence City Council's Climate Change Impacts on Clarence Coastal Areas Report

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The City of Clarence has 191 kilometres of coastline, much of which is low-lying. Significant inundation and storm surge incidents have occurred in Clarence coastal areas in recent decades and significant coastal dune degradation has occurred. Community consultation supported solid scientific investigation into coastal processes in order to plan a response to such events. The Climate Change Impacts on Clarence Coastal Areas Report combined the best available scientific methodology with social research in coastal communities to assist in understanding and planning responses to the impacts of climate change induced sea level rise. A technical report identified the coastal processes and associated coastal hazards related to sea level rise with inundation and erosion as the 2 most significant hazards. The study made use of LIDAR (Light Detection and Ranging) technology to produce a series of hazard maps for the vulnerable areas of Clarence for the Present Day, 2050 high and 2100 high predicted sea level rise. Hazard maps were colour coded to show the extent of inundation and erosion. A matrix was produced showing the relationship between indicative Annual Exceedance Probability (AEP) inundation for sea level rise and the depth of flooding. This demonstrated that under Present Day conditions an area may experience a 1% AEP flood of 300 millimetres, while under a 2100 high scenario such an event would be occurring with an AEP of 76% which would severely compromise the amenity of the area. A similar matrix showed indicative inundation depths for the 1 in 100 year event in the Present Day as 300 millimetres with the corresponding 2100 high scenario as 1.2 metres deep, which would result in a significant loss or damage to property value and amenity. These maps and tables present the consequences of climate induced sea level rise risk in a format that is easy for the community to read and understand. The City's vulnerable areas were grouped into three major categories; areas currently at risk; areas with medium term risk in 25 to 75 years; and areas with long term risk at 75 years and beyond. In response to the identified hazards adaptive management options were recommended based on a hierarchical series of responses of protect, accommodate and finally retreat. The predicted levels of flooding and erosion hazard will not occur in the immediate future but over several decades

and as a consequence the adaptive management options considered first deal with; planning controls; physical works; ongoing monitoring; and 10 year reviews. As an initial response Council has developed a specific coastal amendment to the planning scheme to address increasing risks to existing development. The planning amendment has two overlays; a Coastal Hazard Overlay and an Inundation Overlay. Both Overlays have three zones relating to Present Day, 2050 high and 2100 high sea level rise predictions. The overlays require all uses and development to have a permit and sets out minimum floor levels and other performance measures as part of the specific decision requirements of the overlays. All applications must be accompanied by a report prepared by suitably qualified personnel that demonstrates the specific decision requirements of the overlays will be satisfied. A feasibility study has also been undertaken on sand scraping and beach profiling for the areas currently at risk of coastal erosion for consideration by Council as part of the 2010/2011 budget. Council's plan is to identify a series of triggers as part of its adaptive management process to raise awareness and respond to risk before the risk becomes excessive. Council will manage the risk as it develops. Managing the risk does not eliminate all risk. More extreme events will sometimes occur that exceed the capacity of the plans undertaken by the Council. However, if suitable actions are taken these more extreme events will be relatively rare and the damage and safety impacts will remain relatively manageable. The detailed analysis undertaken and its integration into the business of local government in the areas of planning and asset protection will act as a template for other coastal communities and local authorities around Australia.

## Synthesis of APN Adaptation Activities in the Asia-Pacific Region

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Scientific understanding of climate change is advancing at a significant rate, with new information emerging about the likely impacts of climate change, the options to adapt to these changes, and new approaches to mitigative options. Through many national and international fora, it is becoming clear that climate is one of the most, if not the most, pressing issues in the political arena today. The most recent 34th G8 Toyako Summit underscored its commitments to climate change, adaptation and mitigation as well as the need to support developing countries for financing, transferring technology and capacity building activities for these nations to be able to respond effectively to a changing climate.

The Asia-Pacific Network for Global Change Research (APN)'s growing strength lies in its uniqueness to facilitate underpinning scientific research and capacity building that is systematically targeted for the needs of the Asia-Pacific region as identified by its government-appointed national Focal Points and scientists who, together, develop the science, policy and institutional agendas of the APN. With this, the APN welcomes the continuing opportunity to inform SBSTA of research, capacity development and science-policy interfacing within the Asia-Pacific region relevant to the convention.

Most APN member countries continue to identify climate vulnerability, impacts, and adaptation and/or mitigation assessments as their priority concerns. GHG emissions, inventories, and the capacity to conduct activities in these areas are also considered important, particularly in the least developed nations. Climate change projections, uncertainties and modelling, particularly downscaling GCMs, are important as is access to/and the sharing of data across national borders for climate research.

Taking on board the challenges presented in climate impacts, vulnerabilities and adaptation, this is major interrelated issue for the UNFCCC and post-Kyoto agreements where skills in scenario development and impact quantification for climate sensitive systems will be needed. Particularly challenging for APN countries is the development of systematic efforts to implement adaptation strategies in various sectors likely to be affected by climate change. Currently, many APN member countries are developing adaptation strategies (and in some cases implementing them) in many sectors and all countries see the adoption of adaptation strategies as important to counter impacts and reduce vulnerabilities.

Citing an example from Indonesia in adaptation strategies for future climate risks, fostering a co-evolution of interdisciplinary science is a major challenging strategy that is currently underway. In this regard, there is a need to enhance cross-sectoral governmental communication and coordination, improve education and increase public awareness. In this regard, the APN's capacity development programme, CAPaBLE, is successful in that it can contribute to the process of developing effective climate information systems which meet client needs and are provided to the appropriate users in a timely fashion, allowing them to use this information to assist their decision making.

While the integration of various elements such as climate risk assessments, sectoral adaptation plans and international cooperation is seen as a systematic, coherent and sound basis for developing appropriate adaptation strategies, it is very clear that many APN developing countries lack the human and institutional capacity to plan and adopt such adaptation strategies. There are many limiting factors and developing countries, in particular, have yet to conduct much-needed vulnerability and impact assessments in many areas/sectors in order to plan appropriate adaptation strategies and mainstream these into national policy and plans. The most vulnerable sectors are agriculture, fisheries, water (floods and drought), forests, health and social welfare, transportation, coastal zones, mangroves and maritime resources.

Recognizing this, the APN is conducting seven national and regional projects in China, Indonesia, Philippines, Pakistan, Thailand and Viet Nam that are focused specifically on scientific capacity development in areas of impacts, vulnerability and adaptation strategies and assessment in the scientific, user and policy-communities levels. These key activities and results will be shared at the Climate Adaptation Futures conference.

## The Great Barrier Reef adapting to climate change: identifying options for intervention

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The Great Barrier Reef Marine Park Authority, in its first Outlook Report concluded that the Reef's outlook is poor. Climate change was identified as one of the primary threats to its future.

The Great Barrier Reef Foundation (GBRF) is a not-for-profit, with links to Australian business, philanthropy and the national coral reef research and management sectors. It encourages the private sector, with which it is well linked through its Board and Chairman's Panel, to invest in priority research on the GBR.

GBRF convenes an eminent International Scientific Advisory Committee (ISAC), which is chaired by Professor Paul Greenfield AO.

The research vision (A resilient Reef, successfully adapting to climate change), is underpinned by a research framework on which GBRF bases its approach to identifying the research needed.

Although other agencies are developing climate response plans for the Reef, GBRF believes that further research is urgently needed to reveal and underpin the best possible interventions to the climate change threat and is addressing this in two ways:

1. Utilising its framework to develop an innovative research plan, comprising a portfolio of projects, prioritised for immediate investment;
2. Collaborating, in the determination of that plan and portfolio, with a cross section of business, industry, government, researchers and key Reef agencies.

To do this, it has convened two complementary working groups:

- The first working group will identify, the essential attributes of a sustainable coral reef in the face of climate change, and ultimately develop an index of coral reef health. Respected coral reef scientist, Professor Ove Hoegh-Guldberg, chairs this group.
- The second group, chaired by Dr Andrew Ash, Director of CSIRO's Climate Adaptation Flagship, is charged with developing both solutions and adaptation strategies for reefs facing climate change.
- The portfolio, which is the key deliverable from the working groups, will be launched in the third quarter of 2010 and include:

Projects to advance our understanding of the attributes, including initiatives to measure attributes, assess their current levels and forecast future ratings;

Projects that develop (and deliver to Reef management) ecological and physical solutions to the effects of climate change on the GBR.

Adaptation projects which address the capacity of communities, industries, the research and management sectors and governance structures to adapt to climate change and adopt solutions.

eReefs is one of the projects which has already been developed by GBRF under the Framework.

It is an integrated operational system of critical data sources, forecasting and hindcasting models, visualisation and reporting tools, spanning the paddock-to-ocean scale. It will provide the all-important decision-making and information infrastructure for the Reef's managers and users.

GBRF takes the view that Australia has no choice but to consider both interventions and the appropriate enabling frameworks in anticipation of climate change and that now is the right time to be undertaking this important work. A strong evidence based approach is needed to bring science into what has, in the past, been considered a controversial social and policy realm.

## Climate Change Impact and Adaptation on Concrete Infrastructure Deterioration

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Atmospheric CO<sub>2</sub> is a major cause of reinforcement corrosion in bridges, buildings, wharves, and other concrete infrastructure in Australia, United States, United Kingdom and most other countries. Moreover, corrosion rates will increase by up to 25% if temperature increases by 2C. Clearly, the impact of climate change on existing and new infrastructure is considerable, as corrosion damage is disruptive to society and costly to repair. The paper describes a probabilistic and reliability-based approach that predicts the probability of corrosion initiation and damage (severe cracking) for concrete infrastructure subjected to corrosion resulting from concrete carbonation and higher temperatures. The atmospheric CO<sub>2</sub> concentration and local temperature increases with time over the next 100 years in coastal cities in Australia are projected based on nine General Circulation Models (GCMs) under A1B, A1FI and 550ppm stabilisation CO<sub>2</sub> emission scenarios. They are considered as two of the major environmental influences on corrosion processes. Two types of corrosion agents of concern are modelled: carbonation and chloride (marine exposure) induced corrosion. The effect of various adaptation measures is also considered including: (i) increasing design cover, (ii) surface coatings, and (iii) galvanised

and stainless steel reinforcement. The probabilistic analysis included the uncertainty of CO<sub>2</sub> concentration, deterioration processes, material properties, dimensions, and predictive models. It was found that damage risks increase by up to a few hundred percent over a time period to 2100, and that the results vary for different cities and regions in Australia. The results were most sensitive to increases in atmospheric CO<sub>2</sub>. Increases in design cover for new infrastructure designed in Australia are recommended to ameliorate the effects of climate change. The use of galvanised and stainless steel reinforcement reduced damage risks to negligible values, but at the expense of significant additional construction costs.

## **Coastal Governance in Western Australia: Mapping response capacity to climate adaptation**

**L Stocker<sup>1</sup>**

<sup>1</sup>Curtin University, Australia

The Southwest of Western Australia contains some of the fastest growing local government areas in Australia; they offer great sea change appeal combined with relative proximity to Perth. This area is also a significant national biodiversity hotspot. However it exhibits extreme vulnerability to sea level rise, storm events and saltwater inundation. Since the 1970s there has been a discernible general shift from strong central government as the key decision-makers to a system of governance that includes: the fragmentation and sharing of responsibility and power; the decentralisation and 'agentisation' of policy formulation and implementation; an increasing reliance on partnerships, networks; and new ways engaging the public and stakeholders about projects, plans and policies. Governance of the coastal zone includes the institutional authorities, processes, and procedures used for guiding strategic and key operational decisions about the coastal zone. Governance in the coastal zone now comprises not only complexly interacting levels of formal government (Federal, State and Local) but also development commissions, NGOs, Indigenous Native Title holders and other stakeholders including scientists. There are concerns about multiple jurisdictions, lack of integrated management and continuing controversy on major developments. With a view to enhancing the capacity for coastal adaptation, we mapped the components of coastal governance in WA, identifying and analyzing the potential for improvements in institutional arrangements, policy-making and planning. We used the Lisbon Principles for sustainable governance of coasts and oceans against which to assess WA coastal governance: responsibility, scale-matching, precaution, adaptive management, full cost allocation and participation. We also assessed coastal governance against determinants of adaptive capacity.

## **Adaptation-Mitigation Interactions in Agriculture – Identifying Synergies and Conflicts**

**C J Stokes<sup>1</sup> and S M Howden<sup>1</sup>**

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Dealing with climate change will require both mitigation (reducing greenhouse gas [GHG] emissions that contribute to climate change) and adaptation (measures to cope with residual change that does occur). The two are intimately linked in that greater up-front effort in mitigation to reduce climate change will lessen the amount of adaptation that needs to occur, while delaying mitigation measures will lead to a requirement for greater adaptation later on. Although adaptation and mitigation strategies are meant to be broadly complementary, there is no guarantee that there won't be conflicts and trade-offs for individual adaptation or mitigation actions. Perverse outcomes could arise if measures taken to mitigate GHG emissions leave industries more vulnerable to climate change, or if adaptation measures meant to lessen the impacts of climate change result in increases in GHG emissions. If such conflicts are to be avoided or managed, then it is important that adaptation and mitigation measures are systematically evaluated to anticipate any such conflicts. However, at this early stage of development, mitigation and adaptation strategies have occurred largely in isolation of each other. Before individual adaptation and mitigation measures are further developed and promoted, it would be sensible to ensure that such measures are complementary. Based on a recent review of adaptation options for Australian agriculture, we summarise a range of adaptation approaches with broad applicability across primary industries, and evaluate the likely GHG and environmental implications of each option. We also briefly consider key mitigation measures and how they may affect the robustness of agricultural enterprises to coping with climate change. Our review suggests that proposed adaptation measures in agriculture will have largely neutral implications for GHG emissions. Furthermore many adaptation measures tend to reinforce many existing best practice recommendations, which would have environmental benefits. In contrast, mitigation measures are more likely to create conflicts that leave agriculture more vulnerable to climate change. Adaptation measures with potential negative GHG outcomes include greater energy consumption for cooling, greater use of fertilizer, and greater use of fire to control woody vegetation. Negative consequences of various mitigation measures for adaptation include a greater cost-price squeeze, and diversion of agricultural land/produce/resources to renewable energy production or carbon sequestration. Synergies between adaptation and mitigation include measures to improve resource use efficiency (particularly of water, nutrients and ruminant animal production) and options that overlap strongly with existing best practice recommendations. Building broad considerations of unintended consequences into early stages of developing adaptation and mitigation options will help to ensure that these parallel strategies are complementary and that conflicts are minimised.

## **Delivering Useful Climate Information in the UK: Continuing to learn lessons**

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UK Climate Impacts Programme (UKCIP) has been involved in the delivery of climate information to support impacts and adaptation assessments since its inception in 1997. During this time the UK government, with the support of UKCIP, has delivered three sets of climate information; UKCIP98, UKCIP02 and UKCIP09. There has been an evolution of the information presented reflecting both changing capabilities in the climate science and in the needs

and capacity of the user community. Throughout this period of delivering climate information, there has also been a deliberate strategy to move from a supply-driven focus to one that represents more of a balance between supply and demand; one that is driven based on informed engagement involving both providers and users.

A major focus of UKCIP's involvement in the delivery of these sets of climate information has been in engaging providers and users. Particular developments as a result of lessons learned in this regard are reflected in the delivery of the latest set of climate change information, UKCP09. During the development of this information the users and providers were engaged through multiple techniques including training workshops, a users' advisory panel and case studies, as well as targeted one-to-one interactions. Through these, the provider and user communities were given the opportunity to interact in a mutually beneficial manner. This has influenced the nature and scope of what is delivered and how it is delivered. The investment in engagement at an early stage has positively impacted on the level of uptake of the new set of climate projections and the scope of support required to facilitate effective uptake.

This presentation provides an opportunity to explore the lessons we have learned and the challenges we have come to recognise in being able to continue to engage and deliver useful climate information to users.

## **Climate Change Vulnerability Assessment of the Coastal Tourism Sector in Panglao Island, Bohol, Philippines**

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The vulnerability of the coastal tourism sector in Panglao Island, Bohol, Philippines to impacts of climate change was determined. Specifically the study aimed to identify current indication of impacts of climate change, determine the degree or level of these impacts and identify current adaptation measures. In addition, the study also measured the vulnerability index of the coastal tourism sector and identified the specific sectors that will need improvement to enhance its adaptation initiatives. Vulnerability is taken in this study as the preparedness level to cope with the impacts of climate change and is expressed using vulnerability and resiliency indices. It is a factor of awareness (knowledge, attitude, practice) and institutional capacity of the different sectors. Vulnerability index is computed as risk less adaptation while resiliency index is taken as the ratio between adaptation and the level or degree of climate change impact. Adaptation is a function of knowledge, attitude and practices indices coupled with the institutional capacity index. Five climate change impact were predetermined in this study. These include storm surge inundation, 5 m-sea level rise, seawater intrusion, coral bleaching and dengue health issue. All of these impacts were present in the two municipalities and therefore, were given a risk index of 100%. Combining all the climate change impact, the average degree or level of the impacts was 75.46% for Panglao and 43.94% for Dausi. The overall adaptation index for Panglao was determined to be at 60.01% level and Dausi at the 63.57% level. These indices are in the high level category. The Overall vulnerability index for Panglao was estimated at 39.01% and for Dausi at 36.43% levels. Both estimates are in the moderate risk level. Factoring in the level or degree of risk, the resiliency index for Panglao was estimated at 0.85 and for Dausi at 2.34. Panglao's resiliency index can be deemed as less resilient, while Dausi can be considered more resilient. With the climate change vulnerability and resiliency indices established for the coastal tourism sector in Panglao Island, the challenge now for the coastal tourism sector is to consider how to improve or sustain the adaptive mechanisms to enhance preparedness or resiliency over time.

## **Long-term persistence in future climate simulations: An investigation from a water resources management point of view**

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Although General Circulation Models (GCMs) provide planetary and oceanic simulation of past and future climates, they are limited in their ability to simulate variables of importance to water resources planning and management at regional and catchment scales. Apart from their inability to model processes occurring at scales finer than those that are modelled, GCM simulations suffer from a range of uncertainties that include Structural Uncertainty, Parameter Uncertainty, and uncertainties due to Initial Values and the Boundary Conditions used.

These uncertainties are compounded when simulations are assessed for their representation of low-frequency variability or long-term persistence, such variability referring to variations over time-scales longer than a year. This variability is often driven by forces such as the El-Nino Southern Oscillations (ENSO), which impacts Australian hydrology and causes sustained and widespread drought over the continent.

This research investigates the extent of low-frequency variability in rainfall and a range of hydro-meteorological variables, as present in the historical data as well as GCM simulations of the current climate. Given the potential to change this representation as a result of using approaches for GCM bias correction, the next stage of this research will focus on the extent of such modifications that are likely due to the use of commonly adopted bias correction strategies. Given the importance of representing low-frequency variability in simulations of a future climate, particularly from a water resources perspective, this study has the potential to advise users on the problems raw climate simulations of the future may contain.



## Identifying problems and finding solutions: using the Climate Vulnerability Index to prioritise adaptation responses

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The need for adaptation to climate change has been clearly stated in both science and policy circles, with the need to focus on water highlighted. As stated in the World Water Forum in 2009, 'Water is a primary medium through which early climate change impacts will be felt by people, ecosystems and economies'. It is with this in mind that this paper addresses the issue of adaptation in developing countries through the lens of water resources.

Risk factors most relevant to poor communities tend to be related to lack of access to resources, inadequate property rights, and negligible political influence. Identifying the most appropriate adaptation strategy for any particular location can only be achieved by taking a holistic view of the relevant impact drivers, taking account of the adaptive capacity of local populations, and resource opportunities available to them.

When considering the need for adaptation in developing countries, it is vital to recognise that adaptation to the impacts of climate and other global changes cannot be homogenous across the world. Adaptive responses must be designed to meet the specific needs of local populations, and must be delivered at the appropriate scale. What is needed at one scale is not the same as what is needed at another scale, and in the work described here, a focus on possible community level adaptive responses is provided.

For the purpose of analysing the diverse drivers of change, factors giving rise to vulnerability from climate and other global changes can be classified within a categorical framework, which, when combined, can provide an integrated assessment of human vulnerability. Such an approach has been discussed previously as the Climate Vulnerability Index, where human vulnerability to global and climate-induced changes on water resources is examined. Given that climate impacts will occur within a dynamic, changing world, this approach specifically takes account of climate change in the context of the other global changes that are simultaneously occurring. A number of organisations have recently adopted this approach as part of their recommendations for adaptation.

In applying the methodology of the Climate Vulnerability Index, a selection of variables is identified to represent the core components of what gives rise to vulnerability. Through these, a quantifiable measure is provided of resource availability, access to those resources, the way we use them, our ability to manage them, and the various risks that each of these represents. On the basis of the results of this analysis, appropriate, site-specific adaptive responses can be identified. This enables more efficient targeting of financial and human resources to provide cost-effective responses, helping the most vulnerable people to adapt in the face of change.

In this paper, the Climate Vulnerability Index is used to present a selection of developing country cases from Africa and Asia, and on the basis of the results generated by this approach, a selection of tailored responses are proposed to tackle each of these cases in a site-specific way.

## Rapid Information Delivery: Ten Top Tips for Climate Change Adaptation

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There is no doubt that climate change has become one of the most pressing issues of our time, and that there is a need for more effective communication about potential adaptation strategies. Despite ongoing political debate, there is no clear path for the nation to follow. As Moser and Dilling said (2004 p.46) 'finding ways to engage previously unconcerned audiences and - maybe even more problematically - re-engaging audiences previously turned off by the controversial and confusing discourse... is vital'.

To increase the ability of local authorities and governing bodies to adapt to climate change local level information is needed to support behavioural change. A booklet has been produced to contribute to this information transfer process which aims to make sense, on a local level, of the large amount of generic climate adaptation information available. At the local scale building confidence is important to ensure that sound knowledge is used to deliver more informed, effective and efficient practices and decisions.

In this paper, we present the booklet '10 Top Tips for Adapting to Climate Change', which has been designed to raise awareness about the scope for adaptive capacity. It is targeted towards staff in local government institutions to enable them to appreciate how they can play a proactive role within their existing mandates. There is already a myriad of documentation on climate change adaptation and this project does not attempt to provide yet another one. This booklet has been designed to act as an 'aide memoire', providing a summary of key issues which need to be considered when taking action on climate change, including: determining responsibilities for managing adaptation; identifying key issues within local government mandates; local constraints to adaptation; benefits from integrating strategies; importance of stakeholder involvement, and promoting efficiency and effectiveness through working as a team.

The creation of this booklet comes at an apt time, within the UNESCO decade of Education for Sustainable

Development (2005-2014). The aim of this program is to aid the development of knowledge and skills to enable more informed decision making to address economic, environmental and social challenges. The principles of the Australian Government's Components of Education for Sustainability (DEWHA 2009) have been taken into account in the project design. On the basis of these principles, we hope this booklet will help those engaged in envisioning a better future, through reflection, participation and critical systems thinking, to build meaningful partnerships for adaptation to change. We hope that this booklet can contribute to building capacity in our institutions to support the adaptive strategies that are needed to ensure the future security of this nation.

## Effective water planning to maintain water supply at acceptable levels of risk

M Summerton<sup>1</sup>

<sup>1</sup>Umgeni Water, South Africa

Evidence exists that global water supplies are running out. A recent United Nations report indicates that the average person's water supply could be cut by a third in the next 20 years. Furthermore, indications are that the effects of water scarcity will be felt the most in Africa, due mainly to this continent's lack of adaptive capacity. This is of major concern to Umgeni Water, a bulk water utility to some 6 million people in KwaZulu-Natal, South Africa where water planning using contemporary hydrological and water planning techniques indicates that the risks associated with not being able to supply water are increasing. At a 99% assurance level, these models indicate a 0.5% risk of failure (by August 2010) rising to 5% (by 2011) and 25% (by 2016).

A reliable supply of potable water is of particular importance in the key Mgeni catchment which contributes ca. 20% to South Africa's Gross Domestic Product. Although this region receives up to twice as much rainfall as some other areas in the country and has about 40% of the country's runoff, it is not immune from periodic droughts and water shortages. The main reasons for this are that a) the catchments water resources are already grossly over allocated, b) it has one of the highest population densities in the country, c) the demand for potable water, often at high levels of assurance, continues to increase at around 4% per annum, and d) anecdotal evidence supports the notion of a changing climate, at times exacerbated by the effects of El Niño.

The onset of water scarcity cannot be stopped altogether, but with proper planning and implementation of mitigation and adaptation strategies, the potential consequences can be managed to ensure adequate water supply in the future. For example, drought management should not, as in most cases, just be a relief response, but a highly planned intervention, which should form a normal part of integrated water resource planning. To this end, Umgeni Water continuously monitors water resources, reports on the status of water resources, optimises system operations to maximise water yield and minimise costs and conducts regular risk analysis.

This paper describes in detail Umgeni Water's approach to:

- Assessing the vulnerability to various stressors such as an increasing demand for water and the potential impacts of a changing climate,
- Reconciling water demand and supply using the water planning process,
- Water resource status monitoring to assist decision-making,
- Determining acceptable levels of risks for water supply, and
- Implementing mitigation and adaptation strategies from changing operating rules in the short term to planned capital infrastructure improvement projects in the future.

In order to maintain a sustainable supply of water into the future, thereby minimising the possible effects of water scarcity and drought.

## Toward Improved Community Engagement in Actions to Reduce the Impact of Climate Change on the Great Barrier Reef

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Climate change is the greatest long-term threat facing the Great Barrier Reef (GBR), with severe impacts predicted under even moderate climate change scenarios. Engaging stakeholders in GBR climate change reduction and mitigation strategies is central to both increasing social-ecological resilience and reducing human impacts on climate, and is therefore an integral part of the Great Barrier Reef Climate Change Action Plan (GBRCCAP). Effective engagement with the issue of climate change and the GBR requires that individuals be knowledgeable about the climate change problem, its causes, and its potential impacts on the Reef, care about those impacts and have a desire to be involved in reduction and mitigation activities, and ultimately take action that helps reduce or mitigate the impacts of climate change on the Reef.

We surveyed 1,622 Australian residents to understand the potential for engaging the community in GBR climate change reduction and mitigation strategies. Eighty nine percent of respondents were concerned about the effects of climate change on the GBR, and 75% believed climate change will have a major impact on the GBR over the next 25 years. Our results suggest that communication and education efforts have been successful at increasing public knowledge about climate change and fostering pro-environmental attitudes and beliefs related to climate change and the GBR.

However, while 83% of respondents were interested in helping reduce the impact of climate change on the GBR, only 21% said they were very likely to take some action in the next 12 months. There were a number of constraints preventing individuals from doing more than they currently do to reduce the impact of climate change, the strongest of which were: not knowing what else they can do (69% of respondents), having more important priorities (51%), lack of time (47%), and inadequate understanding of the climate change problem (34%). Results suggest there is high potential for improved engagement of communities in actions to reduce the impact of climate change on the GBR if agencies can develop programs and strategies that help people negotiate these constraints.

## How Europe adapts to climate change

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After two decades of emphasis on mitigation, the European Union has recently accepted its vulnerability to the projected impacts of climate change. But even before the European Union added adaptation to its climate policy menu, and in the absence of socially relevant research on vulnerabilities and adaptation, local, regional, and national levels were already developing adaptation strategies. Climate research in the 1980s focused on changes in the climate system and on the attribution to natural or anthropogenic causes. From the 90s onwards mitigation research was added to the research agenda and initial assessment of potential vulnerabilities and impacts were published, pushing towards a adaptation policy agenda. Only from 2005 targeted adaptation research programmes are being developed in only a limited number of countries. Is this timely, or does this lead to a potential mismatch between adaptation science and policy?

The paper reviews national adaptation strategies that were either formally adopted or under development by the end of 2009 in the EU member states and includes a number of similar efforts at the regional level. The paper is based on a study on national adaptation strategies by the Partnership for European Environmental Research (PEER) and on a study on regional strategies for the European Commission. It focuses on six dimensions of National Adaptation Strategies: (a) the drivers of adaptation policies, (b) the design of the science-policy interface, (c) communication and dissemination, (d) multilevel governance, (e) policy integration, and (f) implementation, monitoring and evaluation (Swart et al., 2009). Similarities and differences are summarized.

Developments in frontrunner countries like the United Kingdom, Finland, The Netherlands and Germany are used by other countries as a source of inspiration, notwithstanding their large differences in specific vulnerabilities, institutional and political structures, and social-cultural norms and values. There are at least three types of strategies that can be identified: 1) those that set a framework for action at national, regional and local level and are operationalised accordingly; 2) those that primarily have been developed to put adaptation on the political agenda, leaving development and implementation of concrete adaptation to follow-up activities; 3) those that result from the deliberated decision not to develop a formal national strategy, leaving adaptation to sectoral and local action.

All countries are currently exploring ways how to optimize the role of scientific information in shaping adaptation policy, struggling with the fact that many adaptation options are about mainstreaming climate concerns into a very wide set of sectoral policies rather than a clear-cut single-sector policy. New governance challenges emerge with the White Paper on climate change adaptation issued by the European Commission in 2009 as the first step towards a European Adaptation Strategy that is scheduled for 2013. The details of that strategy will be developed along four pillars: strengthening the knowledge base through the development of a Clearinghouse on information on impacts, vulnerability and adaptation; integrating climate change into EU legislation; including climate change impacts into relations with neighbouring and other countries; and the development of a combination of policy instruments to ensure effective delivery of adaptation.

The paper concludes with an analysis of key challenges for research to effectively support the development of actual adaptation action to meet the strategies' objectives at the various administrative levels in Europe.

## Adapting in a worst case climate change world

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Efforts to control the emissions of greenhouse gases remain largely unsuccessful and peaking of global emissions within a few decades followed by a decline appears to be unlikely. As a consequence, it is increasingly recognized that the chances to limit global mean temperature to 2°C - a goal adopted by the EU and reflected in the Copenhagen Accord - are rapidly decreasing. At the same time, recent studies suggest that climate and sea level may change according to the high end of the IPCC projections or beyond, while vulnerability of ecological and human systems also appears to be larger than assessed some years ago. This calls for the consideration of "worst case scenarios" for climate change adaptation, which not only assess worst case climate impacts, but also address the way countries and other stakeholders may respond to such accelerated climate changes, if and when they would be confirmed through monitoring activities.

There are four possible ways to respond to extreme climate change: emissions reductions more drastic than considered today, carbon dioxide removal from the atmosphere, solar radiation management, or adaptation to the remaining consequences. The combination of the 2nd and 3rd solution is often called geoengineering. The 2009 Copenhagen Climate Summit demonstrated that even halting growth of global emissions is difficult. The recent Asilomar conference on developing rules

for geoengineering confirmed how controversial these solutions are. Human history teaches us that most probably there will be different views on the need for multilateral agreement on responding to extreme climate change: nations may move from negotiation and collaboration to the pursuance of narrow self-interest with all political and maybe even military means at their disposal. There will also be differences on the urgency of the matter compared to other pressing problems. This suggests that it is very well possible that no internationally coordinated mitigative response to extreme climate change can be achieved, leaving the world the only option to adapt to possible rapid climate change impacts affecting natural and societal systems.

In the paper, we discuss how the consideration of the possibility of climatic changes, more extreme than expected until recently, may affect the current climate change adaptation debate in three interrelated ways. Firstly, while municipalities, regions, and countries currently focus almost exclusively on adaptation to potential impacts within their own boundaries, it might well be that especially in a world with rapid climate change, impacts elsewhere may have very serious indirect consequences on national and local economies and ecosystems. Examples are trade effects (prices of food, energy, timber), higher share of water used and diverted, up-stream, security implications, and increased flows of refugees. This raises the scale of climate change adaptation from local and national to continental and global and requires involvement of sectors that are currently generally not involved in the climate debate. Secondly, the possibility that the climate may change faster or the sea may rise higher than projected recently could imply that adaptation options, which are currently often incremental improvements of current practices, may be insufficient and that more radical options may be needed. This particularly applies to less flexible strategies that require major, long term investments, and this paper elaborates some examples for the water management sector. We argue that a successful adaptation policy requires extreme scenarios to be seriously taken into consideration, together with the more “average” projections. While the high uncertainty in worst case projections may not justify direct costly investments (like additional heightening of dikes), a timely vision how to react if such projections would materialize, can help developing a more robust and flexible adaptation strategy.

## **Impacts of Climate Change on the Straits of Malacca: The “Three Major Effects” and Their Policy Remedies**

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The Straits of Malacca flows within the territories of Malaysia and the Republic of Indonesia. It is an important lifeline to these countries, especially Malaysia. Apart from its significant role in international shipping, the Straits of Malacca is predominantly utilized by Malaysia for fisheries, coastal tourism and other non-navigational uses. Like many other important marine areas in the world, the Straits of Malacca will be impacted by climate change. With the marine pollution problem still looming within the Straits, coupled by the advent effects of climate change, allowing the Straits to be in its status quo will be catastrophic to Malaysia, especially to its economy and the livelihood of its people.

This paper attempts to provide non-technical overview of climate change issues on the Straits of Malacca, by focusing on the “three major effects” of climate change, namely global warming, the increase of seawater temperature and rise of sea level. It will focus on the possible adaptation policy responses, which can be undertaken by Malaysia to reduce the impacts of the “three major effects”.

The first part will describe, in general the possible impact scenarios of climate change due to the “three major effects” to the Straits of Malacca, taking into consideration the geo-morphological characteristics of the Straits of Malacca. The environmental assets in the Straits of Malacca (within Malaysian waters), having the vulnerability to be affected by the “three major effects” will be determined. Possible vulnerable areas, especially in the northern area of the Straits of Malacca will be mapped using GIS.

A review on the national institutional framework, having the effect to prepare Malaysia to combat the “three major effects” on the Straits of Malacca (focusing on the vulnerable areas) will be carried out. The institutional framework is divided into two: regulatory and management. The regulatory framework deals with those maritime related policies and legislations that are currently regulating the environmental related issues in Malaysia. Initial findings have found that the national regulatory framework lacks the remedy to combat the “three major effects”, with only minor ambiguous climate change related provisions in the existing framework. The management framework, on the other hand is satisfactory. It is currently under the purview of specific departments under the aegis of the Ministry of Natural Resources and Environment (NRE), which has been responsible to draft the National Policy on Climate Change.

The paper will then argue that to combat the “three major effects” to the Straits, policy measures or responses should focus on adaptation with particular emphasis on implementing the ‘precautionary principle’ and ‘polluter pays principle’, which in the end to achieve sustainability within the waterway. Mitigation policy measures are not desirable because the activities in the Straits of Malacca do not contribute much to Malaysia’s GHG emissions. Although Malaysia pledged at the 15th Session of the Conference of Parties (COP 15) to the United Nations Framework Convention on Climate Change (UNFCCC, Germany) to reduce her GHG emissions up to 40 % by 2020, it does not have much impact on the activities in the Straits of Malacca.

## **Projections of droughts during the 21st Century in Australia using AR4 climate models**

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Many regions of Australia have experienced the impacts of climatic extremes, including droughts, in the past, and indeed will do so into the future. The socioeconomic impacts of drought can be devastating, both to the livelihoods of the people and industries directly affected, and indirectly to society as a whole. Hence, climate projections that can shed light on

the severity of future droughts in both their frequency and duration are of vital interest to Australian communities.

This research uses the AR4 coupled climate model's projections to compute the meteorological drought indices for several key regions in Australia under the SRES A1B, B1 and A2 emissions scenarios. A Rainfall-Deciles-based Drought Index (RDDI) and the Standardized Precipitation Index (SPI), which are a measure of meteorological drought, were computed using model monthly rainfall data.

The results of the analysis show a significant increase in the number of months per decade under drought conditions for most regions of Australia during the 21st century. The projected increase in the number of droughts has resulted from both the projected increases in the frequency of droughts and their average duration, although these contributions vary spatially across the continent. A trend towards a larger fraction of the Australian continent being under drought conditions at any given time in the future is evident. The implications of those findings for biodiversity, water resources and food production will be discussed.

## How should we share the global burden of adaptation costs now ... and in future?

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One part of the Copenhagen Accord, which was approved to be "taken note of" by delegates at COP15, pledges US\$ 30 billion to the developing world over the three years from 2010 to 2012, rising to US\$ 100 billion per year by 2020, to help poor countries adapt to climate change. By and large, the pledge has been welcomed as a landmark advancement which is expected to push and accelerate realization of adaptation in developing countries. However, here, several questions arise. Will the pledged funding suffice for fully achieving adaptation needed in those countries? To begin with, who should pay to whom and how much for the full achievement? Furthermore, how will the fair share of the burden change in future when socio-economic conditions in developing countries as well as in developed countries change significantly?

Estimation of the costs of adaptation at global scale is clearly a policy-relevant issue and has been a hot research area in recent years. Several large research projects have been conducted by international organizations such as World Bank and UNFCCC for urgent improvement of knowledge on the area. While the costs estimated by those projects are quite uncertain, we still think it is worth discussing in parallel how the costs should be shared by regions for looking for the way to answer to the arose questions.

With the backgrounds stated above, the objectives of the research presented in this poster are:

1. To examine fair inter-regional allocation of adaptation costs based on existing estimates of regional adaptation costs and alternative metrics of fairness (ability to pay, responsibility and others).
2. To examine how the fair allocation will change over the incoming decades to 2050 due to the changes in ability and responsibility of each region to bear adaptation costs as well as the change in regional adaptation costs.

The results of the analysis demonstrate where the burden for adaptation occurs as well as which regions should shoulder responsibility and how sensitive these outcomes are to different rules on fairness which are being played out in international negotiations.

## Deer impact on subalpine forest ecosystem in Japan: Indirect effect of climate change?

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Climate change is suggested as one of potential causes for serious impact of Japanese Sika deer on subalpine forest. Degradation of mountain forest is central issue for conserving Japanese ecosystem and biodiversity. We have started a case study on Mt. Fuji, Japanese symbolic mountain, in which deer impact seems ongoing. Our hypothesis is that deer impact on subalpine forest varies depending on the spatial use of deer, which is influenced by winter condition (e.g. snow depth, frosted floor) and vegetated open field attributed to avalanches. We will present the result of bark stripping study on Mt. Fuji and discuss about the relation to the regional climate.

## Water Planning and adapting to Climate Change in Australia: Policy, Law and Practice

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Australia's national water policy requires water planning processes to consider climate change. Yet the National Water Initiative 2009 Biennial Assessment states that jurisdictions have not expressly considered it in most water plans. Because of severe drought conditions in 2007-8, many water plans in south eastern Australia were suspended. Will this scenario be repeated in the future because of a lack of preparedness for climate variability and climate change?

This paper considers water planning the Condamine Alluvium, in the Queensland headwaters of Australia's Murray Darling River system. Agriculture contributes to about 25% of the region's wealth and current estimated annual groundwater abstraction is 67 gigalitres per annum (GLPA). Around 90% is used by irrigators, 5% for stock intensive purposes and 5% for urban centres. Because of the recent drought and over-allocation, diminished bore performance and declining water quality are evident.

CSIRO scientists endorsed a 'best available' estimate of 40 GLPA of groundwater in the area. This volume was extrapolated from previous studies using simplified groundwater models, and an assumption that unmetered groundwater use increased known extraction by 25%. Using CSIRO/BoM projections, the best estimate of climate change in the region by 2050 consists of four factors: (a) a rise in temperature of +1.2 to +2°C; (b) +3% to +7% potential evaporation; (c) increased rainfall variability; and (d) a 5% to 10% reduction in average annual rainfall. There is a high level of uncertainty in rainfall projections (-21% to +10%), highlighting the importance of risk management in water planning. CSIRO estimates of impacts on streamflow (-8%) and groundwater recharge ( $\pm 10\%$ ) also have high levels of uncertainty.

With the need to cut back current groundwater abstraction by 40%, we discuss the implementation of practical measures which support the consideration of the effects of climate change in water planning.

As a first step, a stakeholder analysis was conducted through interviews with 23 groundwater users and managers to establish opinions and needs about groundwater planning to inform the planning process. Stakeholders identified the need for development of practical tools that target the priority issues of over-allocation and climate variability and climate change. Stakeholders also recommended tools supporting groundwater conceptualisation through visualisation and animation, systems to improve water use efficiency, climate variability matrices, and social-economic assessment incorporated in decision support frameworks to assist in trade-offs.

A second measure determined regional groundwater licensees' perceptions of climate change issues through a survey (N=51). Respondents' views fell into two main groups i.e. how reduced rainfall and streamflow recharge due to climate change may affect the sustainable groundwater yield; and how trade-offs and cut backs might be managed to meet the sustainable yield. 56% of respondents rejected the science of climate change, pointing to a need for joint exploration of this issue. In addition, a large majority voluntarily voiced concern about the impact of increasing coal seam gas extraction on water availability.

Since water is vital for food security, the ability for the agricultural sector to plan for and adapt to climate variability/change has important implications. A risk matrix tool was developed to engage irrigators. In a workshop format this tool

- identifies and assesses climate risks regarding on-farm water management using a process consistent with the Australian Standards on Risk Management;
- identifies change in "best management practice" where likely cutbacks in water allocations and the impacts of both climate variability and climate change are considered in regards to water supply, crop water use and water use efficiency; and
- encourages reflection on how implications of climate change should be considered in water planning policy and processes.

Our research is significant in several respects. As a result of our findings, a statutory community panel recommended that 1.25% of yield be provided for risk factors. Although a small figure, the in-principle acceptance of risk has profound implications in the light of a proposed cut back of about 40% of water use. Secondly, the research documents how on-farm adaptation strategies can be encouraged and how this translates into social learning on climate change in water planning. Thirdly, we find that the precautionary principle needs to be applied in a consistent and equitable manner across industry sectors if agencies require communities to accept the need to adapt for climate change.

## Enabling Climate Adaptation: Navigating Communication Pathways

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Effective adaptation planning requires communicating climate change information with various social actors in a credible and relevant manner that builds determination and capacity to address climate risks and vulnerabilities. Climate risk information is one type of information to be included in a stream of information being considered when making adaptation decisions. Despite considerable progress within the research community in developing new climate risk information, communicating that scientific information and engaging with other kinds of information and ways of knowing pertinent to adaptation remains a challenge. In this paper we explore various pathways for communicating climate risk information, focusing on the processes and the content suitable in different contexts.

There have been few comprehensive efforts to develop climate risk communication approaches that would be sufficiently effective as to stimulate action on adaptation. Poorly developed communication pathways have resulted in situations of inadequate dissemination and improper interpretation of scientific findings of climate change risks, inability within the science and policy communities to fully account for local knowledge and local-scale needs and priorities, and missed opportunities to develop local capacity for understanding the larger scale dimensions of the problem and responding to climate-related threats.

Here we present recent efforts to address these shortcomings through the Advancing Capacity to Support Climate Change Adaptation (ACCCA) project, which developed and implemented participatory communication strategies for addressing the topic of climate risks with different stakeholder groups. The project was implemented through fourteen pilot actions in countries across Africa and Asia. We review the lessons learned from this project on the fundamental concepts of risk communication and principles of communicating effectively, both in terms of the process of engagement and the content of the communication.

ACCCA was based on the premise that building effective risk communication pathways requires fostering a process of social learning through active partnerships between scientists, policy makers, civil society representatives and members of

vulnerable communities seeking to adapt and develop in a sustainable, integrated, bottom-up way, rather than a relying on top-down “expert” judgment. In this sense, communicating about climate risks was understood as a critical process to fostering learning needed to address the challenges of climate change, drawing together people with different types of knowledge.

In general, the risk communication strategies implemented in ACCCA generated rewarding effects on several levels in that community concerns were given voice through multi-stakeholder dialogues with policymakers; the trainings and dialogues contributed to collective generation of knowledge and a growing realization of the implications of climate change; and the nature of participatory approaches to communicate risk gave a sense of stakeholder ownership over the learning process and engendered shared understandings and capacity for action. In addition to opportunities, there were a number of challenges encountered in presenting complex climate risk information in terms that are relevant to a potentially diverse range of stakeholders, in training individuals to develop communication methods and to continue the communication process, and ultimately in how to sustain and scale up the effort.

Some of the key lessons learned from the ACCCA pilot actions regarding effective communication pathways are:

- communication to support adaptation needs to be a two-way process, a dialogue rather than classic dissemination, providing an opportunity to negotiate priorities, meanings, framings and relevance;
- the communication process needs to be an inclusive one, empowering a variety of actors to make decisions and act;
- innovative processes of interactive learning are entry points and catalysts that enhance reflection and co-generation of knowledge;
- understanding of the local context and knowledge is critical; strategic use of space, place and time affects the effectiveness of engagement (i.e. how, where and when people are engaged in communication affects the outcomes);
- catering for a wide range of stakeholders requires the combination of diverse approaches that are tailored to the local needs and are specific to the decision context.
- scientific information needs to be presented in locally relevant terminology and time frames, dealing carefully with issues of uncertainty and confidence so as to inform robust decision-making.

## **The threat of climate change and adaptation behaviours: Studies of the New South Wales population in 2007 and 2010**

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Despite being unavoidable, climate change is often perceived as a distant and varied threat, resulting in inertia with regard to adaptation and behavioural change; especially when changes involve costs, e.g. monetary costs or reduced convenience. Improved understanding, at a population level, of key motivators, enablers, or barriers to the uptake of adaptation behaviours is extremely valuable since this knowledge can be employed in strategies to accelerate the rate of climate change adaptation. Even small behaviour changes achieved at a population level can result in significant impacts in this regard.

This paper will report data collected from representative samples of the New South Wales (NSW) population in 2007 and 2010 to investigate trends over time in threat perception to climate change, accompanying levels of reported behavioural change, and modelling of relationships between these data and a range of health, resilience, and demographic variables.

The research team undertook a study in 2007 of top-level indicators of hazard perception, including climate change threat perception and behaviour change, using a module of questions that were incorporated into the NSW Department of Health Population Health Survey. In 2010, with funding from the Australian Government (National Security Science and Technology Branch of PM&C), questions from the 2007 survey were replicated in an extended survey. This survey included additional questions on the uptake of specific adaptation behaviours, such as reducing energy and water usage, installing rain water collection tanks, and reducing personal transport usage.

Data collection for the current 2010 survey (n=2000) is currently underway and will be concluded by the end of February. Weighted data will be compared, and pooled, with the weighted 2007 data to explore changes in overall levels of threat perception, vulnerability, and behaviour change and to assess the reliability of the 2007 data modelling. Analysis will be undertaken to look at factors associated with the uptake of specific adaptation behaviours, and adaptation overall, and this will be reported.

## **Adapting to climate change: development of an integrated decision support tool for disaster and evacuation planning in regional areas**

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Little attention has been paid in regional road network planning to the potential needs for evacuation planning in the face of natural disasters, including storms, cyclones, floods and bushfires (although the evacuation circumstances are quite different for the latter). Climate change is increasing the likelihood of such disasters, in terms of coverage, frequency and intensity. Demographic change and new settlement patterns are compounding the risks to the population of regional areas. There is a need to develop quality decision support tools to assist in planning for disaster management and evacuations.

This paper provides a specification for the development of an integrated tool for planning and operational management for evacuation situations in regional areas, as part of a framework for the decision making process for emergency management. The tool includes four principal components: (1) a range of disaster impact models that can estimate the dynamic spatial and coverage and intensity of a given disaster in a given region and hence the impacts in space and time of the disaster, (2) a GIS database of physical, infrastructure, environmental, demographic and land use characteristics of the region, (3) a behavioural response model for the affected population, and (4) an infrastructure vulnerability assessment model that can determine critical locations and factors affecting emergency response plans, including evacuations, under a range of disaster scenarios. A range of powerful modelling tools of the passage, dynamics and intensity of different types of natural disasters are available, and the task is to integrate these to process necessary inputs to a disaster management model. The GIS framework offers an important technical tool for this process. Behavioural response is known from the international literature to be a major factor influencing the success of any disaster planning strategy, and the social and psychological factors influencing response need to be understood and utilised. The important and potentially limiting role of the regional road network is covered by the tool, when some parts of the network may be closed or degraded.

The decision support tool thus includes GIS databases of environmental, topographical, transport infrastructure and emergency service facilities in a region, scenario generation models to simulate the effects of disasters (e.g. storms, floods and bushfires) on the study area, and models of road network vulnerability to examine the potential network degradation or failure and then identify degrees of vulnerability for different localities in the region. It may be used to develop and test alternative plans for access to and egress from the region and specific localities under a range of conditions, determine planning and operational priorities, and assess risks. Beyond the evaluation and comparison of alternative management plans, its outputs include identification and assessment of critical infrastructure, and assessments of likely impacts on communities.

## Climate Change Impacts: Addressing the Challenges faced by Malaysian Islands through Policy and Legislations

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Malaysia is surrounded by more than 900 islands, which form an integral part of the nation's total coastline of 4,675 km. While Malaysia's islands serve vital ecological, economical, social and cultural roles, they are perhaps also the most vulnerable areas that will be first affected by the impacts of climate change. Among the detrimental risks posed by climate change to the marine and coastal environment are sea level rise, eroding shorelines, increasing frequency of extreme weather events, changing precipitation patterns, ocean acidification and coral bleaching. Recognizing the urgency to protect this vulnerable ecosystem, Malaysia has launched an integrated research initiative to address the impacts of these threats. The studies take a comprehensive approach where the marine and coastal ecosystems are considered as a single entity but it is important to note that the isolated and vulnerable nature of islands differentiates itself from coasts that are closer to the mainland by way of its ecological function, population pressure and infrastructure. These factors will determine the magnitude of the climate change impact on the islands. Hence, there is as such a need for specifically designed strategies that effectively increases the adaptive capacity of islands while balancing it with mitigating actions. Based on the platform of science and the policies that protect the marine and coastal environment, this research aims to identify adaptation plans which are measurable and achievable through policy recommendations.

## Adding climate impacts and adaptation possibilities to an economic computable general equilibrium model

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The objective of this research project is to model the impacts of climate changes and the possibilities and costs of adaptation using GEMINI-E3, a computable general equilibrium (CGE) of the world economy (<http://gemini-e3.epfl.ch/>). Most large-scale CGE models are purely economic models, without climatic modules or any explicit description of climate impacts and adaptation possibilities. By adding these features to GEMINI-E3, we show how it can be done in other CGE models. As a practical application, we will estimate the economic incidences of climate changes in Switzerland, as well as the effects of adaptation to these changes, the costs and the benefits which result from this. We will stress impacts and adaptation in the following sectors: agriculture, tourism, energy, and infrastructures. Ultimately, the goal of this research is to help prioritize adaptation measures.

The first step of this research was to identify the scientific literature on climate change impacts in Switzerland. Ideally, that literature would indicate what changes in climate variables (temperatures, precipitations, extreme events) are expected and what the effects of these changes on diverse sectors of the Swiss economy could be. From that literature, we derive statistical coefficients that relate climate variables to economic variables such as production costs and outputs. These coefficients and the relationships they summarize are added to the equations that describe economic activity and interactions between sectors in the CGE model. We were forced to redefine some sectors and create new ones in the model, in order to isolate those that are likely most affected by climate changes, such as water supply and tourism.

When the model is augmented with the climate variables, calibrated and tested, it allows simulating the sectoral and aggregate costs of climate changes. Different scenarios for the evolution of GHG concentrations and the resulting climate effects can be simulated. In a CGE model, economic actors optimize under current conditions. Thus, for instance, if reduced precipitations lower agricultural output, farmers can adjust by using more inputs (fertilizers, irrigation, labour) and by switching crops. Rising prices



for agricultural products encourage them to do so. There is thus endogenous adaptation in such a CGE-type economic model.

The augmented model will allow assessing domestic climate policies, in terms of costs of mitigation and reduced climate impacts (if any).

The final step is to add exogenous adaptation. This will take the form of government support for infrastructure and technological improvement, subsidies, etc. Costs and economic benefits of such measures can then be compared and optimized.

## **What is the capacity of local councils in Australia to adapt to climate change impacts in coastal urban areas?**

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The IPCC identifies coastal areas as particularly vulnerable to climate change (IPCC, 2007). Climate change is likely to affect all Australian communities but coastal areas such as low-lying islands and extensive coastal plains will be under particular pressure (Garnaut, 2008; Aboudha and Woodroffe, 2006). Current socio-economic trends are likely to increase vulnerability to climate change. Over the next 30 years the coastal population is expected to increase by 26 percent, reaching 7.2 million by 2036 (Australia State of the Environment, 2001).

Many sectors and systems are highly vulnerable to climate change, including the functions and responsibilities of local governments. The Australian Government regards “preparing Australia for the unavoidable impacts of climate change” as an imperative (DCC, 2009:1). The Australia State of Environment Report 2006 states that “planning for adaptation to climate variability should be priority” (2006:49). However, so far there has been limited incorporation of climate change considerations in relevant planning policy and legislation (Planning Institute of Australia 2007; Garnaut, 2008).

A number of projects have been conducted to build understanding of the physical and socio-economic vulnerabilities and impacts of climate change and to determine adaptation strategies and adaptive capacity. A synthesis of these assessment insights points to several important gaps in our understanding of the capacity and agency of local government and non-government actors to adapt to climate change. In terms of awareness and preparedness, adaptation is very much an emerging issue as councils have until recently focused more on mitigation (Smith et al., 2008; Withycombe et al., 2008). There is also little understanding within councils about the level of vulnerability to climate change impacts (Withycombe et al., 2008). The focus of research has been on vulnerabilities and impacts, however, most Australian impact assessments are presented with little or no socio-economic perspectives (Hennessy et al., 2004). With regard to governance and planning, Australia currently lacks an overarching national coastal policy. Other issues relate to: (i) access to reliable data on potential climate risks (Voice et al., 2006); (ii) a lack of resources and adequate monitoring of policy implementation and review (Hunt et al. 2007); (iii) lack of advice on the best way to reflect these matters in a planning scheme (Gurran et al., 2008); and (iv) the capacity to develop an assessment of impacts that is defensible and is subject to appeal (Gurran et al., 2008). In terms of adaptive capacity, competing priorities, financial constraints and a chronic shortage of skilled planners across the country has resulted in a wide failure to incorporate climate change into planning (Burton and Dredge 2007; Garnaut, 2008). There is also an absence of systematic monitoring and evaluation of climate change adaptation initiatives (Withycombe et al., 2008).

This project consists of two major components: 1. Case studies of adaptive capacity to climate change of local urban government agencies in Australia: 2. An international comparison with a number of local case studies in urban coastal areas in the USA, UK, New Zealand and South Africa conducted in collaboration with international research partners. Focusing on local decision-making and planning processes, the case studies serve to collect primary data on the perception and conceptualization of the climate change problem in selected coastal urban areas, the development of adaptation strategies, the determination of the status of adaptation planning and implementation, key challenges and priorities at the local level, and stakeholder expectations and perceptions of the roles and responsibilities and adaptive capacity of various actors. The participatory research approach includes stakeholder interviews, focus groups, community consultations, workshops with local actors, and cross-country study visits. Lessons learnt with regard to good practice principles and approaches in adaptation planning will be identified and disseminated across the case studies.

The project is expected to build adaptive capacity in coastal urban areas to adapt to climate change. It will achieve this by addressing several key issues currently being neglected in most other research efforts on climate change in Australia; namely the socio-economic or ‘human’ dimensions of environmental change. These include important issues relating to stakeholder perceptions about risks, vulnerabilities and appropriate adaptation responses, the role of social culture, and the building of institutions and policies that foster resilience to shocks and surprises.

## **The adaptive capacity of urban coastal cities vulnerable to climate change impacts: A case study of social networks from the 2008 disaster flood event in Mackay, Queensland, Australia**

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The vulnerability of urban coastal cities to inundation from the impacts of climate change such as sea level rise has been highlighted in the 2007 IPCC report. In addition, predictions of an increased intensity of rainfall are likely to result in subsequent disaster flooding events, particularly in coastal areas.

Emergency managers have highlighted the importance of social networks as critical to the effective management of disasters in each of the stages of the Integrated Emergency Management System. Models can be used to illustrate how social networks are used to achieve adaptation to change.

A study was conducted in Mackay using a purposive sampling research design that was composed of three phases of data collection. Each phase of data collection was targeted at a different group of stakeholders: household residents, businesses and government institutions. Research was conducted to examine whether those established in areas vulnerable to regular flooding that have greater connections within the community displayed more resilience and adaptive capacity in the event of a disaster flooding event.

The study found that those who evacuated for greater periods of time and had lived in the community for longer periods, were more likely to have evacuated to family and friends. This is an indicator of adaptive capacity where households more established in the community had greater options available for them over longer periods in the post disaster recovery phase.

It was found that social networks within the community contributed to the adaptive capacity of households impacted by the disaster flood event, to display resilience. Examples of adaptive capacity were present during the event such as neighbours with reef boats rescuing those isolated by floodwaters and in the response phase immediately after the event where community groups, businesses and households provided food and shelter to flood victims. In the recovery phase family and friends providing accommodation assisted authorities in saving funds for the establishment of 'donga settlements' in a city already experiencing a housing crisis. This enabled the Mackay Regional Council to fund several programs in the recovery phase to address the ongoing psychological impacts of the flood event on the community and to focus on the disaster preparedness phase by commissioning a study that provided technical recommendations for the disaster mitigation phase.

## Potential Consequences of Climate Mitigation for Land Use Change in the 21st Century

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Land use change to meet 21st century demands for food, fuel, and fiber may well depend on both the nature of policies to mitigate anthropogenic climate change and on the success or failure of efforts to improve agricultural productivity. It now appears likely that international agreements and national policies intended to mitigate climate change will provide incentives to reduce deforestation and reforest lands as well as grow crops for bioenergy. In addition, it is becoming more widely recognized that continuing improvements in crop yields are critical for reducing pressure on forested lands while meeting the food demands of a growing global population. Development of improved crop practices and varieties to increase yield is thus an essential component of climate change mitigation, through reduced deforestation, as well as adaptation, through ensuring a resilient food production system.

By applying an integrated assessment model that simulates climate mitigation in both the energy and land systems, we gain insights into these potential consequences for future land use patterns. We use the GCAM (Global Change Assessment Model) to simulate how a climate mitigation policy that achieves a climate stabilization at 4.5 W m<sup>-2</sup> radiative forcing in 2100 and values carbon in terrestrial ecosystems interacts with differing assumptions of future agricultural productivity to determine future land use. The economics-based GCAM projects future land use at an aggregate regional scale, which is downscaled to a 0.5 degree global grid of potential future crop, forest and pasture land. We use these spatial outputs to examine land use transitions in specific ecosystems over the 21st century.

We find that a mitigation policy which includes an economic value for terrestrial carbon provides a strong incentive to preserve and expand forest lands globally. In addition, continued improvements in crop yield are essential, as both a mitigation and adaptation strategy, to spare the land needed to realize the terrestrial carbon storage potential of forests. If crop yields remain at early 21st century levels, GCAM simulates a widespread loss of tropical forests to cropland even with economic incentives to preserve terrestrial carbon for climate mitigation. With continued improvements in crop productivity, the terrestrial carbon valuation policies in GCAM are effective at avoiding widespread deforestation in model simulations. We find that the management of forest land and agricultural development over the next century for all purposes, including climate mitigation, will potentially be a larger determinant of global land cover than physical changes to the climate system.

## Transforming Australia's peanut value chains to adapt to future climates

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Agriculture in Australia has developed in response to a variable, but relatively stable climate. Under projected climate change, one adaptation strategy for farmers and/or industries is to move from areas of increasingly less-favourable climates, to regions becoming more suitable for crops. There are examples of this change currently happening in Australia. Such a transformation may underpin future food production and food security. However it raises many questions, both biophysical and social, that are beyond current experience of those involved in agricultural industries. To better assess the issues facing industries contemplating or undertaking transformation, we are studying the transformation of the peanut value chain in Australia.

The Burnett region in southeastern Queensland (~200 km NE of Brisbane) is the traditional 'home' of peanut production in Australia. The viability of peanut production in the Burnett region has declined by 70% over the past 25+ years due to lower than average rainfall, water stress and increased disease (aflatoxin) incidence. This decline in production is forcing peanut farmers to diversify their cropping options, and so threatens the viability of the peanut processing business in the region.

To manage the impact of climate change on the peanut value chain, Australia's largest peanut processing company, the Peanut Company of Australia (PCA), has embarked on a strategy to diversify the location peanut production to regions of more reliable rainfall. In particular, they have invested in farms in Katherine, in Northern Territory of Australia (~ 300 km S of Darwin). As well as reliable rainfall, the region has good supplies of irrigation water allowing peanuts to be produced in both the wet (summer) and dry (winter) seasons.

The peanut value chain transformation poses many questions for consideration, such as: What will be the impact of this cropping system on the environment in the new region? What are the pest, disease and biosecurity risks? How will the cropping system, and its impact, change with further climate change? Within the social domain, what are key characteristics of the planning and reorganisation phases are the 'preconditions' for a successful transformation? Monitoring the transformation process in both the 'new' and 'old' regions allows us to identify the main influences and magnitude of associated social impacts including the capacity to accommodate and support a transformation.

The study is addressing these questions. Activities and insights to date include:

- Preliminary simulation studies have shown the potential for substantial losses of nitrogen to the local environment, which has significant natural values, if nitrogen fertiliser management and crop rotations in the new cropping system is not optimised. Nitrogen losses could also occur in the form of the potent greenhouse gas nitrous oxide. However, there is potential for build up of carbon in the soils under the cropping systems, off-setting some of these losses. Field experiments have been initiated to better parameterize and validate models, and study soil nitrogen and carbon cycling processes. This work will support PCA's current research into production agronomy of the new cropping system.
- In-depth interviews with company and community stakeholders have commenced to identify key social features of, and influences on, the transformation process. These interviews are exploring the factors that lead to PCA's decision to expand into Katherine, the main challenges associated with this move, the kinds of changes and impacts the expansion will have for PCA and the Katherine and Burnett regions and the key success factors associated with this transformation.
- Potential pests, disease and biosecurity impacts of establishing peanut production systems in Katherine are being reviewed, with a particular emphasis on the landscape design that might result in the best pest suppression for key pests.

The lessons from the above activities will be synthesised and collated to provide a blueprint for enhancing the success of farmers and agricultural industries who are considering and transformational adaptation strategy to climate change adaptation to ensure future food production and food security. The blueprint will detail (a) the key social conditions and influences necessary for successful transformation to occur, (b) the nature of the likely social impacts to be considered, (c) the most crucial issues, both biophysical and social, to be considered to ensure transformation strategies are effective and efficient, and (d) the kinds of information sources that can be drawn upon to support the transformation process.

## Climate Proofing the UNESCO-MAB Noosa Biosphere Reserve

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The United Nations Educational, Scientific and Cultural Organisation's (UNESCO) Man and the Biosphere Program (MAB), designated the former Noosa Shire boundary as a biosphere region in September of 2007. It was a first for Queensland and the Biosphere status was effectively an acknowledgement of work done by a wide range of organisations and individuals in the Noosa community over many years and provides a focus for Noosa's aspirations for a sustainable future. The Noosa Biosphere Limited is a company owned by the SCRC and directed by a voluntary board, with directors drawn from the community and council. Six sector boards are an important component of the community based structure of the Noosa Biosphere. <http://www.noosabiosphere.org.au/>

Biosphere reserves are internationally recognized and serve in some ways as 'living laboratories' for testing out and demonstrating integrated management of land, water, and biodiversity, in order to achieve and demonstrate innovative approaches to conservation, enhanced livelihoods and the development of sustainable communities and regions.

The UNESCO MAB Program's "Madrid Declaration and Action Plan", formulated in 2008, mandates a focus on:

- accelerated climate change with consequences for societies and ecosystems
- accelerated loss of biological and cultural diversity with unexpected consequences that impact the ability of ecosystems to provide services critical for human well-being
- rapid urbanisation as a driver of environmental change.

Building on the community efforts to date, we are developing the "Climate Proofing the Biosphere" initiative that seeks to focus attention on, and prepare for, a major issue facing the Sunshine Coast region. 'Climate proofing'

means making areas and assets more resistant and communities more resilient to climate variability and change.

A community-based, bottom-up, approach to climate change adaptation takes a grass-roots approach to improving community preparation and resilience to the impacts of Climate Change including extreme weather events and sea level rise. The “Climate Proofing the Biosphere” initiative will involve a wide range of partners including the University of the Sunshine Coast, SEQ-Catchments and the Sunshine Coast Regional Council. A number of community and business organisations have already expressed their support for the initiative and we are confident that many more will join the effort as it develops further.

The poster will highlight details of our effort to Climate Proof the Noosa Biosphere and our progress to date!

## **Changing Monsoon Pattern and its Impact on Water Resources in Himalaya: Responses & Adaptation**

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In Himalaya, constraints of terrain and climate impose severe limitations on resource productivity, and consequently, biomass based subsistence agriculture constitutes main source of livelihood and food. Moreover, climate change has stressed traditional agro-ecosystem through higher temperatures, altered precipitation patterns and resultant hydrological disruptions and more frequent and extreme weather events. Himalaya has shown consistent trends in overall warming during past 100 years. Consequently, Himalayan glaciers are retreating faster than world average, and monsoon pattern is changing. Consequently, regime of water resources in Himalaya is likely to change rapidly, with respect to discharge, volumes and availability. Himalaya being tectonically alive, economically underdeveloped and one of the most densely populated mountains is highly vulnerable to the impacts of these changes that may cause substantial decrease in availability of water for drinking, sanitation and food production, and consequently increase proportion of water, health, food and livelihood insecure population in the region. The changing climatic conditions are also expected to increase severity and frequency of natural disasters in Himalaya, besides leading to catastrophic scarcity of drinking water, 30% decrease in agricultural productivity, and massive decline in human health in large part of South and East Asia including India, Pakistan, Nepal, Bhutan, Bangladesh, Thailand, Myanmar and China mainly dependent on subsistence agriculture. Moreover, the impacts of climate change in Himalaya will have enormous regional as well as global implications for fundamental human endeavors ranging from poverty alleviation to environmental sustainability, and even to human security. It is therefore highly imperative to improve the understanding of the impacts of climate change, identify potential response strategies to enhance resilience of natural, social, economic and political systems to long term impacts of climate change, and evolve all-inclusive and adaptive land and water management strategies combined with innovative agricultural technologies in Himalaya.

Main objective of the paper is to analyse trend of changes in precipitation pattern and evolve an integrated and community and user oriented land and water management framework to enhance adaptive capacity of natural and social systems to long term impact of climate change. Besides, monitoring of hydro-meteorological processes, detailed appraisal of traditional land use and community resource structure has been carried out in Kumaon Himalaya in India, using high resolution satellite data, field survey and mapping techniques, and employing community based resource appraisal and management tools. Local indigenous knowledge, institutional mechanism and traditional resource management systems that evolved through long process of human adjustment to local environmental conditions was documented, evaluated and incorporated in proposed land and water management framework.

Studies indicated that Himalayan glaciers are melting much faster (10-15 m/year) than glaciers in other regions. Besides, changing Indian monsoon pattern is causing large rainfall variability reducing number of rainy days (25%), decreasing rainfall (40%) and causing severe drought in Himalaya. This is disrupting hydrological regime in Himalayan watersheds through reduced groundwater recharge and drying of natural springs (45%) and thus impairing basic ecological services, particularly drinking water and irrigation. These environmental changes could cause respectively 25%, 15%, 21% and 20% decline in drinking water, irrigation, hydropower, and agricultural productivity in Himalaya and adjoining plains which could bring 9–13% loss of Gross Domestic Product (GDP) in India by 2100.

A comprehensive land use framework has been evolved based on hydrological and terrain conditions, people's options and priorities of government agencies for conservation and sustainable development of water resources in view of long term climate changes. Proposed water management strategy focuses on conservation and replenishment of available water resources by making provisions for water conserving forestry and horticultural practices, cultivation of less water requiring and drought resistant food as well as cash crops, development of spring sanctuaries and rainwater harvesting schemes based on local indigenous knowledge and in agreement with local communities and government agencies.

## **Will diversity assist adaptability? A case study contrasting diverse and specialised fishing sectors in the Queensland Inshore Fishery, Australia**

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In the face of climate change, individual fishers and fishing sectors should be aiming to become more diverse, rather than specialised. A diverse fisher or fishery will have more choices, and hence is likely to be more adaptable

to often unpredictable changes in species distribution and availability resulting from climate change. Traditional fisheries management, however, has aimed to increase economic efficiency and improve management through encouraging fisheries to be dominated by a few large operators, each specialised to target a few or even single species. This specialisation makes the fishing effort directed to particular species and areas easier to manage, but limits options available to fishers when they are determining how and when to adapt to change.

Using the Queensland (Australia) East Coast Inshore Finfish Fishery (the “Inshore Fishery”) as a case study, this presentation shows how diverse fishers within a diverse fishing sector are likely to have higher socio-ecological resilience (i.e. resilience within the fishery) and be more adaptable to climate change. The Commercial Inshore Fishery on Queensland’s east-coast contains a diverse array of operators. Fishers harvest a diverse range of species and markets are available for byproduct species as well as the main target species. This suggests fishers will be able to easily adapt to environmental factors that impact the availability of one inshore species by shifting their effort to readily available substitutes that are more resilient to an environmental change. Most commercial fishers also operate in more than one fishery, meaning they are able to shift effort to other fisheries if they need to. In contrast, the Inshore Charter Fishery is highly specialised, with a high dependence on a single species (barramundi) within a limited area. Further, most charter fishers are dependent solely on the Inshore Fishery, within which they have a high economic investment, suggesting limited capacity to diversify into other fisheries if needed. The charter fishery has a very high turn-over of operators, further indicating low socio-ecological resilience. In the face of change, charter fishers are limited in their options for adaptation, and most are likely to exit the fishery.

The contrasting characteristics of these two sectors suggest a very different capacity to adapt to change, and provides insight into how and why fishing sectors could be encouraged to be more adaptable and hence resilient to climate change in other areas. Perhaps there is an opportunity to learn adaptation skills from fisheries which have been operating in and adapting to climate variability for a long time. The challenge will be in determining how to manage diverse fisheries without compromising ecological sustainability.

## **Mainstreaming climate change adaptation into development policy: A case of UK Department for International Development (1997-2009)**

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This paper reviews the approach adopted by the UK Department for International Development (DFID) to address the impacts of climate change in developing countries. Like many other donors, DFID has adopted a three-pronged approach to supporting developing country efforts to address climate change impacts, namely: (i) financial contributions to global initiatives, such as the Climate Investment Funds and the UN Special Funds for Climate Change, (ii) efforts to integrate climate change into its core development activities and (iii) support for research. A core feature of DFID’s approach is to increase the integration of climate change into non-climate specific activity. The mainstreaming approach being used provides insight into the way in which other donors and government bodies can incorporate climate change into planning, processes and decision making. This paper reviews the approach that DFID has adopted and draws lessons from the various mainstreaming approaches including: learning hubs, communication, sustainable operations board, knowledge network, working with regional partners, climate funds board, the use of climate change champions, internal leaders through the mainstreaming team, and targeted recruitment. We consider the effectiveness of the mainstreaming strategy and make recommendations on mainstreaming from the lessons learned by DFID.

## **Observed adaptation to climate change: UK evidence of transition to a well-adapting society**

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This paper investigates whether and to what extent a wide range of actors in the UK are adapting to climate change, and whether this is evidence of a social transition. We document evidence of over 300 examples of early adopters of adaptation practice to climate change in the UK. These examples span a range of activities from small adjustments (or coping), to building adaptive capacity, to implementing actions and to creating deeper systemic change in public and private organisations in a range of sectors. We find that adaptation in the UK has been dominated by government initiatives and has principally occurred in the form of research into climate change impacts. These government initiatives have stimulated a further set of actions at other scales in public agencies, regulatory agencies and regional government (and the devolved administrations), though with little real evidence of climate change adaptation initiatives trickling down to local government level. The sectors, requiring significant investment in large scale infrastructure have invested more heavily than those that do not in identifying potential impacts and adaptations. Thus we find a higher level of adaptation activity by the water supply and flood defence sectors. Sectors that are not dependent on large scale infrastructure appear to be investing far less effort and resources in preparing for climate change. We conclude that the UK government-driven top-down targeted adaptation approach has generated anticipatory action at low cost in some areas. We

also conclude that these actions may also have created enough niche activities to allow for diffusion of new adaptation practices in response to real or perceived climate change. These results have significant implications for how climate policy can be developed to support autonomous adaptors in the UK and other countries.

## Vulnerability of, and adaptation in, energy systems to climate change and extreme events

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The Fourth Assessment Report of the IPCC (2007) concluded that due to the immense inertia of the Earth's biogeophysical system, a considerable degree of climate change will be unavoidable even if very ambitious efforts will be made to curb greenhouse gas emissions over the next few decades. There is a great deal of scientific uncertainty regarding the nature, magnitude and frequency of different extreme weather events as climate change unfolds but many studies indicate increasing frequency and intensity of such events in most world regions. Extreme weather events will possibly increase old and spawn new threats for energy installations and infrastructure. The presentation will address the related key scientific and policy relevant issues.

While there is a reasonably good understanding of the impacts of non-weather natural hazards on energy systems and some initial assessments of climate hazards have been made, there are still many open issues that need to be explored in order to consider the new knowledge in national energy planning. The scientific importance and timeliness of these issues is demonstrated by the fact that the IPCC launched a Special Report on "Managing the Risks of Extreme Events to Advance Climate Change Adaptation" in 2009. The policy relevance is apparent from the fact that globally tens of trillions of dollars will need to be invested in energy systems over the coming decades and many of the new installations and infrastructures will be subject to significantly changing weather patterns over their multi-decade lifetime.

The presentation will address the following topics:

- scientific uncertainties about the changes in the nature, magnitude and frequency of extreme events triggered by anthropogenic climate change, their formulation for use in impact and risk assessments for energy system;
- the impact of these extreme events on energy installations and energy supply infrastructures;
- technological options and policy strategies to reduce exposure and vulnerability and to increase the resilience of energy systems to weather-related and non-weather hazards;
- integration of promising options and strategies in national energy planning and international energy strategies.

The presentation will cover the impacts of selected extreme weather events (including temperature, precipitation, wind; tropical cyclones, floods, droughts, coastal storm surges (also considering sea-level rise); forest and wild fires, landslides) on key components of the energy system:

- coal fuel cycle (front end: mining, transport, etc. to back end: CCS)
- oil and gas: extraction, transport, processing, delivery
- thermal power plants (coal, oil, gas)
- hydropower (dams, water, power plant)
- nuclear power (fuel cycle and power plants)
- solar energy (heat, PV, CSP)
- wind power (offshore, onshore)
- electric grid (transmission, distribution, transformation)

and methods for incorporating weather extremes in energy planning tools (energy supply models, risk assessment frameworks, etc.).

The presentation will draw on the results of an international workshop organized by the author at the International Centre for Theoretical Physics (ICTP) in April 2010 and will be the first presentation of the insights from this event. The joint IAEA-ICTP workshop involved experts from climate change/extreme events, energy systems, risk assessment and energy planning to review the state-of-the-art in the relevant fields and provided a platform for exploring linkages and for synthesizing knowledge across these domains. The presentation will report the outcome in terms of a better knowledge base to integrate emerging climate change related risks into energy systems planning, particularly in developing countries.

Developing countries require special attention because mainstreaming climate change impacts, vulnerability and adaptation in development planning is one of the four major components of the Bali Roadmap. For energy planning it means that there is a need to assess the risks from changing patterns of extreme weather events for energy systems and account for them in national energy planning for expanding the energy infrastructure. These issues are of particular importance for developing countries where the fast expansion of energy systems will take place in regions projected to be exposed to increasing extreme weather events.

## Minimising conflicts in a changing climate: integrating biodiversity conservation and climate change adaptation

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Projected sea level rise will necessitate shifts in present-day coastal and sub-coastal vegetation communities, with subsequent impacts on dependent species. Numerous wetland flora and fauna, already threatened by habitat loss through urban and agricultural expansion now face extirpation due to sea level rise (SLR). This will be through further fragmentation and loss of critical habitat, range retraction and the vulnerability of small populations to random population fluctuation, catastrophic events and the deleterious impacts of inbreeding. The scenario will very likely be played-out across Australia, and here we use south east Queensland (SEQ) as an exemplar sub-tropical case study to identify and prioritise climate change adaptation responses. As part of the SEQ Climate Adaptation Research Initiative, we use the 'Sea Level Affecting Marshes Model (SLAMM)' to simulate the outcomes of SLR. SLAMM is a spatial model that determines potential changes in the extent of wetland communities following coastal inundation and saline water intrusion. Unlike a simple 'bath-tub' inundation model in geographic information systems (such as ArcMAP), the SLAM model simulates coastal erosion, accretion and saline water intrusion, in addition to inundation. It has been applied to temperate North American systems in the past, but this will be its first application to an Australian ecosystem. Using SLAMM, we simulate multiple SLR scenarios over 90 years, based primarily on projections forecast by the Intergovernmental Panel on Climate Change. We also simulate worst-case projections of up to 2.5 metres above (present-day) sea levels. Known responses of SEQ wetland vegetation communities to saline water intrusion, accretion and inundation were used to parametrise the SLAM model, and the current distributions of wetland communities were mapped using spatial data provided by the Queensland Government. The potential future distributions of the coastal vegetation communities were then mapped accounting for the impacts of SLR (referred to herein as the baseline analysis). We then modified the baseline analysis to explore the impacts of anthropogenic development buffers, and human adaptation responses to SLR (e.g. sea wall construction) on the extent of coastal vegetation communities and dependent threatened taxa. The SLAM model includes the option of strategic sea wall placement to test the usefulness/effectiveness of such responses. We applied this option and simulated the impacts of sea-walls on the projected extent of wetland communities and critical areas for vegetation migration identified under the baseline scenario. We then incorporated the results from the baseline analysis and the sea wall analysis with predictive spatial population models for a subset of threatened and endemic taxa. Demographic and spatial data for these species were derived through available literature and Government sources. The viability analyses incorporated the impacts of habitat change through the spatial function provided by RAMAS GIS, thereby allowing assessment of vertebrate population (and range) shifts under SLR. Strategic adaptation responses for species conservation, such as the creation of habitat corridors and urban development buffer zones, were also incorporated into the analysis. Overall, we have identified the vulnerability of coastal vegetation communities to sea level rise using an innovative modelling approach that simulates coastal accretion and erosion (in addition to inundation). We have then linked the changes in habitat extent to spatial population viability models to explore the impact of SLR on dependent threatened taxa. We have also assessed the impacts of human adaptation responses to mitigate the impacts of SLR and identify areas that will be critical to conserve biodiversity in SEQ, in the context of climate change.

## Climate change and irrigated agriculture: impacts and adaptation strategies in the Rio Segundo basin, Argentina

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In the Rio Segundo basin, placed in the semiarid boundary of Córdoba province in central Argentina, up to present water supply for irrigation (groundwater) is not a limiting factor and a number of farmers are using supplementary irrigation. As future regional climatic projections indicate that temperatures will increase more than 3°C by 2080, while precipitations will little increase during summer, water demand will increase and is likely that crop production will be affected. The aim of this work was to assess the impacts of future climatic scenarios on irrigated crop production in the Rio II basin and, to propose potential adaptation measures. For this purpose we used crop simulation models (DSSAT v. 4.02). Climatic inputs for present climate were obtained from meteorological stations placed in the basin. As future climate we used outputs from a regional model for the 30-year period centred in 2080. Monthly climatic variables were obtained for the grids (50 km\*50 km) covering the Rio II department (some 500.000 ha). Daily values of precipitation, solar radiation and maximum and minimum temperatures were obtained by means of a weather generator parameterized after observed climate. Typical crop management inputs: planting dates, plant density, cultivars, fertilization and irrigation and soil inputs related to physicochemical properties for the main soil series, were considered.

Simulations were done for the most frequent crop sequence with and without considering CO<sub>2</sub> effects. The typical rotation includes 4 crops in 3 years: the double crop wheat/soybean (WH-SB2), followed by fallow, maize (MZ), fallow and soybean (SB). Without considering CO<sub>2</sub> effects, an overall decrease in crop yields was found for this crop sequence. Reductions averaged 1%, 7%, 28% and 29% for WH, SB2, MZ and SB respectively, and irrigation requirements slightly increased (4%). When CO<sub>2</sub> effects were considered, yields increased by 18%, 34% and 5% for WH, SB2 and SB, while MZ yields decreased by 21%. In addition, irrigation requirements decreased by 15%. Increased CO<sub>2</sub> benefited crop yields and water use efficiency and the shortening of crop cycles, as consequence of higher temperatures, led to lower seasonal water use.

In spite of these positive effects, as future warming will promote extended frost-free periods, it would be possible to take advantage of changing crops calendar in order to maximize the use of resources. Adaptation strategies indicate that anticipating planting dates by some 20-30 days will permit to incorporate an additional crop in the rotation (like soybean as second crop after maize), as well as to modify the irrigation strategies leading to water savings. Increased productivity and extra water savings, without significant decreases in rainfed crop yields, would be possible applying this strategy. Notwithstanding, cultural practices leading to preserve soils sustainability should be assured.

## Scoping of Climate Change Impacts on Human Health and Vulnerable Populations

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The changing climate will have broad-reaching effects upon human health. Within the human health field it is recognised that the impact of climate change is considered the largest threat to global health of this century and that there will be many other unforeseen vulnerabilities, yet to be identified.

In recognition of the need for a greater understanding of the implications of climate change on health, the Victorian Department of Health commissioned a project to produce an appropriate methodology for assessing the impacts of climate change on human health, identifying key vulnerabilities and coping capacities. The methodology will underpin the development of recommendations for future actions to ameliorate adverse health effects on the Victorian population over a 5, 10 and 15 year period.

Assessment of population health and wellbeing vulnerability to the effects of climate change is an emerging field with development of the methodology necessitating the merger of the disciplines of climate change adaptation and environmental and public health.

Methodologies for devising a suitable assessment methodology are themselves embryonic as recognition that climate change has potential to wreak significant health harm arrived relatively recently to climate change adaptation circles. The process is further compounded by uncertainties regarding the onset of certain climate effects, the possible location and intensity of these effects, at the regional level, known as downscaling.

Bringing together an assortment of skills, expertise, information and data resources in a rigorous methodology for a vulnerability assessment process, that met the needs and constraints of the Department of Health was challenging.

The methodology developed is applied in five key steps for the geographical area under consideration, with each step further divided into a series of tasks. The methodology was first developed as a draft and refined through its testing on the issue of heatwaves in a rural and metropolitan Department of Health region. Within each region two population centres, representative of a broad range of vulnerabilities, were assessed.

As a tool, it was agreed the assessment methodology must carry sufficient flexibility to be applied in a range of settings, and to satisfy diverse knowledge needs. The adopted methodology can be applied across geographical areas, or according to specific climatic effects, or indeed across defined population sub-groups.

The paper presents details of the multifaceted impact assessment methodology developed for the Department of Health and of the processes, trials and tribulations, of testing the methodology prior to completion. A key point for example was consideration of the value of quantitative vs qualitative approaches to health assessment and the respective applicability and role of either in the overall methodology.

This is a joint paper to be presented by the Victorian Department of Health, Arup and Australian National University.

## Enhancing Resilience to Coastal Hazards in Asia-Pacific: The Role of Early Warning Systems in linking Disaster Risk Reduction and Climate Change Adaptation

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The Indian Ocean tsunami of 2004 spurred various institutional and policy changes in strengthening disaster risk reduction (DRR) and developing early warning systems (EWS) to tsunamis and other coastal hazards in line with the priorities of the Hyogo Framework for Action 2005-2015. Recognising the failures in achieving a timely international agreement on mitigating green house gases, the need for climate change adaptation (CCA) is increasingly being emphasised. Adaptation funding is expected to be as much as hundreds of billions of dollars per year globally. Although governments and NGOs are reframing strategies to take advantage of the new funding opportunities, actors are struggling to define aims for adaptation, to design guidelines, methods and tools for implementation, and to develop mechanisms for monitoring and evaluating the success of adaptation responses. It is evident that DRR and CCA share common linkages such as addressing vulnerabilities, building resilience, and long-term



sustainability but they are frequently treated as separate issues by implementing government agencies and NGOs.

The technological aspects of EWS have received considerable attention by donors and governments. But addressing community based disaster risk management in EWS development rarely receives the same attention and resources. We argue that technocratic approaches are ineffective without addressing the human context that includes cultural norms and religious doctrines, knowledge and perceptions of risk, the strength and trust in existing governance processes, and levels of active and sustained stakeholder engagement in disaster preparedness initiatives. We will address the ways in which existing EWS in the Asia-Pacific region address and integrate DRR and CCA, and whether these systems are increasing resilience and decreasing vulnerability towards multiple hazards.

Ongoing work is aimed at exploring what role EWS play in Asia Pacific to reduce vulnerabilities to multiple hazards, how current systems are designed and how they function, what the roles and responsibilities of different stakeholders are, in what situations the systems have recently been utilised, and what lessons can be learnt to promote community resilience in response to multiple hazards. Through cases study analysis and cross-case learning, the project is expected:

- to contribute to improving the communication of early warning information,
- to strengthen trust in early warning messages,
- to develop indicators to monitor and evaluate the effectiveness of multi-hazard EWS, and
- to identify synergies between DRR and CCA efforts that aim to enhance community resilience and lessen vulnerabilities to coastal hazards.

Ongoing work is a collaborative effort between Macquarie University, the Stockholm Resilience Centre, the International Federation of Red Cross and Red Crescent Societies (IFRC) Regional Disaster Management Unit (DMU) for Southeast Asia, and RC National Societies in Asia Pacific.

### **Impact of climate change on partitioning efficiency of pigeon pea (*Cajanus cajan*), a grain legume for semi arid rainfed ecosystems of the tropics**

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An important grain legume crop viz., pigeon pea (*Cajanus cajan* L. Millsp.) cv ICPL 88039 (an extra short duration ICRISAT cultivar) was grown under two levels of elevated CO<sub>2</sub> (550ppm & 700ppm) in open top chambers and compared with ambient chamber control (370ppm). The present study was carried out on grain yield and harvest index of this legume crop. This crop contributes to human food, sustaining the much needed nutritional security of vast majority of the populations (including the poor due to affordable price as compared to animal source) of most of African and Asian countries some of which in particular India, who are predominantly vegetarian in food habits. The fodder is useful as a component of concentrated feeds apart from being a soil fertility builder through leaf fall, root nodulation etc. Under the present climate change scenario, the pivotal component of change viz., CO<sub>2</sub> is likely to influence crop growth. The results showed a significant increase in total biomass (91.3% & 26.8%), grain yield (150.1% & 58.4%) as well as fodder yield (67.1% & 13.8%) at 700ppm and 550ppm of CO<sub>2</sub> respectively over ambient control of 370ppm. However, it was interesting to note that the improved photosynthetic partitioning efficiency towards grain at 700ppm & 550ppm over ambient control resulted in the enhanced HI value of 30.7% & 24.9% respectively. The above results indicate pigeon pea a suitable futuristic crop that can well adapt to climate change, sustaining the very much needed nutritional security of both human and cattle populations inhabiting the drought prone rainfed dryland ecosystems of tropics of the world.

### **Knowledge of climate refugia (past and present) to inform conservation in a changing world**

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Considering climatically suitable habitat as refuges for species in otherwise hostile environments has practical importance in identifying the potential persistence of species threatened by climate change. For such species, refugia may represent a gradient from long term broad-scale climatically stable areas over geological time through to small-scale short-term climatic stability in microhabitats. Examining such a gradient provides a greater degree of insight into how species / biodiversity may be influenced-by and adapt-to future climate change. This paper will demonstrate how such knowledge can be used to better inform conservation strategies.

The relative influences of contemporary climate and historical stability in structuring current patterns of species richness is still debated. However, the stability in the climate of rainforests of the east coast of Australia since the last interglacial period has structured phylogeographic patterns in species distributions. Further it can explain 40-80% of the variance in species richness patterns of low-dispersal species in the Australian Wet Tropics region (AWT). It appears that in the AWT, the stable refuges of the past will likely be the refugial areas of the future, maintaining areas of highest richness and reinforcing structuring of species lineages.

In contrast, instability in climates over a relatively short term can have large impacts on distributional patterns of individual species. Highly variable spatial and temporal patterns in temperature and precipitation across the Australian tropical savannas (ATS) have led to a bird assemblage with high temporal variability in movement patterns and a high incidence of nomadism. An examination of monthly variability in temperature and precipitation from 1950 to present has shown that such fine-scaled temporal instability produces substantial fluctuations in distributions of climatically suitable habitat both within and across years;

this instability is not accounted for in most climate change impact assessments (using long term climate means). Despite the fluctuations, overlapping areas of suitable habitat that persist across years (refugia) can be identified. Unfortunately, few of these persistent refuges have been currently afforded any protection (e.g., within national parks, reserves). Indeed, probabilistic projections of these persistent refugia into the future show even less overlap with areas currently afforded protection.

At a mesoscale, identification of thermally-buffered environments is important. Factors such as foliage cover and proximity to coast, in addition to elevation, act to ameliorate local temperatures and generate climatically suitable habitat (refuges) in otherwise hostile environments. In the AWT, a disproportionately high number of endemic species (45 %) are encompassed within just twenty-five percent of the coolest identified rainforest. This data is being used to (i) identify important areas of cool habitat for protection; and (ii) efficiently guide restoration in degraded landscapes to expand extant networks of thermally buffered refugia.

At the finest spatial scales, local environmental processes, microhabitat and species behaviour may allow persistence not apparent at coarser scales. Previously thought to be the most vulnerable vertebrate in the AWT, the microhylid frog (*Cophixalus concinnus*) only occurs in several square kilometers of forest on the top of a single mountain. It was thought that a 2 degree increase in temperature would drive the species off the top of the mountain. We demonstrate substantial temperature buffering afforded by boulder field habitat occupied by the species suggesting that exposure and vulnerability may be overestimated.

## **Adaptation to climate change: a longitudinal media study of an Australian rural community**

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Communities of place or localities evolve dynamically. Traditionally shaped by their geographic location and social, economic and political forces (both internal and external), communities today are now facing a new challenge, that of climate change. Rural communities are particularly vulnerable to climate change and in Australia, communities such as Mildura in Western Victoria are dependant on the land for their livelihoods and face unique challenges in adapting in the face of changing climate. In the words of the Mayor of Mildura “water issues are at the core of our community’s wellbeing”.

This paper analyses media coverage over the period 2000-2009 to track the impact of climate variability and climate change on the rural communities of Sunraysia. The Sunraysia region is based around Mildura in North Western Victoria, often referred to as a green oasis because of the intense horticulture the region is famous for. Sunraysia lies on the Murray River, encompassing the local government areas of Mildura and Wentworth on the Victoria/New South Wales border. The livelihood of many residents in Sunraysia has traditionally relied on intensive horticulture largely dependant on irrigation, in particular grapes, citrus, as well dryland farming, including grain. Among other things the Mildura/Sunraysia region produces 95% of Australia’s dried vine fruit, 69% of table grapes and 23% of wine grape crush.. Nearly 40% of Mildura businesses have an agricultural base and around one in five jobs in the Mildura region are involved in agriculture. The population of the region is approximately 60,000 and Mildura is one of the fastest growing cities in Australia.

The qualitative data analysis software NVIVO was used to conduct a longitudinal analysis of adaptation to climate change in the Sunraysia region over the period of a decade (2000-2009). The paper addresses how changes in climate and water availability have impacted Mildura and the communities of Sunraysia, and community response to the challenges brought on by climate change.

The text corpus for the analysis was drawn from the Factiva Dow Jones Media Database using a key word search of Mildura or Sunraysia in all media. No other search limitations were imposed so as not to over represent the relative importance of the issues around climate change to the community. In order to narrow the focus to articles which were specifically about Mildura or Sunraysia, rather than those which happened to include a mention of one of either of the keywords, articles were sorted by order of relevance and only the top 30% of full text articles for each year were selected for the analysis. NVIVO word searches were used to locate those articles which contained references to climate, water, water, the Murray, rain or rainfall, storm and temperature. These articles were then coded, focussing on cause and effect relationships associated with weather, water and climate.

Key issues for the region have been ongoing drought and subsequent low inflows into the Murray River. Uncertain rainfall and changing water allocations have had severe social and economic impacts on the community and the paper outlines key factors in the community response to climate change.

## **Hotspots and consortia joining forces for national and regional adaptation strategies for The Netherlands**

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In 2008, The Netherlands saw the birth of a national research program for making the country climate proof: Knowledge for Climate. To that end, the program has the ambition to balance scientific excellence and practical relevance. Government, research institutes and other matching partners will invest more than 70 million euro in the total research program.

Central to Knowledge for Climate are the so-called hotspots that represent the regions requiring the most significant

investments with regard to adaptation to climate change in the coming years. These hotspots are (a.) Schiphol Mainport and Region, (b.) The Hague region, (c.) Rotterdam region, (d.) Major rivers, (e.) South-West Netherlands Delta, (f.) Shallow waters and peat meadow areas, (g.) Dry rural areas and (h.) Wadden Sea. At the end of the research program, in 2014, each hotspot will deliver 'Options for the regional adaptation strategy', based on region specific characteristics, the best scientific research possible and meeting the actual regional demands and priorities. For that purpose, the hotspots work closely together with the consortia that have been selected after an open call and an intensive review procedure, for each of the following themes: (1.) Water safety at national and regional level, (2.) Freshwater supply at national and regional level, (3.) Climate-proofing rural areas, (4.) Climate-proofing urban areas, (5.) Infrastructure and networks, (6.) Improving climate projections and the set of instruments used for modeling, (7.) Governance of adaptation and (8.) Decision support tools.

In Knowledge for Climate, those who ask for knowledge and solutions continuously interact with those who supply it. Operating on this science-policy interface demands extra effort from all of those who are involved, as compared to their daily routines and mindsets. Policymakers are facing the challenge of looking beyond the relatively short-term time horizons that prioritize political agenda's. Scientists are being challenged to let practitioners be part of the research process, from problem formulation to the dissemination and implementation of the results. For instance, Knowledge for Climate is putting into practice the so-called 'on the spot Ph.D.', whose aim is to balance between the world of fundamental knowledge production and that of daily and actual societal circumstances by actively participating in those two worlds simultaneously. The 'Knowledge for Climate Ph.D. Network' will be the platform for the almost 50 doctoral researchers to be inspired by senior researchers and practitioners and to exchange experiences.

Knowledge for Climate has embarked on a remarkable journey as a next step in the long history that The Netherlands has in adapting to the natural environment. From September 29 to October 1, 2010, Knowledge for Climate, together with the sister research program Climate Changes Spatial Planning and the City of Rotterdam, will be hosting the international conference 'Delta's in Times of Climate Change' in Rotterdam, supported by the C40. For further information on Knowledge for Climate and the conference in Rotterdam, please visit [www.knowledgeforclimate.org](http://www.knowledgeforclimate.org).

## Climate disaster risks, vulnerability to Agriculture in Vietnam and some measures to deal with them

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The most frequent climate disaster that affect in Vietnam are Typhoon, Floods, Droughts... Typhoon is the most significant hazard in terms of people affected and relief provided. The relief disbursements for typhoon between 1971 and 2000 were US\$ 1 million (1977) – US\$ 100millions (1997), whereas typhoon accounted for Vietnam. The surprising prevalence of flood shows that Vietnam receives an average of 1,800 - 2,400 mm of rain-fall annually, somewhere annual rainfall is more than 3000 mm (Nam Dong, Tar My, Bato...), more than 4,800mm (BacQuang) and some where is less than 1000mm such as in Ninh Thuan and Binh Thuan provinces annual rainfall are 750mm - 850mm (Nha Ho). A large part of the Country is drought prone from December to March or April in Central Region drought appear from February to June or July, if the subsidiary rainy season from May to October is deficient, drought may appear from November to May in Central Region drought may be appeared to August. In our analysis, we use a Regionalization of Vietnam climate into seven climatologically homogeneous climatologic regions such as: Northwestern; Northeastern; Red River Delta; North Central Regions; South Central coastal; Central Highland and Mekong River Delta Regions.

Current and state of Climate:

1. Disaster Events in Vietnam; Typhoon, flood, drought and frost (low temperature) happen at different times in every year. Especially for the recent years the cause of global change climatic disasters are more active in Vietnam
2. Economic impact of climate disasters typically assessed in aggregate terms focused on lives lost and damages to property in Vietnam; Three-quarters of the country suffers from flash flooding over 70% of the population of Vietnam is affected by water disasters. Average damages in ENSO years 1982, 1987, 1991,1994,and 1997( Elnino years) and 1988, 1995, 1998 (Lanina years) is US\$ 134 million/year,
3. Mitigation measures to minimize impacts of disasters on Agriculture in Vietnam for sustainable development:
  - Response measures to minimize disaster damages caused by ECE phenomenon;
  - Basic and long-term measures of concern and the need to implement; Adequate crop pattern to cope with natural disasters;
  - The designing sustable cropping pattern in agriculture production especially for rice crop with the climatic disaster aims to following demands:
  - Effective avoid and mitigating damage caused by disaster.
  - Having proposal options for agricultural production,( especially for rice) that are adaptable to disasters of all kinds in order to keep national food security.

Some of the ways in the potential of ENSO forecasts could usefully be taken into account in the design and preparation of long-rang forecasts would be through research into:

1. Rainfall behavior in Central Vietnam;
2. Typhoon behavior in Central and southern Vietnam;

3. Influence of temperature on rice production in Northern Vietnam during the Winter- spring season; and
4. Water management for rice production in Central Vietnam during the winter- spring season. There are doubtless many other features requiring study that would promote improvements in the availability and usefulness of long-rang and seasonal forecasts in association with ENSO events.

## Climate change and response measures for developing Agriculture in Vietnam

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As well known, in Vietnam people living and working in Agriculture and Rural are estimated more than 73% of Population (in 2006), most of whom are poor people in the country side They are directly influenced by climate changes, which with sea water level rise will affect agriculture, through effects on cultivation areas, crop production, soils, weeds, pests and diseases and also livestock, water supply and hydrology, ecosystem and conservation, social-economic, environments as well. Therefore studying the "Climate change scenarios and response measures for developing agriculture in Vietnam" is very important.

1. The current climate change and disasters in Vietnam; For assessment the current climate change and disasters in Vietnam we have studied the trend of change of climate elements which are relating with agricultural production in 50 recently years, such as average temperature, the dates of beginning and ending temperature through 20 and 25 OC, absolute minimum temperature, sunshine duration, rainfall, typhoon, flood, sea level rise, ENSO phenomenon and drought,...by month, season and annual in 7 Agro-economic Regions of Vietnam.
2. Climate change and sea level rise scenarios in Vietnam for 21st century; By Global climate change scenario we have designed criteria for the selection of methods for climate change scenario development in Vietnam include: (1) Credible level of global climate change scenario; (2) Level of details of climate change scenario; (3) Inheritance; (4) Up-to-date; (5) Regional appropriate; (6) Comprehension of scenario; (7) Possibility for Updating.
- 2.1 Climate Change Scenarios; Greenhouse gas emission scenarios selected for climate change scenarios development are: Low scenario (B1), Intermediate scenario of the medium scenario group (B2), and intermediate scenario of the high scenario group (A2). Climate change scenarios for temperature and rainfall are computed for seven climatic regions in Vietnam as follows: Temperature: Obviously, temperatures in winter increase faster compared to that in summer f a. or all climatic regions. Temperatures in the northern climatic regions increase faster than in the southern climatic regions. b. Rainfall: Rainfall in dry season may decrease in most climatic regions, especially the southern climate regions. Rainfall in rainy season and annual rainfall may slightly increase in all climatic regions.
- 2.2 Sea Level Rise Scenarios; Sea level rise scenarios for Vietnam are computed basing on low (B1), medium (B2), and high (A2) emission scenarios. Basing on sea level scenarios, inundation maps are constructed for every coastal provinces and lowland region in Vietnam.
3. Adaptation and mitigation measures to cope with climate change scenarios for developing Agriculture in Vietnam.
  - 3.1 Identifying agroclimate indexes on the bases of climate change scenarios for:
  - 4.2 Adaptation measures proposals to cope with the impacts of climate change on agriculture
  - 5.3 Recommended policies should be addressed in the sectoral action plan in order to cope with the impacts of climate change on agriculture
  - 6.4 Some adaptation strategies for sustainable development on agriculture
  - 7.5 Migration crop and changing crop calendar for adapting with potential climate change

The report is useful for policy analysis and decision- makers for rational exploit of Natural resources and manager for sustainable development on agriculture.

## Adapting cities to climate change: a spatial approach to decision making

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It is not a matter of debate anymore that climate change is taking place and is causing extreme weather events including, sea level rise, frequent heat waves, droughts, floods and storms surges, increased air and sea surface temperature, ocean acidification. There is enough scientific evidence to prove increase in frequency and magnitude of the above is expected

These changes pose significant threat to our cities and urban infrastructure. As a line of defence against climate change, mitigation and adaptation strategies need to be put in place to secure communities against the loss of life, investment and heritage. Mitigation and adaptation are complimentary, however, in light of the inevitability of adverse impact despite toughest mitigation efforts, the significance of adaptation strategies and measures cannot be overemphasised.

Research on climate change and its impacts covers a wide spectrum of issues including, theoretical, governance, policy, financial, etc. However, from the viewpoint of built environment professionals three most frequently asked questions are:

1. How can impacts and adaptation considerations be measured within the existing policy environment?
2. How can guidance be provided to decision makers and professionals to help increase the resilience of settlements and infrastructure and reduce unnecessary exposure to hazards?
3. How can a multidisciplinary adaptation approach across diverse sectors be developed
4. This paper describes a spatial framework based approach that is suited to pursue answers to these very questions.

A brief review of existing international and Australian Standards, codes, other literature and the principles they are based on is presented. A review of strategic documents from organisations such as Infrastructure Australia (government), Departments of Planning and Infrastructure (state government);

Australian Green Infrastructure Council (non-government); Urban Development Institute of Australia (non-government), ASBEC, PCA etc. to identify the community's priorities and aspirations is conducted.

A framework customised to include the issues identified in the above review is presented. This framework is known as Local-area Envisioning and Sustainability support System (LESS). An analysis of Sydney Metropolitan Area is presented to demonstrate the operationalisation of the framework.

LESS has been designed to monitor, map and measured indicators from domains such as environment, socio-economic, governance etc and can be used for triple bottom line sustainability assessment of inhabited locations across Australia. It is based on the 'Drivers-Pressure-State-Impact-Response' (DPSIR) concept being followed internationally by bodies such as the United Nations and European Union.

LESS can be used for:

- Diagnosing vulnerability of a location against climate change
- testing if an adaptation measure will lead to sustainable development
- establishing consensus among stakeholders on the most critical environmental problems (such as Climate Change related risks) and on the nature and extent of adaptation measures

LESS embodies the use of two new indices:

1. Sea Level Rise Factor: This index helps assess the level of risk arising as a result of sea level rise or storm related inundation. It uses a location's geography and topography to estimate if they are likely to be inundated. Juxtaposing this information with contextual spatial data such as location of dwellings, infrastructure etc vulnerability of a location, and extent and intensity of hazard is modelled.
2. Constraints Severity Index (CSI): Taking into account the environmental challenges and opportunities such as sea-level rise factor, extreme heat conditions, bush fire prone land, steep landforms etc, CSI, a weighted unified index, estimates:
  - a. which locations might be less or more appropriate for sustainable development
  - b. which locations need adaptation measures taken on a priority.

## Four propositions for developing socially just adaptation to global change in Australian Indigenous communities

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This poster presents four propositions based on findings from fieldwork conducted in the Indigenous community of Warruwi on the coast of the Northern Territory, Australia. Beyond ensuring infrastructural adaptation, shaping sustainable, implementable and socially just adaptation strategies for Indigenous Australians requires solidarity and diplomacy with ancient Indigenous jurisdictions, and consideration of risks arising from the hegemonic narratives and discourses that compose the climate change debate and its wider political context.

Solidarity relates to scale politics. Reaching agreement between the global threat of climate change and the local need for response requires understanding and respect between institutions at the various scales of governance. Coarse resolution vulnerability assessments have labelled Indigenous groups as particularly vulnerable, but this obscures local observations and perceptions. Indigenous Australian jurisdictions have remained resilient to environmental change, and to imposed governance and institutional change through 200 years of colonial rule.

Diplomacy relates to the politics of recognition. Ancient Indigenous jurisdictions have acted as 'informal' institutions since colonisation, and are thus being engaged in a process of deep colonising by which they are erased through non-recognition by governments. Meanwhile, they shape the effectiveness of government projects and policies by acting in concert or otherwise with imposed governance structures. Diplomatic efforts to put into place cross-cultural governance systems have been difficult, and the solution is not to romantically go backward to conditions in pre-colonial Australia. New governance relations can be formed between non-Indigenous and Indigenous Australia, and climate change adaptation policy can be such an opportunity.

Narrating history is a political process, and impacts on how adaptation is approached by setting up the actors and events that are seen to be instrumental in shaping the present and future. Aboriginal jurisdictions of Australia are conventionally presented as prehistorical, rather than concurrent governance structures. Indigenous perceptions of, explanations for, and solutions to change therefore risk being overrun by hegemonic understandings of present and future climate-related challenges. The immediacy of the threat of climate change demands urgent action, which risks sweeping away efforts to work with Indigenous institutions in a tide of urgently pressing government agendas that have so far failed at recognising and cooperating with Indigenous jurisdictions. Paradoxically, allowing disaster to strike by not preparing for climate change may reinforce state institutions and further damage Indigenous institutions, as disaster victims are aided through conventional governance structures and knowledge systems.

Knowledge is constructed through the politics of discourse. Indigenous knowledges collect information and interpret them using terms and concepts that are often unfamiliar to western science, and vice versa. For instance, the concept of extinction is incomprehensible to some Indigenous cultures, as all phenomena persist in the Dreamtime. While this view discords with Western scientific explanations of change, any debate of the superiority of one cultural explanation of change over another is redundant; the importance lies not in the explanation, but rather in how these explanations shape cultures, and therefore management priorities. Implementable adaptation strategies need to be developed within the cultures, perceptions, institutions and priorities of any given locality, Indigenous or not.

## **A roadmap for climate change adaptation process on a multipurpose hydropower and agriculture basin in central Chile**

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In many developing countries, hydropower represents a significant contribution to the electricity generation matrix. In Chile, a combination of run-of-the-river and reservoir systems contributes approximately 50% to the total electric input, and plans for further development are under way, in order to match projections of a 100% demand increase in the next 20 years. In many cases these hydropower systems coexist with other water users such as agricultural and urban areas. Although the objectives and interests of these different groups are not always the same there are opportunities for fruitful collaborations that could maximize the overall basin water resources use benefits.

The Maule basin is a good example of a basin with the characteristics aforementioned. This basin located in the Central-South region in Chile holds one of the largest hydropower generation systems in the country partially operated by the firm Colbun S.A. Downstream of this system there is booming agriculture area covering almost 150,000 hectares and supplied by a network of irrigation channels that fed from the hydropower infrastructure. A large proportion of this area is irrigated via poorly designed irrigation techniques which highlight some opportunities of water usage improvements.

On the other hand, recently finished investigations have shown that climate change present a series of challenges to this region. Increasing temperature levels and decreasing precipitation levels would change water supply and demands patterns affecting the operations of all users in the basin.

Concerned by all these issues a project partially funded by the State and by the private industry has been developed to cope through a well planned, inclusive and long term perspective adaptation process based where different actors in the basin would be involved in constructing the basis for a fruitful future. The background and early stages of the project are presented in this opportunity.

## **Framework Models for Adaptation Strategies for Buildings**

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Two models are proposed for the assessment of impacts of climate change on buildings subject to extreme events such as cyclonic wind or bushfire. Such models are necessary to assess the effectiveness of any proposed climate change adaptation strategy for buildings.

The first model uses the concept of reliability as the metric for the assessment. For a region, the probabilistic characteristics of the demand (i.e. the severity of the hazard) are established for the current climate as well as possible scenarios for the future based on climatic model data. The portfolio of buildings in the region is then studied to determine the resistance of the buildings to that hazard for the present, as well as future projections. The relevant parameters to be considered are the strength distribution of various groups of buildings within the portfolio, the rates of new construction, demolition, deterioration, and changes to construction and maintenance practices (past, present and future). Reliability indices can then be calculated for the present and projected future scenarios. The outcomes will help to determine the adaptation strategy to be adopted to maintain the reliability at a predetermined level.

The second model uses the concept of fragility as the metric for the assessment. For any particular group of buildings of similar characteristics under a specific hazard, the fragility curve describes the probable level of damage as a function of the severity of the hazard. The fragility curve for each sub-group of buildings has to be determined and combined to obtain the overall characteristics of the buildings for a region. The process is repeated for any future scenario, taking into account also the new construction rate, the demolition rate as well as the deterioration rate of buildings already in existence. The fragility curves, thus established, can then be used with climate modelling data to assess the likely impacts of climate change on buildings for a number of scenarios for any future time.

A couple of examples are used to demonstrate the working of the models. In the first example, the reliability model is used to demonstrate the gradual improvement in the cyclonic wind resistance of the housing stock as the result of new more robust construction and demolition of older stock assuming no deterioration. For an assumed new construction rate of 2% pa and a demolition rate of 1% pa applied to the weaker members of the population, Monte-

Carlo simulation shows that any rule change will take 40 years to take full effect. In the second example, the fragility model is used to demonstrate the same in terms of reduced damage. Assuming that the fragility curves for both the old stock and new stock are known and that the construction and demolition rates are the same as in the previous example, the fragility curves can be constructed for a number of time intervals by proportioning with the number of old and new houses projected to exist at that time. It is observed that it will take even longer to transform the characteristics of the fragility curves. The two models are therefore in broad agreement with each other.

## Climate Change and Primary Health Care Intervention Framework

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The World Health Organization argues that climate change will result in both beneficial and harmful effects for human populations and that the harms are likely to outweigh the benefits (World Health Organization 2008). Climate scientists can sketch an outline of the probable changes by country, and even region within a country. The likely health effects are known (Horton et al 2008:10). The effect of climate change on communities is much harder to predict although there is sufficient contemporary and historical information to begin tracing the outline of the issues we will face and the adaptations required (eg Garnaut 2008). In Australia, as elsewhere, there is a great deal of climate change relevant activity at multiple levels of society. There are high levels of community awareness of climate change but not yet high levels of consensus on what needs to be done and by whom. This paper is based on the idea that successful adaptation to climate change requires existing institutions to modify their current knowledge, practices and rules (the institutional pillars described by Scott 2001) to promote community adaptation to the changing climate. In other words: \* What do primary health care people need to know about climate change and its health and social effects? \* How do organisational priorities and processes, programs of work and specific work practices need to change to accommodate the imperatives of climate change? \* What are the appropriate 'rules' (including the norms and expectations of people working in and between organisations, and accountabilities) that are appropriate in a response to climate change (Walker and SEHCP 2009). This paper discusses ways primary healthcare agencies can conceptualise the adaptation problem in their community and draw upon existing knowledge and practice skills to assist communities in the adaptation journey. In Victoria the major primary health care agencies are linked to one another through Primary Care Partnership structures and processes that provide an institutional foundation for sector-wide responses to climate change. In a sector-wide response agencies implement initiatives that are consistent with their mandate and capacity but reinforce initiatives taken by other agencies. The concept of a storyline, a brief scenario capturing the logic of changes and potential responses, is used to link evidence of climate change effects on communities and individuals to potential responses by primary health care agencies (Walker and SEHCP 2009). Examples from the South East Healthy Communities Partnership will be used to illustrate the approach.

## The absolute homeless and increasing climate variability: insights from Waterloo Region, Canada

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Highly developed economies in northern latitudes are faced with both challenges and opportunities as a result of climate change. Within the rich countries, some groups are particularly exposed to the risks posed by climate change, and often these groups are those with the least capacity to adapt. This paper presents a case study of impacts and adaptation among one particularly exposed element of Canadian society, the absolute (living on the street) urban homeless of Waterloo Region, Ontario. The paper highlights exposure to and management of day to day weather conditions as well as extreme events, and links these to adaptation strategies both on the part of homeless individuals and the regional social service system which strives to reduce exposure. Insights are presented into the role of non-climatic stresses on the homeless which result in a reduced suite of adaptation strategies and lowered adaptive capacity. In many cases, exposure to events such as extreme cold and rain events is exacerbated by reduced access to public spaces and shelters due to bans resulting from criminal activity or the inability to restrict substance abuse in inside spaces. While extreme cold events can be expected to be less frequent based on IPCC projections, problematic conditions such as slush and heavy precipitation events may become more frequent. Social services in Waterloo Region are already often already at capacity, and increased load can be expected given the growth in the number of at-risk individuals and households as result of recent job losses in the manufacturing sector. Insights into individual exposures and capacity from the target population itself coupled with projected challenges will contribute to prioritizing portions of the social service provisioning system for future adaptive capacity.

## Reliability model for adaptation strategies for housing in cyclonic regions

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This paper describes the capability of a reliability model to assess the impacts of climate change on housing in cyclonic regions. Such a model will be useful in the development of appropriate adaptation strategies to cope with the problem.

The parameter for assessing the impacts of climate change is the reliability of the housing under cyclonic wind. This reliability index may be computed for the current situation and any future scenarios once the supply and demand characteristics

are established. The parameter for describing the demand is the peak gust wind speed. Historical data are available to assess current cyclonic wind characteristics, while future characteristics of extreme wind events are based on projections by climate models. The parameter for describing the supply is the resistance of the houses against wind pressure.

This paper is focussed on the construction of the supply (resistance) model. The parameters to be considered are:

- (i) The portfolio of the resistance of the housing population which may contain many house types built during different periods. There was a major change to the construction practice in cyclonic areas as a consequence of the 1974 Cyclone Tracy, Northern Territory, Australia. Housing in cyclonic areas can therefore be divided broadly into two groups before and after the building regulation changes in 1980.
- (ii) Rates of building and demolition: These rates have a major influence on the resistance distribution of the housing stock in a particular region.
- (iii) Rate of deterioration: This could vary with the material of construction, the environment and is further complicated by the effects of structural maintenance and/or retrofit.

In studying the role of maintenance and retrofit on the housing resistance distribution, the following assumptions are made: (i) Lognormal distribution with coefficient of variation of 10% for current housing population, (ii) 2% pa new construction rate, (iii) 1% pa demolition rate on the members of the population, (iv) 0.5% structural deterioration rate, (v) 10% of houses are maintained and (vi) 2% of the houses undergo major retrofit.

Reliability index, which relates the mean values and standard deviations of both load and capacity, is commonly used in engineering to express the level of reliability. Examination of the variation of reliability indices of the housing stock also shows that without maintenance or retrofit, the reliability index decreases from 3.1 to 2.45 in 100 years. Applications of maintenance alone reduce the decrease in reliability index marginally, to 2.55; however, maintenance and retrofit combined keeps the reliability index at a value of 2.95 after 100 years.

This example demonstrates the capability of the model to quantitatively assess various measures that may be considered as adaptation measures for climate change such as:

- a. Specification of maintenance and retrofit;
- b. Raising the design resistance level of new construction;
- c. Rezoning the wind hazard regions; and
- d. A combination of the above.

Applications of the model to specific cyclonic regions such as Darwin, Northern Territory, and Townsville, Queensland, are proposed for further investigation.

## Dependency of Electricity Demand on Temperature and Economic Growth for South East Queensland, Australia

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This study investigates the relationships between electrical energy demand and dominant economic as well as climatic parameters for South East Queensland (SEQ), Australia. As the fastest growing region of Australia, this region is projected to have a 50% increase in population and a 0.5°–1.5°C increase in temperature due to climate change in the next 20 years. Understanding the climate, economic, and population growth impacts on the electricity demand is important for future energy infrastructure planning and investment.

The electricity demand data used in this study were obtained from Energex, an electricity distribution supplier for the SEQ. This set of data recorded the electricity demand every 30 minutes from January 2004 to March 2009. Maintained by the Australian Bureau of Meteorology, the climate data used in this study were recorded by a weather station at Amberley, Queensland. The economic parameters such as the gross regional product, population, and gross income per capita were obtained from Australian Bureau of Statistics reports and the Queensland Treasury Office of Economic and Statistical Research.

It was found for the SEQ that the relationship between electricity demand and air temperature in a half-hour time interval can be adequately modelled by a second-order polynomial function. Comfort temperature, defined as the temperature at which the minimum demand occurs, can be estimated from the U-shaped demand-temperature relation. The diurnal pattern of comfort temperature corresponds roughly to the diurnal pattern of electricity demand, with the lowest comfort temperature (11.2°C) being around 4:00 and the highest (22.4°C) being around 17:30.

The trend of global temperature has been on the rise; therefore, the sensitivity of electricity demand to temperature is of importance to policy-making authorities and the industry. Identified by the demand-temperature relation, the sensitivity is low (< 4% of the demand) between midnight to 6:00 within the temperature is 0°–30°C. The sensitivity is high (> 5% of the demand) between 9:00 and 21:00 for temperature < 10°C or > 30°C, with the highest occurring around 19:00. That is, the sensitivity is higher during daytime when people are awake and is lower in early morning when people are generally asleep.



Electrical energy demand is also closely related to economic and demographic factors. In this study, the gross income per capita is used as a variable to account for the effect of economic development on electricity demand. As a result, the electricity demand is modelled as the superposition of a second-order polynomial function of temperature and a logarithmic function of gross income per capita. High correlation is found between the predicted and the historical electricity demand data; however, because of the short historical data and likely future policy/regulation changes, extrapolation of the derived electricity demand model for estimating future demand may be subject to large uncertainty.

This study is part of the South East Queensland Climate Change Adaptation Research Initiative.

## Implications of Climate Change Impact on Building Energy Efficiency and Mitigation Effectiveness

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The residential building sector contributed around 13% of the total Australia national greenhouse gas (GHG) emissions in 2005-06. It is anticipated that the projected population growth, the trend of smaller family sizes, and the desire for more comfortable indoor environment and larger houses etc, will put upward pressure on the energy demands and increase the GHG emissions from the residential building sector in Australia. Construction of high energy performance buildings, such as low- or zero-energy buildings, has been advocated to be one of various means to mitigate GHG emission. In Australia, the building energy efficiency is rated on the basis specified by the Nationwide House Energy Rating Scheme (NatHERS). The average energy rating of the existing housing stock is estimated to be around 2 stars. Currently, most Australian states and territories require a minimum of 4 to 5 stars for new house designs with this requirement scheduled to rise to 6 stars in 2011. In recent years, 7 star houses have also been built and offered by several building companies in Australia. However, the energy consumption of buildings closely depends on the surrounding climate, which is subject to possible changes. It implies that the energy rating of buildings may also experience changes, and especially, mitigation efforts by currently designed high-energy-performance buildings or its effectiveness may be compromised. This study investigated the potential impact of climate change on the energy ratings by taking a 5-star residential house in five regional climates varying from cold to hot humid in Australia. Nine General Circulation Models (GCMs) under three carbon emission scenarios were applied to project the local climate. It was found that the energy rating in the Alice Springs and Darwin is projected to drop between 1.2 and 2.9 stars by 2050 and between 1.8 and 5 stars by 2100. In Sydney, the energy rating is projected to drop considerably between 1.5 and 2.1 stars in 2050 and between 2.2 and 3.9 stars in 2100. Considering the changes, building regulators may need to take into account the impact of climate change when reviewing the energy rating scheme.

## Regional Assessment of Coastal Inundation in Southeast Queensland under Changing Climate

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Urban human settlement and infrastructure are likely to be significantly exposed to climate change impacts, including the increase of temperature, precipitation and sea level and changes in wind patterns. Impacts will especially arise due to changes in the intensity and frequency of extreme events related to heat waves, extreme rainfall, storm surge and cyclone, along with their secondary effects in terms of drought, flood, flushing, subsidence, landslide and bushfire. In coastal regions, inundation is an increasingly major natural hazard to coastal settlement, with risks being exacerbated by rapid population growth and urbanisation. Potential sea level rise and increases in storm surge due to climate change will further exacerbate these risks in coastal regions such as Southeast Queensland (SEQ), and should eventually change the way we plan, design, construct and maintain our coastal built environment. This study applied the GIS-based hotspot assessment technique to identify the areas that may be subject to high impacts of inundation caused by storm surge and sea level rise, measured in terms of economic loss related to population relocation, and building and infrastructure damage. Adaptation options are explored in terms of 'retreat' and 'defend' approaches, implemented through changes in long-term planning and in the design of built environments in relation to coastal topology.

This study is part of the South East Queensland Climate Adaptation Research Initiative, a partnership between the Queensland and Australian Governments, the CSIRO Climate Adaptation National Research Flagship, Griffith University, University of the Sunshine Coast and University of Queensland. The Initiative aims to provide research knowledge to enable the region to adapt and prepare for the impacts of climate change.

## Deterioration of Concrete Structures under Changing Climate in Australian Coastal Cities

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Concrete is the predominant construction type used in Australia's critical infrastructure. Its performance, therefore, is vital for the provision of the nation's essential services and the maintenance of its economic activities. The key performance requirements for the design, construction and maintenance of concrete structures relate to safety, serviceability and

durability. The deterioration rate of such structures depends not only on the construction processes employed and the composition of the materials used but also on the environment. Changing climate may alter this environment, especially in the longer term, causing an acceleration of deterioration processes and consequently acceleration in the decline of the safety, serviceability and durability of concrete infrastructure, especially in coastal areas, which generally experience more severe environmental exposure. Investigation of concrete deterioration in Australian coastal cities under changing climate is being carried out as a part of the project funded by Department of Climate Change and CSIRO Climate Adaptation Flagship. It is based on the Monte-Carlo simulations that involve nine General Circulation Models (GCMs) with three emission scenarios, i.e. A1B, A1FI and 550ppm stabilisation, representing medium, high and policy-intervened GHG emission scenarios. Deterioration of concrete structures is represented by the probability of reinforcement corrosion initiation and corrosion induced damage at a given calendar year between 2000 and 2100, and all of them are more or less affected by the changing climate depending on locations. The findings from the investigation provide the basis for assessing climate adaptation strategies for concrete structures – this is the topic of a companion paper.

## **Developing an integrated approach to climate change refugia in Old, Climatically Buffered, Infertile Landscapes (OCBILs)**

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Anthropogenic climate change threatens society and the Earth's biota. By identifying areas that can act as refuges under projected climate conditions, adaptation and conservation activities can be focused where they will provide greatest benefit. Recent theory (Hopper 2009) proposes an integrated series of hypotheses explaining the evolution, ecology and conservation of biota on old, climatically buffered, infertile landscapes (OCBILs). High levels of biodiversity have been associated with OCBILs, providing imperatives for the identification and management of refugia in these generally subdued landscapes. Our aim is to determine what and where are the likely climate change refugia in OCBILs to enable understanding and management of refugia in OCBIL environments. We outline our approach to examine the environmental characteristics and biological attributes associated with refugia in OCBILs, using case studies from the subdued landscapes of the south-western Australian (SWWA) global biodiversity hotspot. Our examples derived from the application of high resolution spatial analysis together with phylogeography, ecophysiology and community assembly rules allow an integrated, transdisciplinary approach to determining the attributes of refugia. We show that the physical environments of refugia provide more resources and greater habitat options than that of the wider landscape matrix. We also show that the biological attributes, including phylogeographic patterns and the resilience of plant communities, is greater in refugia than in the surrounding matrix. The framework developed allows for the general identification of climate refuges, and provides a mechanism to determine appropriate management actions.

## **Spatial risk-based assessments of impacts and adaptation: a case study of domestic water harvesting systems in Queensland using the SimCLIM modelling system**

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Climate-related risks, such as those associated with droughts, floods and severe tropical cyclones, are significant obstacles to sustainable development – whether in developing or developed countries. Global warming and regional changes in climate and sea level threaten to exacerbate the risks by increasing the frequency and magnitude of extreme events. In order to ensure that development is sustainable in the long term, it is therefore imperative to incorporate adaptation measures that reduce vulnerability to current climatic variability and extremes as well as to the additional risks arising from future climate change. To achieve this aim, methods and tools for impact and adaptation assessment are required which merge “top-down” approaches to global climate change assessment with “bottom-up” approaches to hazard risk assessment and management.

This paper describes and demonstrates an integrated software modelling system, called SimCLIM, which strives to meet these needs. The results of a case study application of the SimCLIM system are presented that focus on the reliability of domestic water harvesting systems in southeast Queensland, a regional of high spatial and temporal variability in rainfall. Using the SimCLIM scenario generator equipped with gridded daily time-series data, a multi-model ensemble of downscaled daily GCM precipitation changes, and a domestic water tank model, “risk landscapes” are created. These risk landscapes, based on cell-by-cell daily simulations of water tank performance, depict the probabilities of failure of the domestic systems to provide water under both current climate and scenarios of future change. Additional simulations are then performed in order to examine the combinations of adaptation options required to reduce the risks to “acceptable” levels. The opportunities for extending such risk-based assessments to other regions, sectors and development contexts are discussed.

## **An Environmental Regulator Adapting To Climate Change - Journey so far for EPA Victoria**

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Recent EPA studies on the impact of drought and bushfires on the environment have shown the significant impacts of climate change on air quality and river health. Climate projections for Victoria imply more frequent and intense disturbance of the natural and built environment in the future.

To build organisational resilience to climate change EPA Victoria conducted a risk assessment in the context of observed and projected climate change from now to 2030. The objectives were to:

- Identify risks to EPA's purpose and mandate arising from a changing climate.
- Prioritise risks requiring immediate management.
- Identify critical knowledge gaps that limited EPA's ability to respond to climate risk.
- Provide the information needed to develop an EPA climate adaptation plan.

The risk assessment process followed was an adaptation of the process published by the Australian Government in 'Climate Change Impacts & Risk Management A Guide for Business and Government'.

As context for assessing risk a scenario for 2030 was developed to include potential climate as well as social, economic and technological changes.

Seven risk assessment workshops were conducted focusing on EPA's major services areas. Environmental performance, major projects, pollution response, monitoring and assessment, regulatory, beyond compliance and internal support services. EPA staff were provided with climate change scenarios and through the workshop identified risks arising from climate change to the activities and capacity of EPA to deliver the outputs expected by Government now and by 2030. Workshops were attended by over 20% of the organisation.

Climate change risks identified had potential financial, legal, safety, environmental, strategic, service delivery and reputational impacts to EPA as a result of the potential for:

- Increased intensity and frequency of extreme events such as bushfires, heatwaves, floods, storms and storm surges.
- The changing environmental background condition.
- The rapid introduction of new technology.
- A changing social and economic landscape.
- Changing community and government priorities.
- Organisational capacity to address climate change.
- Unforeseen external influences.

In the short term EPA will be developing a climate change adaptation plan which will detail actions to address the risks identified. Critical knowledge gaps that limit EPA's ability to mitigate and manage risks will also be addressed.

In the longer term EPA will apply knowledge gained to integrate the management of climate change into every aspect of environment protection.

## **Beyond fluffy findings. Making qualitative research on climate change useful for decision making**

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Qualitative research gives rich and detailed information that can be particularly useful for interdisciplinary issues such as climate change adaptation. The information can be valuable for a broad range of government and management users in providing evidence for complex and emerging issues such as community resilience and adaptation to environmental change. However, qualitative research is not commonly used by government policy makers. This is partly because of the difficulty of translating a myriad of personal stories and perspectives into a clear direction for decision making, as well as the time and resource investment needed to secure adequate results.

In October 2009 The Victorian Department of Planning and Community Development conducted a qualitative research project that aimed to address this issue of balancing local and policy relevance to provide better information for users. The research was conducted in the northern Victorian town of Lake Boga where the likely future impacts of climate change are already emerging as tangible environmental changes for the community. In 2008 the lake that was the major source of recreation and tourism for the area dried up completely. In a series of 35 in-depth interviews, information was gathered that gives detail to this community's attitudes, experiences and responses to the lake drying.

A number of aspects of the research project design make it an innovative approach to research for government policy and decision making. The project design included the following stages:

Consultation with stakeholders during project development. The project scope and direction were established in consultation with both Melbourne-based policy stakeholders as well as with a number of key community members in the study area. This enabled a balance between the priority of policy relevance and the need to keep the research locally meaningful.

Establishing local context. The initial stages of the project established a solid working knowledge of the study area, including local history, news coverage of major issues, preliminary interviews with former residents and experts on the area and preliminary demographic analysis.

Building local support for the fieldwork. The fieldwork stage relied on a comprehensive effort to slowly build connections and trust within the community before conducting the interviews.

The sample was carefully selected using a variation of the snowballing technique.

Testing the findings. Following preliminary analysis the key findings and emerging themes were presented to the policy stakeholder group. The group was asked to give feedback on which aspects were the most useful for policy development and decision making. Preliminary results were also presented to the interview participants as an additional trust-building process. Feedback from both groups was able to be incorporated into the final report.

This project produced a report that enables the translation of information into a number of emerging policy issues relevant to climate change adaptation. Significantly it has become an example of how carefully designed, locally-specific qualitative research can be more than just interesting stories.

## **Pacific Island Climate Forecasts for late 2009; a canary in the mine? The importance of climate services for users**

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In order to adapt to a changing climate, users require information about the climate system at a range of different lead times; daily, weekly, monthly, seasonal and long range. Seasonal forecasting in particular has become a key piece of climate information that users can take and use to modify their decisions and practices and hence be increasing adaptive to their variable surroundings.

However there are many and varied forms of seasonal forecasting models, from simple regression models to complex statistical schemes and at the top of the model evolutionary scale, fully coupled dynamical forecast systems. Although an end user may not be concerned with where their forecast has come from, many users are unaware that climate change also has the potential to impact upon some seasonal forecasting systems.

Despite a moderate strength El Nino event, outlooks for the November 2009-January 2010 period produced by a statistical forecast scheme for the Pacific Island Countries (PICs) involved in the Pacific Islands – Climate Prediction Project presented somewhat of a conundrum, whereby forecasts for sites within a small number of individual PICs showed somewhat spatially inconsistent outlooks.

On closer inspection, these sites were those where the historical information from both the Coral Sea region and the equatorial Pacific (i.e., ENSO region) were used as predictors to make the rainfall forecasts. Ordinarily when the ENSO region is warm (i.e., El Nino), the Coral Sea region is average to cool. However in mid 2009, both regions were anomalously warm, something rare at this time of year in the recent ocean temperature record, and hence something that, treated separately, had historically resulted in opposing rainfall conditions.

This talk will highlight some of the difficulties that may arise when using various forms of models, and hence how the delivery of climate information for users extends well beyond the simple provision of a set of numbers. An understanding of the models themselves, as well as putting a climate forecast into the context of other models and current conditions, emphasises the need for true climate services, not just climate data, in order for users to make best use of the available information.

## **Attribution of earlier winegrape ripening in the Southern hemisphere: analysis of vintage records**

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Forty vineyard blocks in eleven winegrape growing regions from south-eastern Australia, representing a range of agro-climatic zones, are assessed in this study of observed changes in phenology of managed biological systems through time. In all blocks assessed, across all regions and varieties, we note a trend to earlier ripening.

Earlier ripening is not desirable in most cases. Grapes are ripening at a warmer time in the year with probable changes to fruit composition. A potential negative consequence is the production of higher alcohol wines and this has been observed in recent vintages. Compression of the harvest period also creates pressure on winery infrastructure and problematic harvest logistics.

While in all regions a warming trend is evident we wanted to test the assumption that the warming is responsible for the earlier ripening of the grapes. This attribution analysis, assessing drivers of change, explores the theory that both climatic and non-climatic forces affected the changing rate of accumulation of sugars in grape berries. We found that when longer term datasets are analysed less than one third of the observed overall shift in ripening can be attributed to corresponding increases in temperature.

By re-testing assumptions we have potentially exposed some management levers that could reverse the undesirable early ripening trend. Factors such as vineyard yield, irrigation regime, canopy management, vine health and perhaps increasing carbon dioxide have been suggested as affecting the trend in rate of ripening. The contribution from these will require further quantification and will be explored in subsequent studies.

## Community-based adaptation, vulnerability and poverty

J Webb<sup>1</sup>

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Community-based adaptation (CBA) is increasingly recognized as part of an efficient, sustainable and effective response to climate change. However, tools and methodologies to move CBA forward are not well established. There is widespread agreement on the need to protect the livelihoods of the most vulnerable, but little knowledge and experience of how best to do this. Poverty and marginalization are key determinants of vulnerability and therefore of vulnerability to climate change, however the voices of the poor and marginalized are rarely heard in decision-making on adaptation.

Climate change is only one of many challenges facing poor people. In order to effectively reduce vulnerability, climate change adaptation must form part of a holistic response which aims to build resilience of individuals and communities to withstand the range of shocks and stresses that they are exposed to.

CARE is an NGO working in poverty alleviation, sustainable development and emergency relief across 70 countries. CARE's work in community-based adaptation takes an integrated approach which combines traditional knowledge with innovative strategies to address evolving challenges. This information is gathered and analysed through a Climate Vulnerability and Capacity Analysis and on this basis CBA responses are developed which involve acting in four inter-related areas:

- Promotion of climate-resilient livelihood strategies such as climate-adapted crops and agricultural techniques in combination with diversification of incomes and capacity building;
- Disaster risk reduction strategies to reduce the impact of increasing natural disasters on vulnerable households;
- Capacity development for local civil society and governmental institutions to better support communities in adaptation efforts; and
- Local-level advocacy and social mobilization to address the underlying causes of vulnerability, such as poor governance, lack of control over resources, or limited access to basic services.

CBA actions are taken at the individual and household level, the community and sub national level and at the national level. It is not enough to focus only on localised responses – these have to be taken within a wider enabling environment. CARE's approach endeavours to feed community-based experience into policymaking at regional, national and international levels. This involves evidence-based advocacy as well as constructive engagement with decision-makers. Replicability of community-level initiatives is increased through a focus on capacity development for a wide range of stakeholders throughout the process of adaptation, and on development of practical tools and methodologies to facilitate integration of adaptation into ongoing development processes.

The presentation will look at CARE's community-based adaptation projects in Africa and Asia that take an integrated approach and focus on disadvantaged social groups, particularly women. The projects began with participatory vulnerability assessments, which provided information on livelihoods strategies, climate vulnerability, and existing coping strategies in the target communities. This analysis led to the development of practical adaptation strategies tailored to local contexts.

Co-hosted by Australia's National Climate Change Adaptation Research Facility and the CSIRO Climate Adaptation Flagship, this conference will be one of the first international forums to focus solely on climate impacts and adaptation. It will bring together scientists and decision makers from developed and developing countries to share research approaches, methods and results. It will explore the way forward in a world where impacts are increasingly observable and adaptation actions are increasingly required.

The Climate Adaptation Futures Conference will showcase leading impacts and adaptation research from around the world. It will explore the contribution of adaptation science to planning and policy making, and how robust adaptation decision making can proceed in the face of uncertainty about climate change and its impacts.

## Rapid assessment of climate change uncertainty in evaluations of adaptation options

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Assessments of adaptation options are required in preparing environmental and socio-economic systems for climate change. This assessment must address key vulnerabilities of the systems, and so be relevant to the range of possible but uncertain impacts that may arise as a consequence of climate change. Such an exercise requires an ability to evaluate the responses of system exposure units to the full range of potential climate changes. A key challenge in this process is evaluating the diversity of exposure units, climate change projections and adaptation options without becoming inundated by factorial combinations of these components. There is thus a requirement for approaches that reduce the complexity and number of factorial combinations in adaptation assessments while enabling systems responses and adaptation options to be evaluated across the range of potential climate change.

This research addresses the issue by developing an approach to produce local climate change scenarios based on multiple GCM projections, under a range of greenhouse gas emissions scenarios, over the 21st century. The objective was to capture and summarise the range of projected climate changes and model uncertainty along a gradient of change so that a few scenarios could be selected that are representative of changes along the entire gradient. This reduces the number of factorial model runs required in adaptation assessments, allowing more effort to be directed towards evaluating the range of adaptation options. Climate change

projections from 22 GCMs for the Australian continent were acquired from the OzClim online database. Projections were acquired showing mean annual change in temperature and mean annual percentage change in rainfall (relative to 1990) for the A1B, B1 and A1FI emissions scenarios, for the years 2020, 2030, 2050, 2070 and 2100. Change factors for grid cells overlying locations of interest were extracted from the projections, compiled in a database, and grouped into classes along a gradient of projected temperature change. The median, 10th and 90th percentiles of rainfall change for each temperature group were then identified and used to define how the projected rainfall change (and uncertainty) varies along the gradient of projected temperature change. Climate change scenarios were derived by identifying points along the gradient from which inferences can be made across the rest of the gradient.

To demonstrate and evaluate an application of the approach, scenarios were developed for select locations in the north-eastern Australian rangelands. The scenarios were used to scale historical climate data for input into a pasture production model (GRASP), which was run to simulate climate change impacts on forage production, animal performance and land degradation. The application shows that climate change impacts on rangeland systems may track projected changes in temperature and rainfall captured by a suite of climate change scenarios. Therefore, modelled impacts (and uncertainties) can reasonably be approximated by extrapolation across the gradient of projected climate change. This implies that the approach to scenario development can be used to simplify assessments of impacts and adaptation options by reducing the number of analyses required to elucidate systems responses and the performance of adaptation options under projected climate change.

## **Plant invasions in Mediterranean climate “hotspots” of Australia and South Africa: do past invasions inform us about plant responses to future climate change?**

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Two of the world's ecological “hotspots”, south west Australia and the Cape region of South Africa, have similar climates and a native flora with Gondwanan origins and phylogenetic similarities. Both regions share and have exchanged invasive plant species that are significant problems for regional conservation objectives, thus contributing to the threatened aspect of the hotspot classification. These invasions may provide lessons of what to expect of invasion processes under future climate change, for both native and introduced plant distributions. Using this canvas of world-scale flora regions, we will compare and contrast the potential changes for plant invasion dynamics due to rapid climate change, the major emerging threat to these regions. We will integrate ecological data with contrasting forms of species distribution modelling to project current and future distributions of key weed species exchanged between the two regions. This research will be used to synthesise conservation management and adaptation responses for invasive plants that will be relevant for both current and future climates.

## **How do you define a native species in a rapidly changing climate?**

**B L Webber<sup>1</sup> and J K Scott<sup>1</sup>**

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At the intersection of research on global change and on biological invasions it is becoming increasingly clear that there is a fundamental problem that hinders future progress – how do you define whether a species is native or alien in a rapidly changing climate? Many national policies have a goal to preserve native species and control alien species. However, reaching common consensus on a functionally relevant suite of definitions describing biological invasions may not be possible if species introductions are defined by anthropogenic dispersal (albeit with caveats) or if the temporal divide separating native range shifts from alien introductions is not explicitly addressed. All species have the ability to expand their range and the current global climate is changing at an unprecedented rate driven by anthropogenic greenhouse gas emissions. It is anticipated that entire biomes will shift and for a species to survive, they will be required to track suitable climates at rates that most extant organisms will never have experienced before. Here we propose a unifying approach that allows for the incorporation of rapid climate change into the concept of biological invasions via the integration of biogeography and niche theory with invasion terminology. This approach provides a realistic framework for invasive species management and the preservation of biodiversity in a rapidly changing world, and is essential for formulating appropriate adaptation policies and responses.

## **Climate adaptation information from Digital Elevation Models (DEM)**

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Sea-level rise and its effects on coastal communities will create significant challenges for adaptation planning on both short and long timescales. To give Australian communities the opportunity to undertake timely adaptation to climate change it is important that easily accessible information be available on the expected climate changes.

The most important information to inform adaptation decisions regarding sea-level rise is geographical data covering coastal and near-coastal land areas. Fundamental to this is a digital elevation model (DEM) of sufficient precision and quality to allow the accurate determination of risk areas associated with sea-level rise.

Three-dimensional maps of the natural and man-made coastal features based on the DEM can then be used to produce a virtual representation of coastal erosion, flooding and inundation under a range of climate change

scenarios. These interactive maps provide important climate adaptation decision making tools as they identify areas likely to be at increased risk from climate change impacts such as storm-surge, sea level rise and erosion.

The availability of these new interactive maps allows planners to make more informed decisions when planning infrastructure and community developments; provides transportation industries with access to comprehensive spatial data to assist in transport infrastructure planning; and supports rapid and informed response to emergency situations by emergency managers.

Here, we present the conceptual framework behind the use of high-resolution digital elevation maps to inform and improve climate change adaptation decision making.

## **Role of rainfall change on the patterns and processes of terrestrial ecosystems**

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Against a background of climate change and accelerated human activities, changes in natural rainfall regimes have taken place and will be expected to become more pronounced in future decades. Long-term shifts in natural rainfall variables may challenge the existing cultivation systems worldwide and eventually alter the spatiotemporal patterns of land use and topography. Meanwhile, specific features of soil crusting/sealing, plant litter and its decomposition, and antecedent soil moisture content (ASMC) will accompany rainfall variability. Moreover, secular changes in rainfall will influence the vegetation dynamics and cultivation systems in practice over time and space, forcing local farmers adopting new techniques or measures to adapt themselves to these variations. All these changes, however, will increase pressures on the patterns and surface processes of terrestrial ecosystems, possibly increasing the risks of land and ecosystem-service degradation. An improved knowledge and understanding of this issue, therefore, is essential for maintaining a healthy earth. In this study, the characteristics of changes in natural rainfall, its role on terrestrial ecosystems, the challenges, and its effect on surface biophysical processes are elaborated and discussed. The major priorities for future research are also highlighted, and it is hoped that this will promote a better understanding of the interrelations between rainfall change and terrestrial ecosystems.

## **Scenario Planning for a resilient irrigated agribusiness community in Sunraysia**

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**Background:** The 'Sunraysia' region of North-West Victoria is one of Australia's premier producers of irrigated horticultural crops. The region faces challenges and opportunities associated with issues such as climate change, reduced water security, drought, and market volatility. These issues require that industries and communities change how they think about and plan for their future to ensure the long term sustainability of irrigated agribusiness in Sunraysia.

Climate change in particular is likely to require that irrigated agribusiness change from their current operating paradigms, which will have flow-on effects to supply chains, market presence and investment in agriculture.

**Project:** The Resilient Agribusiness project aimed to assist industry, service providers, governments and other agencies along the agribusiness chain to develop future scenarios of the potential impacts of climate change, social-demographic changes and market forces on irrigated horticulture in Sunraysia up to 2018 and to incorporate those possible futures into their long term strategic planning.

The methodology was adapted from the "Irrigation Futures of the Goulburn Broken Catchment" project, a scenario building and active community engagement project.

**Community Engagement:** Community Engagement was achieved through the careful selection of a Stakeholder Leadership Committee (SLC) who included CEO's, board members and key decision makers from across the agribusiness supply chain.

A key rationale of the project was that participants, via the SLC, would take the lead in shaping the outputs of the project and building the scenarios. The DPI Project Team took the role of facilitating this process. Therefore, it was the SLC who identified and prioritised the 'topics of information needed for long term planning about the future of irrigated agribusiness in Sunraysia'. The SLC also chose the key regional people to participate in the scenario planning workshops.

**Scenario Building:** Scenario Building is a process that involves a creative, forward looking search for patterns that might emerge in the future. Rather than identifying one preferred future, participants identify a range of plausible futures. Resultant scenarios can then be used to construct specific strategies to cope with change.

Whilst the decisive role taken by the SLC contributed to the success of the scenario planning process and the choice of a broad participant group, their initial prioritisation of issues indicated regional impacts of climate change (including carbon trading) rated much lower than immediate concerns about water security and economic and market trends, even when considering long term planning. Industries and community were adamant to avoid dealing with climate change in isolation and preferred it in context with issues such as economics and social aspects.

To ensure all participants had a similar level of knowledge on the issues raised by the SLC, the Project Team collated the most recent data and information as they applied specifically to the Sunraysia region. This was

distributed prior to a series of four scenario planning workshops, during which participants identified four possible scenarios for Sunraysia's future. It was not until well into the workshop series that participants fully appreciated the impact that regional climate change could have on their industries, businesses and the region.

The Project Team has since tested the scenarios for plausibility and has prepared them in a variety of formats for different audiences including detailed summaries, short stories and catchy working titles including; "Modern Mungo (Dystopia)", "Status Quo", "Making an Effort" and "Embrace the Chameleon (Utopia)."

The process currently underway is presenting the scenarios to decision making committees (mainly boards) of key agribusinesses in the region to discuss the strategic implications of all four scenarios. Questions asked at this level include; how does your organisation respond to or seek to influence each issue? It is anticipated that incorporating scenarios into strategic plans will help each industry/business/agency to anticipate and respond to change in a confident and co-ordinated manner and build a resilient agribusiness community in Sunraysia. Next steps will be to discuss identified main themes with industries, putting these themes into the industry's strategic plan context and looking at gaps and next steps.

The process so far has enabled industry and business leaders to base their planning on up to date information on topics outside their specific industry. The identification of a range of plausible futures through the scenario planning workshops has broadened the scope of their thinking from an industry based preferred future to a regionally based series of possibilities.

## **Design Challenge: Climate Change. The Water Atlas. WaterLand Topologies of Hamburg's Elbe River Island**

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Climate Change is a growing matter for (spatial) design, as we need tons of ideas how to implement scientifically proven facts like i.e. global warming, greenhouse effect or sea level rise into our built environment, in education or in policy making.

The essence of design possesses the potential to innovate and the ability to act, particularly when complex, non-linear systems, whose developments are difficult to predict, are involved. Designing is a highly integrative process of thought and modes of activity; it interprets, produces functional solutions and formulates aesthetically touching expression. It thrives on the interaction of intuition and rationality, ranging from the engineering sciences to the natural sciences to the humanities and art. Design is essentially always experimental as neither the development of the designed matter nor its adequacy can be entirely tested beforehand. Design requires just as much lay knowledge as it does professional expertise; it always acts at the centre of society. Using a variety of specific approaches and tools – from pencil to computer – designs are usually developed, represented and communicated in the form of drawings, mappings, diagrams, models, films, texts or calculations, which at the same time can be highly beneficial tools for communication with affected public, policy or decision makers.

My presentation would like to introduce the case study Water Atlas for the River Elbe Island in Hamburg, Germany, which, on the basis of a depictive interpretation of the 52qkm Hamburgian tidal influenced river island below sea level, elaborates scenarios for forthcoming new interrelationships between water and land particularly in regards to sea level rise – the WaterLand Topologies of the River Elbe island.

The STUDIO URBAN LANDSCAPE, a multi-disciplinary laboratory and network for design in research, teaching and practice over 20 members, attached to the Leibniz University in Hanover, Germany, was commissioned from the IBA Hamburg (International Building Exhibition Hamburg) to develop the Water Atlas, which functions as a spatial-dynamic planning tool on the basis of design scenarios for low lying coastal areas and shows the interrelationships of the island's complex water system and makes an integrative view possible; one that sees land and water as a whole and generates development prospects.

In a combination of maps, photos, diagrams and texts, the Water Atlas vividly depicts the interplay of human influences, topography, and water with all its facets in order to understand the effects of climate change such as sea level rise or increasing storm tides and identify links for adaptation. Thus, it provides an information base and orientation framework for all professions and stakeholders and is intended to raise awareness of the issue of water as an exceptional challenge for settlement development in the face of climate change.

The first section of the WASSERATLAS presents a pictorial interpretation of the island as WaterLand topologies. Even though Hamburg is 110 kilometers from the coast, the North Sea tides force seawater against the Elbe flow and cause the water level to rise and fall by about 3.5 meters twice a day. The WaterLand picture that has been elaborated as the fundamental characteristic of the area describes it according to the interrelationships of topography and water variations at three levels: the water level (below mean low tide), the water-land-level (between mean low tide and mean high tide) and the land level (above mean high tide). Three main existing principles in dealing with the water dynamics within the Elbe islands' three distinct spatial types were found. The application of all principles to each of the spatial types was the starting point for the development of 3 x 3 scenarios, showing variable approaches and design strategies.

All scenarios include optimization of the existing principles and demonstrate various design-oriented approaches to dealing with the available WaterLand topologies and all scenarios pursue the objective of improving living conditions on the river Elbe Island. In this we took account of the effects of climate change. The '3 x 3 scenarios' revealed possible



courses of action that must be taken into consideration in the future designing of the WaterLand. Which of the scenarios could and should be applied at which location can only be determined through considering the respective context.

Working with these scenarios developed in the Water Atlas has led to new collaborations within Hamburg's policy makers, planners and administrations as their implementation necessarily require multi-disciplinary, integrative strategies and solutions for climate change adaptations. Therefore the Water Atlas can be utilized as a case study how to develop ideas for climate change adaptation strategies under uncertainty, complexity and the pressure to act.

## Local Climate Impacts Profile - a way to help adapters ask better questions of climate science

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In response to a tendency among potential adapters to climate risk to devote too much attention to the minutiae of future climate projections at the expense of consideration of their current risks, the UK Climate Impacts Programme (UKCIP) has engaged in a debate about two alternative paradigms of adaptation. One, expressed as "Predict, Optimise, Relax" is predicated on the primacy of future climate information in a linear scientific chain of climate – impacts – consequences – responses. It undervalues the uncertainty in the science and has the potential to allow maladaptation. The other paradigm, expressed as "Assess, Hedge, Review" puts decision-makers into a more powerful position by allowing them to base their future adaptation actions on current experience and a more mature understanding of the nature of future climate information. It encourages an adaptation pathway approach that may be more robust.

UKCIP developed the Local Climate Impacts Profile (LCLIP) as a tool to enable adapters to learn about climate risks by looking back over recent weather-related incidents. The tool was initially developed for use by Local Government to explore the costs of, and responses to extreme weather events. The tool was piloted within Oxfordshire County Council, and has subsequently been used in some 120 local authorities. The paper discusses the value of LCLIPS in raising awareness of the adaptation agenda among officers and elected members and in quantifying the scale of the issue. Further stages, currently being trialled, encourage the adapting organisation to set up an ongoing system to record the organisation's experience of climate risks, to assess their attitude to risk and the thresholds for action, and therefore to give them the knowledge to explore future climates in a properly sceptical way.

## Potential benefits of a storyline approach to the provision of regional climate projection information

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A key challenge for the science of climate projection and impact assessment is to serve the rapidly growing climate information needs in an environment where there is:

- The view that substantial differences between GCMs in simulated future regional climate is a major challenge for adaptation planning
- A common desire amongst many users to use a few as possible future climate scenarios in impact assessments, often a 'best guess' assessment, just when there is rapid growth in the number of potentially relevant GCM and downscaled results;
- No standard methods for producing probabilistic projections (which can synthesis results from multiple GCMs) and applying them in impact studies.

If effective methods of filtering out unreliable models could be found, this would reduce uncertainty, new model runs could be routinely assessed as they come along, and a small set of simulations could be used in impact applications. However, there is an emerging view that we do not as yet have a robust process for filtering available models down to a few 'best' models. Furthermore, even if we could, may need not serve the requirements of a risk assessment approach to adaptation planning, where low probability but high impact scenarios need to be considered. So to address the challenge above, a different approach is needed.

'Representative concentration pathways' have recently been adopted as a basis for running GCM simulations for the IPCC AR5. This approach recognizes that the climate system responds to the evolving greenhouse gas and aerosol concentrations, and does not need to 'know' about the varying socio-economic scenarios that may underlie any particular concentration pathway. So as long as a suitably wide set of pathways is developed, climate modelers can apply these in new simulations for the AR5, while in parallel, the integrated assessment modelers can assess potential socio-economic scenarios and estimate which of the concentration pathways any scenario is most likely to follow.

Here we extend the above concept to consider the idea of sets of 'representative future regional climates' or regional 'storylines' for any region of concern. To construct such storylines, we would need to consider changes to a range of variables commonly needed in impact assessments, such as mean and extreme temperature, rainfall, potential evaporation, solar radiation and windspeed. A set of such climates could be found using cluster analysis, or related data reduction techniques. However, for the presentation a classification based simply on changes to annual rainfall and temperature will be shown. This choice was guided by fact that these variables are the two most commonly required in impact assessment.

Storylines may be defined by their high level descriptions (such as, 'warmer and drier', 'hotter and much drier' etc.) but under these there can be a richer level of detail based on wider results of the models that fall in a classification. The expansion of a storyline may include reference to various future climate data sets (such as downscaled data) that fall under that classification and possibly relevant impact results. Likelihood of a storyline would be assessed with reference to the GCMs results (including model weighting or exclusion as appropriate) or considerations such as physical arguments or recent observed climate trends. Application scientists may choose to use a subset of storylines, such as the 'likely' case, plus, extreme risk and least change cases for the impact system under consideration. Future climate data sets suitable for use in the application need only be developed to populate those cases.

Systematic application of this approach requires various challenges to be addressed, such as robustly classifying future regional climates into a small high level set, estimating likelihoods, and deciding on suitable regionalisations. A key benefit of the approach is that the needs of the risk assessment can be addressed with the simplicity of only a small set of future climates. Furthermore, storylines, and not GCMs, can be the 'boundary objects' which anchor discussion between climate science and impact communities, simplifying communication. Since the storyline descriptions need not change as new GCM results emerge, they can also provide a framework for assimilating impact assessments undertaken at different times with different sets of GCMs.

The presentation will present examples of the application of the storyline line approach in recent CSIRO work.

## Modelling the Impact of Climate Change on Peatlands in the Bogong High Plains, Victoria

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High mountain landscapes are rare and restricted in Australia, they occur at the top of the highest mountains, which are at comparatively low elevation. The Victorian Alps occur in the mountainous northeast of the state, the most extensive tract being the Bogong High Plains (BHP) (~120 km<sup>2</sup>). Peatland systems are an important component of high mountain catchments, they receive high amounts of water in the spring thaw and during high intensity summer storms and they transmit most of this water over a period of several hours, removing particulate matter and protecting the underlying soil from erosion. Though small in size these peatlands form part of the local carbon budget, they also form the habitat for a number of threatened and endangered species.

The Australian Alps have a naturally low level of bare ground. The introduction of cattle and frequent fire in the period following European settlement increased the amount of bare ground in all vegetation types, and it is likely that it reduced the extent and condition of peatlands. A formal hazard assessment process was carried out and identified climate change, reduced water supply, modified fire regime, weed invasion, water diversion, grazing and trampling by vertebrates and recreational pressures as the main hazards currently acting to threaten peatlands of the BHP. The most wide-ranging hazards were associated with climate change, which is a source of direct and indirect impacts.

A Bayesian network model was used to assign probabilities to the relationships identified in the hazard assessment, to reflect our understanding of causal pathways and processes that act to influence peatland condition. The model was used to predict the consequence of different management and climate change scenarios. The outputs of the model indicated that climate change impacts on water supply and fire frequency are the most serious threats to peatlands, followed by weed invasion.

Regression models were used to describe the current distribution of peatlands on the BHP and to make predictions of distribution changes under climate change. The environmental data used to build the models was modified to simulate the anticipated effects of reductions in runoff for 2030 and 2070. Results indicated that reduced runoff is likely to have a large impact on the peatland systems of the BHP (under the driest scenarios model predictions indicated a 33% decrease in area for 2030 and 76% decrease in area for 2070).

Management strategies were devised to mitigate the effects of climate change through planned adaptation. Intact peatlands, due to their hydrological structure, have the ability to buffer against external influences such as changing precipitation patterns. Peatlands could be managed to enhance (or restore) this capacity, opportunities exist particularly in those peatlands where the hydrological structure has been damaged. However, there is significant uncertainty around the likely success of peatland rehabilitation activities. An adaptive management program is recommended to address key questions: to what degree rehabilitation could affect condition, influence the probability of a peatland burning (through increased moisture retention) and/or increase resilience to an overall decrease in water supply.

## Modelling Extreme Events in a Changing Climate using Regional Dynamically-Downscaled Climate Projections

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The ability of regional dynamically-downscaled global circulation models (GCMs) to assess changes to future extreme climatic events, such as heat waves, drought, floods and bushfires, and the likely impacts for adaptation was investigated. Although global models provide the best estimate climate change on a global scale, they cannot provide a detailed picture of climate change at the local level - where people, businesses and ecosystems will ultimately feel (and need to

respond to) a changing climate. Climate Futures for Tasmania, a jointly funded and collaborative research initiative of the Antarctic Climate and Ecosystems Cooperative Research Centre in Hobart, has generated projections on a high-resolution 0.1° (~14km) grid across Tasmania using the CSIRO Conformal Cubic Atmospheric Model (CCAM). Two future emission scenarios and multiple GCMs were used for the period 1961-2100. Extreme value methods were employed for the analysis of temperature and precipitation extremes and a bias-adjustment procedure was developed to correct extreme magnitudes against observed data. Changes to the magnitude, intensity, frequency and duration of extreme events were modelled and analysed using a suite of indices to demonstrate evolving changes to extremes. Estimates of precipitation return periods were calculated using events fitted to a Generalized Pareto distribution through a robust extreme value threshold selection procedure developed for gridded precipitation datasets. Results were correlated against mean trends, both seasonally and annually, and compared to station and gridded observations. Future trends in individual and multi-model projections were compared with existing Australia-wide and global scale results calculated from GCMs. Increases in both daily maxima and minima temperature associated with climate change were noted, resulting in fewer cold nights, more heat waves and increased bushfire weather occurrences. Projections of future precipitation extremes were found to correlate well with changes to regional climate drivers and spatial variance was also found across the state that closely matched observations. Results demonstrate that dynamical downscaling captures regional climate variability (particularly relevant for precipitation) and displays significant ability in modelling future changes to extreme events at the local scale. This paper assesses the likely impact of the changes to the future Tasmanian climate and demonstrates how this information may be employed for emergency planning and adaptation strategies through stakeholder engagement and data availability.

## Tourism, Climate Change and Adaptation: New South Wales Local Government Responses

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Climate change is one of the most significant contemporary challenges facing humanity. Apart from attempts to mitigate climate change through reductions in greenhouse gas emissions, planning for the impacts of climate change is arguably the most important path forward. While the social and economic impacts will be significant, planning for the physical impacts of climate change (PICC), including sea level rise, coastal erosion, increased incidences of drought, extreme weather events, reduced agricultural production and more, is central to stemming the environmental impact and consequently the social and economic impact of climate change, including the impact on tourism industries.

In Australia, all levels of government have a role through regulation and policy in adapting to the PICC. However it is at the local government level where much of the responsibility is expected to fall. The challenge for local governments is to identify climate change vulnerabilities and reduce the risks. The implications of the PICC for tourism are dependent on how successfully this challenge is addressed. This study aims to examine the perceptions of NSW local government planners regarding the planning that has been implemented for the PICC and for tourism at local government level in New South Wales, and analyse the implications for local government and for tourism industries.

The data for the study were collected through a voluntary, anonymous questionnaire which asked about planning for climate change, tourism planning and climate change action. The questionnaire was posted to each of the 152 local governments (councils) in NSW, with the aim of eliciting responses from one planner from each council in NSW. A total of 56 questionnaires were completed and returned, and the results show a high perceived vulnerability of local government areas (LGAs) to the PICC but a broad lack of confidence in planning measures. Increased extreme storm events were rated as the most significant potential physical impact of climate change, followed by damage to infrastructure and increased drought. The effectiveness of all planning and policy instruments, the NSW standard Local Environmental Plan (LEP) framework and the Environmental Planning and Assessment Act 1979 was perceived as very low, indicating a broad scale lack of confidence in planning measures in NSW for the PICC. The perceived effectiveness of these same planning elements rated only slightly better for tourism planning.

One quarter of respondents thought their council had taken no steps at all to plan for the PICC. Furthermore, 61.8 percent of councils are believed to have taken less than three steps to plan for the PICC. The most selected step planners thought their council had taken was collaboration with other council(s). The overall efficacy of steps that had been taken received a low rating from the planners. Respondents, on average, thought their council should take more than double the number of steps over the next five years to plan for the PICC than they have to date. Additionally, respondents overwhelmingly thought that their councils should undertake risk assessments for the PICC over the next five years. The development of policy and collaboration with other councils were also considered important steps that councils should take. Two thirds of planners thought that special provisions addressing climate change should be added to planning instruments and the NSW standard LEP framework.

These results were found to have considerable implications for local governments and for tourism industries in NSW. Local governments that fail to plan for the PICC are considered more vulnerable, not only to the PICC, thereby reducing their resilience, but also to civil and public liability claims and litigation. The implications for tourism industries include increased vulnerability to the PICC but are also compounded by the poor perceived efficacy of the tools to plan for tourism. The results of the study indicate that improved tools for planning for the PICC and for tourism are needed. These improved planning tools can emerge through the application of an iterative adaptive management framework which facilitates constant learning from past inadequacies and applying the lessons learnt to adjust the planning tools. Implications of the results of the study, along with recommendations for future research and the development of appropriate measures to improve the planning framework for local government in New South Wales are presented.

## Where is high impact learning for adaptation in schools?

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Almost 20% (one fifth) of the population of the state of Queensland go to school everyday as students, teachers, ancillary and management staff. Therefore the formal schooling sector represents a significant community resource point for communicating climate change adaptation. It is our view that the school sector (and the related early childhood education and care sector) need to be included in national and state planning for communicating environmental change and response strategies. The situation would be equally valid internationally. Schools in Australia are taking up the challenge of educating for sustainability through government supported policy and programs, which, while certainly well intentioned, are not yet very well funded. Teachers are professionals who work with their eye on the future. As EfS is progressively taken up across the school sector it has the effect of creating an environmentally aware teaching workforce and educating students how necessary it is to think about climate futures. Capacity for resilience to environmental change is slowly being built by the sector. But whether this resilience can translate into sector adaptation in the face of abrupt climate change is a discussion educators still need to have. We argue schools can play a more active role in promoting action for reversal of deteriorating environmental conditions. Present education policy frameworks focus on sustainability rather than adaptation, however, education adaptation could readily be integrated into formal education. The capacity to address these challenges is developing within the school sector.

## An integrated framework for assessing the vulnerability of biodiversity to climate change: prioritising research and adaptation strategies

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Global climate change is the most significant current threat to biodiversity in many tropical biodiversity hotspots. Impacts on biodiversity, both negative and positive, will be diverse, complex and interactive, as will the biotic responses. It is now necessary to prioritise and integrate future research and management in order to minimise impacts. We provide a framework to assess the vulnerability of species to global climate change that considers the diverse factors that determine the key elements of sensitivity and exposure. Sensitivity of a species is mediated by the potential for ecological and evolutionary responses as well as species and ecosystem resilience. Sensitivity is then balanced against exposure where changes to regional scale conditions may be tempered by habitat buffering at finer spatial scales. The framework is then completed with explicit recognition of adaptive management and feedback mechanisms that will follow any realised impact. All of these components affect the relative vulnerability of a species and need to be considered in any comprehensive assessment of the impact of climate change on biodiversity. Objective prioritisation of vulnerability is the first step towards planning efficient adaptation strategies that maximise benefits and avoids wasting management resources on unnecessary, or lower priority, actions. I will present this framework and illustrate with examples from our research within the rainforests of the Australian Wet Tropics World Heritage Area.

## Methods for assessing vulnerability of sustainable forest management to climate change

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An assumption underlying sustainable forest management has traditionally been that the climate is relatively stable and therefore that the environmental processes and conditions that shaped forests in the past would be similar to those shaping forests in the future. However, the practices and approaches that worked in the past may not work in the future largely because the assumption of a constant climate no longer applies. Ambient climates at particular locations in Canada are changing and they will continue to change at an unprecedented rate. Climate change is a new influence or factor affecting Canadian forests and forest management. Sustainable forest management goals (as currently defined) may become increasingly difficult to achieve using current management practices and approaches. The reality of climate change means that forest management objectives, systems, practices, and approaches will need to evolve, adapt, and change. The question is how, when, what, and where are changes required. It is difficult to answer these questions without a systematic assessment and understanding of where sustainable forest management is vulnerable to climate change and implications for adaptation planning. The evaluation of vulnerability of sustainable forest management to climate change requires adapting and applying current vulnerability assessment methodologies to the unique problem of assessing SFM vulnerability. The first step in assessing SFM vulnerability to climate change is to define SFM and SFM objectives. Definitions of sustainable forest management vary from place to place and from context to context. At the national level in Canada SFM is defined by the Canadian Council of Forest Ministers Criteria and Indicators framework. Criteria for sustainable forest management include 1) biological diversity, 2) ecosystem condition and productivity, 3) soil and water quality, 4) role of forests in global ecological cycles, 5) economic and social benefits from forests, and 6) societies responsibility. Vulnerability assessment needs to consider exposure, sensitivity, and adaptive capacity relative to these criteria. It also needs to be designed in a way that the information supports adaptation planning. Canada is a world leader in sustainable forest management and is in the process of developing methodologies and approaches for vulnerability/opportunity assessment of sustainable forest management. Key components of assessment concepts being considered include: 1) defining the system decision/policy context, 2) evaluating current vulnerability, 3) developing scenarios, 4) evaluating biophysical risks and impacts on

forests, 5) evaluating risks and impacts on sustainable forest management criteria, 6) identifying constraints that restrict or limit adaptation and capacity to adapt, 7) assessing vulnerability/opportunity, and 8) development of adaptation plans. Unique and novel new approaches, concepts, and methods are being developed within a number of these components. Ultimately the goal is for the development, communication, and application of SFM vulnerability/adaptation planning assessment frameworks that satisfy a range of new and unique requirements including: consistency with internationally accepted methods, appropriately tailored to guide adaptation decisions relative to SFM goals, acknowledges uncertainty of future climates and future forest impacts, promotes a collaborative approach that relies on and integrates both science and practitioner knowledge, applicability across a range of scales and contexts, and that is trans-disciplinary and integrated.

## **Greater use of kangaroos to produce low-emission meat and adapt to climate change on the rangelands**

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Kangaroos are adapted to Australia's variable climate and are abundant in the temperate rangelands where cattle and sheep are raised. They are not contained and roam from property to property seeking out best pastures in response to local rainfall. Kangaroo harvesting is regulated under nationally coordinated wildlife trade management plans that have consistently been endorsed by professional ecologists and wildlife managers and their associations. Nevertheless under current arrangements it is rare for landholders to benefit from the kangaroos on their lands or play a role in their management.

Ruminant livestock produce the GHG methane and so contribute to global warming. Methane from the foregut of cattle and sheep constitutes 11% of Australia's total GHG. This means that methane from livestock is equivalent to two thirds the emissions produced by the Australian transport sector. Kangaroos, on the other hand, are non-ruminant forestomach fermenters that produce negligible amounts of methane. When agriculture is eventually covered in an Australian emissions trading scheme, ruminant livestock owners or downstream service providers such as abattoirs and shipping terminals will have to account for livestock emissions. One of the ways being trialled by Australia's livestock industries to reduce methane emissions is to introduce kangaroo gut microorganisms to cattle but this approach has not been successful.

Another option, particularly for Australia's vast rangelands, is for pastoralists to use kangaroos to produce low-emission meat. If kangaroo numbers increased to grow the same amount of meat, permits for kangaroo emissions would be significantly cheaper than those for cattle and sheep, perhaps providing the incentive for farmers to switch to kangaroos. On the rangelands where kangaroo harvesting currently occurs, increasing the kangaroo population to 175 million from 34 million while reducing the cattle and sheep by 20 % per year to 2020 would lower Australia's GHG by 16.4 megatonnes or 3 % of Australia's total emissions.

To manage kangaroo's free ranging behaviour and increase the value of the product, some graziers in Queensland established a cooperative in 2009. They are following trends throughout the world, where native species play an increasingly significant role in rural production processes. The Cooperative had support from the National Landcare Program and the RIRDC. It sought to reduce grazing pressure and encourage the restoration of trees, shrubs, understorey and grasslands, reduce soil degradation, potentially increase water quality, extend wildlife corridors while improving the quality and consistency of kangaroo products and the animal welfare standards under which they are taken.

While a broad scale changeover from beef and sheep to kangaroos is unlikely to be a solution to either climate change adaptation or greenhouse gas amelioration, greater use of kangaroos is an option that warrants further investigation. If rainfall decreases in southern Australia in winter and spring, cropping and irrigation will revert to grazing for animal production. Thus, rangelands will increase in area, although some currently marginal areas could be expected to become unproductive.

The Queensland Cooperative project is currently languishing while waiting for further investment to continue the trial, including a re-estimation of the methane production by kangaroos. Notwithstanding support from catchment management agencies, other funding sources seem reluctant to invest because of criticism from both animal rightists and uniformed elements in pastoral industries.

## **Fear, Hope and Action: Facilitating positive behavioural and social change through exploring, visualizing and communicating alternative futures and pathways**

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This paper provides a critical overview of emerging strategies for exploring, visualising and communicating alternative social, economic and ecological futures and pathways. Such strategies are increasingly being used to help facilitate the behavioural and societal change needed to mitigate and adapt to climate change.

There is increasing evidence that behavioural and social change strategies which rely primarily on communicating the threats and dangers of climate change are likely to provide an insufficient basis for creativity and action – and indeed may at times accentuate responses of paralysis and disengagement. Evidence from a wide

range of historical, public policy, sociological and psychological sources suggests that large scale transitions and transformations at social, community and individual levels often depend on the capacity to break out of 'business as usual' thinking through imagining and communicate alternative futures and pathways.

The paper will therefore provide a critical overview of strategies, methods and tools that have been used to engage individuals and communities in developing imaginative and transformative climate change adaptation responses. These will include:

- Scenarios
- Modeling
- Story telling and narrative strategies
- Visualisation (e.g. through visual arts, multi media and films)
- Simulation games (including computer games)
- Illustrative and pre-figurative examples (eg. ('Transition Towns')
- Citizen juries and other community engagement and deliberative decision making methodologies

Drawing on Australian and international examples we review the key characteristics of a variety of 'imagineering' strategies and their respective effectiveness in promoting rapid transformational change in diverse settings. We also summarise key challenges and obstacles including the importance of avoiding the technological and social determinism sometimes associated with 'futurology' techniques as well as the need to improve access to relevant data sets and technical skills. We conclude with some reflections on the relevance of these approaches to the broader political challenges of driving the national and global transformations needed to reduce the risks of dangerous climate change along with future policy development and research priorities.

## **Indigenous people and climate change adaptation: Facilitating equitable access to information**

**E Woodward<sup>1</sup>**

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Indigenous people in remote regions of Australia comprise a unique group within the adaptation-response community. With strong socio-cultural ties to ancestral lands, habitats and wildlife, and with livelihoods that are highly dependent on natural resources, they are among those most vulnerable to climate change. Indigenous peoples' engagement in discussions about climate change adaptation requires a concerted effort because many do not have access to the communication technologies, products or social networks favoured by national governments when providing information to the 'public'. This has led to inequities in the delivery of climate change-related information in Australia.

Around 20% of Australia forms part of an Indigenous estate with many communities situated in coastal and floodplain areas or along river banks. Most of these communities are also remote, isolated and face significant socio-economic challenges driven by poverty, poor health, low literacy and high unemployment. The ability of Indigenous groups to adapt to climate change impacts will be challenged by the same factors that have contributed to their marginalisation. For remote Indigenous communities in northern Australia to be equipped to discuss and debate climate change adaptation options and avenues for reducing vulnerability they need access to locally relevant, easily digestible climate change information delivered in socially and culturally appropriate forms. In this presentation I will draw on experiences in northern Australia to provide guidelines on the equitable communication of climate change-related information.

Effective communication is a skill that requires thought, preparation and often trial and error to get right. A climate change travelling 'road show' is effective in initially providing information to Indigenous communities about climate change. Institutional structures that currently facilitate the bringing together of community members from wide geographical areas, for meetings of Land Councils, catchment management groups, planning and policy reference groups, and language group/land claims meetings should be tapped into for information delivery. Further, Indigenous social networks exist that are founded on extensive family relationships, and form part of a complexity of social and economic ties based on exchange and reciprocity. These networks will play a key role in adapting to environmental variability and stress, and are important networks to incorporate in the distribution of climate change information.

As well as face-to-face discussions, materials need to be provided so that information can be taken away and shared within extended family networks. The design and delivery of communication materials need to be cognisant of low literacy levels, and should be undertaken with input and consistent feedback from those with on-ground experience in the communities in question. Products should be trialled in conjunction with community members and local people can be engaged to seek independent feedback from community members as to whether information was understood. It is vital that communicators work in accordance with local networks and processes and seek local advice as to which situations are appropriate to present in and whether translators will be useful.

## **Data in support of climate change adaptation in the Pacific**

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Climate change adaptation depends on reliable, long-term climate data. Such data supports the construction of climate change projections, and additionally, at the individual country level, provides a historical basis on which to develop downscaled climate change projections needed to develop effective adaptation strategies. It is desirable

to have data at a sufficiently representative number of stations to ensure that projections adequately represent all significant climate niches, along with major socio-economic and vulnerable areas, within a country.

Unfortunately, many developing and least-developed countries lack the resources to adequately observe, manage, and make accessible their climate data, and in some cases the original paper-based records are at risk of loss. This is very much the case in many Pacific Island Countries, which are also among the most vulnerable countries in the world to climate change. The Australian Government, as part of a much larger Australian Climate Change Adaptation Initiative (CCAI), has provided funding through its Pacific Climate Change Science Project (PCCSP) to, among other things, (i) improve understanding of key Pacific Region climate features; (ii) model the potential effects of climate change on these; (iii) apply new downscaling techniques to better reflect climate change at sub-island scales. The project recognises that to support this work, the project's research scientists must have access to high quality data for a sufficiently representative number of stations across the Pacific-southeast Asian region. Therefore, part of the project is devoted to developing an in-country capability to secure, digitise, manage, and provide access to, climate data in 15 participating countries within the Pacific-southeast Asian area.

The work to be described will include data rescue activities (which have actually been ongoing in the area for some years), and the development and implementation of robust in-country data management systems in the 15 partner countries. The author will outline a number of issues the project team has had to address in carrying out the work, issues with general applicability to obtaining data from developing and least-developed countries throughout the world. Such issues include technological and resource limitations, and the challenges of capacity-building and training peculiar to developing countries. It is important that such issues be understood and addressed, because data from all such countries are needed for the construction of global climate change projections, but also because the impacts of climate change will be particularly significant in many of these developing and least developed countries. Links to other international projects undertaking related work, such as ACRE and some World Meteorological Organisation initiatives, will be briefly described.

## Prepare the next generation for changes – education programs of climate change adaptation at the University of Southern Queensland

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To ensure that climate adaptation research will quickly be disseminated to the public, it is essential to integrate the measures of sustainability and adaptation into the education. It is indisputable that climate change will have far-reaching consequences for a range of professions, so many professional activities will require knowledge of the climate science and adaptation in their decision making processes for long-term planning to cope with the impacts of climate change. The required adaptation skills are discipline dependent, so the need of tertiary, post-graduate, and professional curricula of climate change adaptation is expected.

Recent market analysis commissioned by the University of Southern Queensland (USQ) has identified the sustainability sciences, including the field of climate change science and climate change adaptation, as an area to focus and expand on. USQ has developed the only Australian undergraduate Bachelor of Science (Climatology) available in Australia since 2001. Supported by the Australian Government's Department of Climate Change, the university is working on to redesign its programs in science for communicating climate science to a broad clientele, and to introduce curricula on the application of adaptation skills to issues affecting Australia. Three new programs have been established in USQ: Bachelor of Science in Environmental Sustainability, Master of Science in Climate Adaptation, and Graduate Certificate in Climate Change Adaptation (in partner with Australia National University).

The major aim of the bachelor program is to provide students with the skills and capabilities to respond by working within their professions to the challenges and opportunities that arise from global and regional environmental changes. These include a thorough appreciation of climatic changes and variability which pose one of the most important and complex issues society is dealing with. It requires the skills and raises awareness of the importance to work across the traditional scientific disciplines and communicates an understanding of how scientific knowledge integrates with diverse socio-economic and political systems in order to achieve sustainable economic prosperity.

The master and the graduate certificate programs are designed with similar initiative, but these programs further emphasize on the appreciation of the impact of climatic changes and variability on natural and human systems, such as the built environment, agricultural production systems, regional, national, and global economies, and the approaches of adapting and mitigating these impacts.

These programs will provide students with the skills and knowledge basis that will empower their employees to achieve sustainable business practice in a rapidly changing world. On completion of the award, students will be able to practice the principles of sustainable development, adopting and mitigating the risks of environmental change including climate change and climate variability while responding to opportunities, and contribute to environmentally sustainable natural resource management.

Courses in these programs associated with climate change adaptation are under development. Core courses of these programs include Climatic and Environmental Risk Analysis, Adaptation of Climate

Change, and Climate Change and Sustainable Development. These courses are also open to other cross-Faculty programs, and aims to integrate our knowledge of climate change issues and adaptation skills into other professional programs offered across the university. In addition, State Government departments and policy makers who need scientific basis for future policy are seen as key clients.

## IC Tag Sensing Technology Used for Climate-Change Adaptation Strategies

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Application of information and communication technology (ICT) has been increasingly demanded in wide areas related to civil engineering practices. In addition to RS, GPS, and GIS, which have been put into practical use already, sensing technologies including the use of optical fibers have emerged as promising tools. Particularly, IC sensors are greatly anticipated from the viewpoint of convenience for widespread use and cost savings. Furthermore, IC sensor miniaturization has brought about recent rapid development of micro-electromechanical systems (MEMS) technology and has reduced costs. Consequently, large-scale sensor networks can be built for monitoring infrastructure. Using such networks with IC sensors, several attempts have been made to use sensor IC tags with MEMS acceleration sensors for measuring atmospheric CO<sub>2</sub> concentrations and its distribution over wide areas and for measuring vibration characteristics of structures, ground and earth structures. The latter method can detect the infrastructural vulnerability under conditions of severe climate change, which can exacerbate the effects of earthquakes. For those purposes, sensor networks have been emplaced at many locations in structures for measurement of CO<sub>2</sub> concentrations and on railway embankments in Ibaraki prefecture, Japan. In the latter case, earth structure conditions are detectable through analyses of acceleration data measured on embankments and cut-off slopes. The applicability of the sensor network has been verified as a technique for monitoring urban spaces and the integrity of transportation infrastructure. Analyses of the measured data suggest that this innovative sensing technique using IC tags constitutes a powerful tool for proposing adaptation strategies and systems in countries and areas that are vulnerable to climate change.

## The potential impacts of climate change and land transformation on biodiversity in Mediterranean climate south-west Western Australia – a global biodiversity hotspot

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The world's five Mediterranean climate regions are projected to be amongst the most significantly affected by anthropogenic climate change, and show the highest levels of confidence in projected changes to rainfall. These regions harbor a substantial proportion of the Earth's vascular plant flora, and all have the exalted but unfortunate status of being recognized as global biodiversity hotspots, those places on Earth richest in endemic species, but under the most threat. Widespread land transformation, associated habitat fragmentation, invasive species and introduced diseases have caused and continue to drive substantial declines in biodiversity. Projected climate change may interact with these factors to further threaten biodiversity.

In Mediterranean climate south-west Western Australia (SWWA) mean annual temperatures have increased and since the 1970's there has been a significant decline in autumn and early winter rainfall. The consensus among Global Climate Models is that temperature will continue to increase and rainfall will continue to decline in the SWAFR.

Patterns of biodiversity in SWWA are strongly influenced by climate. Unlike the other Mediterranean climate regions of the world SWWA is of low relief and with the exception of the Stirling Ranges which are just 1109 m a.s.l., there is limited scope for altitudinal migration into cooler and moister montane refuges. Under projected climate change, warmer and more arid conditions are expected to shift southwards and westwards, and there is a possibility that the coolest and wettest climate zones on the south coast, containing many relictual and mesothermic phylogenetic lineages may disappear. Where the latitudinal extent of the continent permits shifts in geographic range, extensive land transformation for agriculture and urbanization will limit the amount of habitat available for colonization, and habitat fragmentation will restrict dispersal.

As a first step in assessing the vulnerability of SWWA's biodiversity to climate change we have modeled the potential impacts of three climate change scenarios and their interaction with land transformation on the ecogeographic domains of regional biomes, endemic plant species (*Banksia* spp.) and the endemic marsupial quokka (*Setonix brachycurus*). The models predict that the combined effects of climate change and land transformation may have significant adverse impacts on biodiversity in the region with one regional biome the karri forest potentially losing all suitable climate range, 66% of *Banksia* spp. and quokka losing greater than 80% of their range by 2070 under the high emissions scenario. These results need cautious interpretation in light of the many assumptions and uncertainties in the climate and ecological models used. Nevertheless, the potential impacts identified provide insights into the relative sensitivities of regional biomes to projected climate change, highlight the need for a better understanding of physiological and climate thresholds and ecological monitoring to detect change, and stress the importance of ecological restoration and identification and management of climate refuges as adaptation actions.



## Applicability of Ensemble Pattern Scaling Method on climate change information construction: A case study of South East Queensland Climate Change Mapping

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Regional climate change assessment and the climate change management strategy planning require climate change information at a proper spatial scale. We discussed in this paper the design, delivery and uptake of regional climate change information for South East Queensland (SEQ) of Australia. Eight climate variables were identified. Their related change information needs to be delivered as a package ready to be used for climate change risk assessment. Beside baseline climatology, the scenarios of year 2030, 2050 and 2070 were selected to represent mid- and long term scenarios. Result from an ensemble of nine GCMs coupled with 2 AR4 SRES emission scenarios (A1FI and A2), as well as one result from an individual GCM (CSIRO MK 3.5) were required to demonstrate the range of probabilities of the future changes.

Given the scope that defined by DIP (Queensland Department of Infrastructure and Planning), a total of over 8000 outputs needed to be generated, which necessitated an efficient climate change information construction. Thus the Pattern scaling method, which constructs climate change scenarios based on the normalized change patterns from GCM outputs, was selected. The method allows an easy cross model sensitivity analyses and uncertainty examinations, thus provides the possibility of representing the whole range of uncertainties involved in climate change projection. However, in applying pattern-scaling, two fundamental sources of error need to be addressed: nonlinearity error and noise due to the internal variability of the GCM.

We developed a two-step ensemble approach to investigate the applicability and uncertainty associated with applying pattern scaling at regional scale. The first step ensemble examined the linearity accuracy and GCM internal variability, and second step ensemble produced the inter-model variability of the GCMs and associated confidence intervals. In general, the linear relationship weakened when the analysis was applied to regions compared to national scale, but the error incurred from such GCM internal variability is still much smaller compared to the inter-model variability. Pattern scaling seems to be a good compromised method in construction of future change, especially for trend analysis.

Over SEQ, the outputs indicate a dry trend for the whole region. The results highlight that by 2070 many areas display additional 10 days without rainfall annually. The western and south western of SEQ are particularly exposed to the reduction with as many as 315 days without rainfall annually. Even though the mean annual precipitation is likely decreasing, the change in the 99th percentile daily precipitation intensity indicates slightly enhanced precipitation extremes for SEQ. By 2070 there is a significant increase in the number of days over 35°C annually in the west and mid-western SEQ. While the east coast remains likely unchanged by 2050, the number of days over 35°C increases from 16-20 day ranges to 44-48 days for the west, with Noosa and Lamington National Park likely to have up to a four-fold increases. In terms of regional planning and development activities the climate change may have considerable implications on agriculture, potable water supply and infrastructure life-span.

## The role of legislation in enabling climate change adaptation at the local government level

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It is increasingly being recognised that public policy and/or legislation can play an important role in facilitating adaptation to climate change. This approach has been implemented in New Zealand with planning for climate change explicitly required in legislation.

The Resource Management Act 1991 (RMA) is the key legislation that sets out how New Zealand manages its environment. In 2004 the RMA was amended to require all persons exercising duties and functions under the Act to “have particular regard to ... the effects of climate change”. One of the implications of this amendment to the RMA is that local authorities, who are primarily responsible for implementing the RMA, must include the consideration of climate change impacts in its regional and district planning documents.

The paper will review the success of this legislation amendment by presenting the results from an analysis of local government planning documents to identify how local authorities have implemented the requirement to plan for the effects of climate change. The paper will particularly focus on how local government is, or is not, planning for future sea-level rise.

The paper will also review the regulation that is being scoped to support the existing policy framework, in particular focusing on flood risk management and sea-level rise. Evidence supporting the need for further regulation will be reviewed and the role of climate science to underpin the legislation discussed.

The paper will conclude with insights from the New Zealand perspective on the use of legislation as a tool for enabling climate change adaptation. Lessons learnt from the analysis will be highlighted and the transferability of the approach of regulating for climate change adaptation will be discussed.

## The Louisiana United Houma Nation Case Study of Native American Adaptation and Mitigation

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The climate change-related relative sea level rise of 3-10mm per year in the next 50 years only exacerbates the vulnerability of the New Orleans metropolitan area and the rest of coastal Louisiana in the United States. When one accounts for both subsidence endemic to Louisiana's deltaic coast and global sea level rise, recent estimates of relative sea level rise project the Gulf of Mexico will be anywhere between 2-6 feet higher in the next century. Despite these recent and dire predictions, with the exception of populated areas in New Orleans that are below sea level, urban and rural populations of Louisiana's coastal zone have long existed with the natural flooding propensity of the region – with many small towns in the deltaic plain, in particular, prioritizing residential land use along the limited levee areas of bayous and former distributaries of the Mississippi River.

The problem now is that many of the small rural towns in coastal Louisiana that have been able to sustain themselves near sea level for the past century will succumb to sea level rise during the next century, further exacerbating coastal erosion, and those that remain above sea level but on the ridges of the former Mississippi River distributaries will no longer have the wetland buffers that have historically protected them from diurnal fluctuations of sea level, intermittent storms, and less frequent but increasingly catastrophic hurricane/tropical storm surges.

One promising case study of community-based adaptation and mitigation to climate change in Louisiana is that of the United Houma Nation (UHN). The UHN constituents lie primarily outside levee protection systems. Prior to 2005, the 17,000 members of the United Houma Nation were faced with declining livelihoods and displacement due to continued coastal erosion and saltwater intrusion. Estimates suggest that Hurricanes Katrina and Rita directly affected over 7,000 tribal members with nearly half of these displaced. Hurricane Katrina left over 1,000 tribal members homeless in rural areas and the storm surge from Hurricane Rita inundated lower Lafourche and Terrebonne parishes devastating 4,000 homes of tribal citizens. In 2007, Hurricanes Gustav and Ike again inundated Lafourche and Terrebonne Parishes.

Following Hurricanes Katrina and Rita, the UHN mobilized to provide both immediate relief in the form of shelter, food, and necessities and long term rebuilding assistance to tribal citizens. These disaster preparedness and relief distribution systems were reactivated with Hurricanes Gustav and Ike. While the needs of individual citizens continue to be addressed, the tribe recognizes that the survival of historic UHN communities is at risk and to survive difficult decisions will be required.

The UHN has launched the Campaign for a Sustainable Houma Nation to galvanize support and resources for the work that lies ahead both within and outside the Houma community. In the near-term, the UHN has begun to develop an emergency response plan with the intent to be certified as a Community Emergency Response Team by the Department of Homeland Security, a Hazard Mitigation Plan which will provide the opportunity to compete for federal mitigation dollars pre and post disaster, and Memorandums of Understanding with neighboring tribes to support evacuation.

In terms of long-term adaptation to climate change, the tribal council is taking the first steps to provide an adaptation option to citizens. UHN is embarking on the development of a voluntary relocation strategy that is among the first for coastal communities in the United States to date. This option is built around the creation of new Houma communities, located far enough inland to reduce the risk from hurricanes and severe storms, and "hardened" community centers, located in the lower bayou communities to maintain regular ties to the people and places that constitute home. The UHN intend to identify new lands that maintain their connection to water while reducing their vulnerability to periodic and disaster-related flooding through non-structural and structural measures. Relocation timing, funding, level of participation, and mechanisms for land acquisition and assemblage are still being determined.

## Developing Policy for Adaptation to Climate Change at the Indonesian Local Government Levels

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The escalating big policy problem of climate change for Indonesia is to reduce the adverse impacts of climate change in the most effective ways and as quickly as possible because of the increasing trends, variability and extremes of climate related disasters and threats. This was acknowledged by Indonesia when it ratified the Kyoto Protocol, which also created a political and social necessity for Indonesia to adequately respond to climate change (IPCC 2007). If Indonesia does not develop effective and timely climate change adaptation policy, then "with most Indonesian people living in natural resource-dependent communities and about 30 per cent living in areas less than 10 metres above average sea level" Indonesia may face serious if not disastrous consequences for coastal human settlements with any escalation of climate change impacts. Much is needed to develop suitable policies for Indonesia for climate change adaptation, which lacks coordination, institutional capacity and human resources. This paper outlines the background and progress so far, and what is needed for policy development in key areas for Indonesia.

## Vulnerability Assessments as a platform for social learning

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Local councils are increasingly undertaking vulnerability assessments in order to anticipate and plan for the impacts from climate change. Case studies were undertaken of four vulnerability/risk assessments at the scale of local government conducted by the CSIRO, universities and/or consultants. The reviews were conducted through qualitative interviews with key informants who were asked questions around what aspects of the process worked, what didn't work and what knowledge or actions came out of the assessment. Learning's from this evaluation of processes and outcomes can be used to guide the design and implementation of future risk/ vulnerability assessments.

Cash et al (2003) identifies the three criteria of credibility, salience and legitimacy of the information produced by assessments as essential in linking knowledge and action. The credibility and salience of information produced by either consultants or researchers as the brokers of expert knowledge in assessment processes was essential for gaining buy-in on a project. However the reliance on experts risks a trade-off being made with the legitimacy of the process. Where information was produced external to the policy process it has the potential to disempower policy makers or practitioners by making them believe that the experts have it under control or that they couldn't add any value to the process.

A key theme that emerged from the case studies was the role played by 'social learning' in facilitating climate adaptation. Social learning can be defined as social processes among a group of people who seek to improve a common situation through shared understanding and collective action.

In all assessments the expected learnings did not always eventuate. In many of the organisations the outcomes were not as expected because many didn't know what they were getting or had expectations for a level of detail which wasn't delivered in the end. However, this did not necessarily lead to dissatisfaction with the process, because 'double loop' learning occurred whereby original assumptions were questioned. In reassessing what is credible, salient and legitimate the assessment process is able to better position itself to achieve long term outcomes. These outcomes are achieved because the assessment process catalyses ongoing engagement, enables stakeholders to see things differently, and demonstrates the need for not just assessments but broader adaptation planning.

The case studies show that vulnerability assessments can provide the platform or social arena in which social learning occurs. This occurs through an adaptive, iterative and ongoing process of revising and renegotiating outcomes amongst stakeholders who interact with new knowledge as it is introduced. Learning can occur either horizontally as information and strategic actions to achieve common goals are shared within and across institutions. Alternatively it can occur vertically at the boundary between science and policy.

The implications are that more research is needed into the potential for better facilitating social learning in vulnerability/ risk assessments through more careful consideration of diverse participants (experts, policy-makers, practitioners) and greater investment in the early stages of assessment design to recognise, facilitate and monitor learning activities.

## Using Value-at-Risk (VaR) to assess natural impacts on coastal Infrastructure under climate change scenarios

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Value-at-risk (VaR) (Jorion 2007) is a risk measure, frequently used in the financial sector, for communicating portfolio risk in terms of the loss of value due to variability, given a degree of confidence (e.g. 1% probability, or once in 100 counts). As time goes by, the VaR method has been further developed into a proactive tool for trading off risk and value of investment portfolios. This paper will present a case study in the Hornsby Shire area of using the VaR method to assess the impact (loss in \$ terms) of natural hazards on coastal infrastructure under climate change scenarios.

The VaR method consists of a portfolio mapping process. An infrastructure portfolio is breaking down into component groups, say, those built before World War 2, those built in or before 1975, and those after 1975. These portfolio components are characterised by their resistance to natural hazards according to the safety standards of the time. The value of each of these component is mapped on selected risk factors (e.g. flood height, wind speed, etc.) so that their respective component VaRs can be simulated or estimated.

In this research, we will be investigating the relationship between the total portfolio VaR, the component VaRs and their respective risk factors. Since the key risk factors rarely occur together, we assess the component VaRs in terms of the marginal distribution of the risk factors (i.e. varying only wind speed while holding other factors constant) rather than their joint distribution. The purpose is to quantify the overall climate change impact on coastal infrastructure in terms of key risk factors (e.g. higher flood, stronger wind, etc.)

The investigation will shed some light onto the possible increase of infrastructure portfolio loss due to

risk factors to be affected by climate change. The relationship may help us to trade off risk and value between various controls (e.g. reducing flood loss by increasing the building standard as flood is one of the most common hazards in Australia). This added knowledge will be beneficial to insurance industry and the government, who have the responsibility to fund the cost of redevelopment and recovery.

## Research on climate change adaptation selection in underdeveloped areas of northwest China

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Climate change is one of the most important environmental, social and economic problems that the world currently faces. Despite the increasing actions committed to greenhouse gas reduction, there are still a series of problems inevitable, such as drought, fire, as well as sea-level rise. Thus, human society have to adapt these impacts and changes in order to reduce the negative impacts of climate change to the minimum level, and to promote the coordinated development of natural ecosystem and human society. Taking the underdeveloped areas in northwest China for example, starting with the fragile ecological environment and huge socio-economic development demand, this paper analyses the potential impacts of climate change on underdeveloped areas in northwest China and its adaptation options, and provides some references for underdeveloped areas to develop future climate policy and participate in international and national climate change adaptation action.

## Developing ENSO-based irrigation water forecast system in a region with limited hydro-meteorological observations to mitigate the impacts of climate variability: a case study in Lombok, Indonesia

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Uncertainty in water supplies due to climate variability is the major constraint for sustainable production of irrigated agricultural system in many countries like Indonesia. In Lombok, Indonesia, the high year-to-year variability of streamflow is linked with the El Niño Southern Oscillation (ENSO) phenomenon, and forecasting streamflow based on ENSO ahead of growing season can potentially improve agricultural productivity through tactical decisions on water and cropping management. However, paucity of hydro-meteorological data limits this application as long-term (>50 years) data sets are required to produce statistically valid forecasts. The paper describes how an integrated modelling approach is developed to simulate long-term streamflow and water allocation from limited observed hydro-meteorological data, which enables forecasting the streamflow based on the Southern Oscillation Index (SOI).

First, the Integrated Quantity and Quality Model (IQQM) that can simulate daily streamflow and irrigation allocation up to 100 years was implemented to simulate the Lombok Irrigation System. The IQQM was configured by schematically representing 33 direct river/tributary inflows, 42 ungauged catchment inflows, 18 groundwater inflows, 86 effluent flows (transmission loss and effluent diversion) and 57 irrigation areas (weirs) covering total 65,000ha of irrigated land. Then the model was calibrated using limited observed daily flow data (1995-2000) and the calibration quality for each irrigation area/weir was assessed using a set of statistical indicators. The results have shown that the simulations of streamflows and diversions at 43 irrigation weirs in Lombok have achieved 'adequate' quality or better, indicating the adequacy for tactical decision purposes. However quality indicators for other 14 weirs were 'inadequate' or 'poor', meaning that cautions should be exercised when applying the IQQM simulation output in those weirs.

The IQQM simulation requires long-term daily sub-catchment inflows as inputs. The observed data in Lombok are generally of poor quality and of short length. In this study, WeatherMan which is a weather data disaggregation tool was used to extend the daily meteorological time-series data through disaggregating of historical monthly records. The generated daily time series were then used to drive the catchment rainfall-runoff model, IHACRES to extend the short-term observed sub-catchment inflows to the long-term daily time series datasets. The generated datasets were used to drive the calibrated IQQM to simulate the streamflow and irrigation allocation at irrigation weirs for the period of 1950 to 2000.

Finally the simulated long-term streamflow was associated with ENSO to forecast its variability within the study area. The results showed that the median flows in La Niña years were significantly higher than that during El Niño and ENSO-neutral years. For example, in one irrigation area (Majeli weir), the median available irrigation water in La Niña year is about 100 Gl more than that in an El Niño year which allows growing an additional 2500ha of rice crop (based on 40 Ml/ha/year). The information can therefore assist rice growers and water managers to make better decisions, which may potentially increase gross margin of agricultural production by 30% in the study area. (This research was funded by the Australian Centre for International Agricultural Research).

## Managing Climate Change Adaptation with Knowledge-based Risk Management Approach

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Companies are increasingly aware of the needs for adapting to climate change. Some of these companies recognize that adaptation is critical for business sustainability, while others see it as an opportunity for the introduction of innovative products into new markets. Although there are many discussions on the strategic importance of adaptation, there are few available tools that can support companies in the management of adaptation and mitigation processes at operational levels.

We attempt to address this issue by investigating tools and methods of integrating climate change adaptation and mitigation into the conventional business/project risk management process. Our approach is based on the use of a knowledge-based risk management tool. A modularized system architecture that consists of three main modules is being developed:

1. The identification module uses an underlying generic model of key climate change risk factors to heuristically and systematically assist project managers in the identification and quantification of relevant risk factors.
2. The assessment module uses outcomes of the identification module to customize the causal relationship (Bayesian Belief Network [BBN]) and relative significance (Analytic Hierarchy Process [AHP]) of the identified factors. This module evaluates and reprioritizes all identified risk factors based on the short term and long term costs and benefits analysis with calculated likelihood and consequences that are derived using the BBN and AHP models.
3. The action planning module uses a library of best practices and lessons learnt to assist managers in formulating the adaptation and mitigation action plans for each identified risk factor in risk registers.

This study was conducted using an existing software platform IRMAS (Intelligent Risk Mapping and Analysis System). This is a web-based risk management system that was developed and validated by the authors and their colleagues.

## ACRONYMS

ABARE	Australian Bureau of Agricultural and Resource Economics
ACF	Australian Conservation Foundation
ACIAR	Australian Centre for International Agricultural Research
ADFA	Australian Defence Force Academy
AIMS	Australian Institute of Marine Studies
AMCS	Australian Marine Conservation Society
AMPTO	Association of Marine Park Tourism operators
AMSA	Australian Marine Sciences Association
ANSTO	Australian Nuclear Science and Technology Organisation
ANZLIC	Australia and New Zealand Spatial Information Council
ANU	Australian National University
APS	Australian Public Service
ARC	Australian Research Council
BCAS	Bangladesh Centre for Advanced Studies
BoM	Bureau of Meteorology
BRS	Bureau of Rural Sciences
CARICOM	Caribbean Community
CGIAR	Consultative Group on International Agricultural Research
CoAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CRC	Cooperative Research Centre
DAFF	Department of Agriculture Fisheries and Forestry
DCCEE	Department of Climate Change and Energy Efficiency
DEHWA	Department of Environment, Water, Heritage and the Arts
EPBC	Environmental Protection and Biodiversity Conservation
FAO	Food and Agriculture Organization (United Nations)
FRDC	Fisheries Research and Development Corporation
GBRMPA	Great Barrier Reef Marine Park Authority
GCCC	Gold Coast City Council
GISS	Goddard Institute for Space Studies
IIED	International Institute of Environment and Development
IPCC	Intergovernmental Panel on Climate Change
IMOS	Integrated Marine Observing System
ICES	The International Council for the Exploration of the Sea
JCU	James Cook University
MDBC	Murray Darling Basin Commission
NARP	National Adaptation Research Plan
NCCARF	National Climate Change Adaptation Research Facility
NOAA	National Oceanic and Atmospheric Administration
NZCCRI	New Zealand Climate Change Research Institute
OECD	Organisation for Economic Cooperation and Development
QCCCE	Queensland Climate Change Centre of Excellence
RDC	Research and Development Corporation
SYKE	Finnish Environment Institute
SCU	Southern Cross University
SOPAC	South Pacific Applied Geoscience Commission
UKCIP	United Kingdom Climate Impacts Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
UNSW	University of New South Wales
USC	University of the Sunshine Coast
UQ	University of Queensland
VUT	Victorian Institute of Technology
WCRP	World Climate Research Programme
WHO	World Health Organisation
WRI	World Resources Institute

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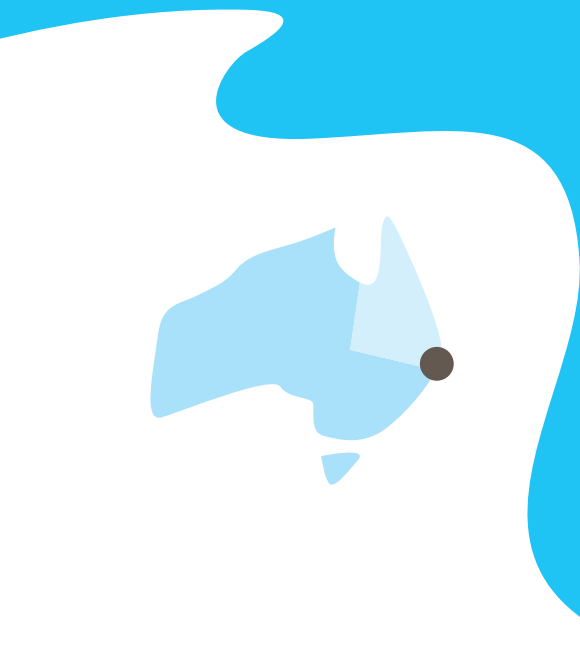
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