SPATIAL ENABLEMENT IN SUPPORT OF ECONOMIC DEVELOPMENT AND POVERTY REDUCTION

RESEARCH, DEVELOPMENT AND EDUCATION PERSPECTIVES

EDITED BY
HARLAN ONSRUD and ABBAS RAJABIFARD

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Spatial Enablement in Support of Economic Development and Poverty Reduction

Harlan Onsrud and Abbas Rajabifard (Editors)

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Foreword

This book is the result of a collaborative initiative between the Global Spatial Data Infrastructure Association (GSDI), the School of Computing and Information Science at the University of Maine, and the Centre for SDIs and Land Administration (CSDILA) in the Department of Infrastructure Engineering at the University of Melbourne. The articles featured in this peer-reviewed book were mostly the result of the traditional Call for Papers for the GSDI 14 Global Geospatial Conference "Spatial Enablement in Support of Economic Development and Poverty Reduction", but also contains contributions of full articles which were solicited for publication in this book.

The authors and reviewers were advised of the theme in advance and, in most cases, they addressed this theme in their papers. Even in cases where the theme was not directly referenced, the article reflected the impact and application of spatial data infrastructures that are now being developed worldwide. The peer-review process resulted in 15 chapters that when considered together, reflect how SDIs are enabling us all today, particularly in meeting the global challenges of poverty and sustainable economic development.

We thank the authors of the chapters and the members of the Peer Review Board. We are grateful to the GSDI Association Press for its willingness to publish this work under a Creative Common Attribution 3.0 License. It allows all to use the experiences and research presented in this book to their own best advantage. We would like to thank Dr Hamed Olfat, Ms Serene Ho and Ms Pamela Chew for their editorial assistance in preparation of this publication, as well as Mr Matthew Hamilton for the design of the cover.

Harlan Onsrud and Abbas Rajabifard (Editors)
GSDI Association

Peer Review Board

About Editors

Harlan Onsrud is a Professor of Spatial Information Science and Engineering in the School of Computing and Information Science at the University of Maine and a research scientist with the National Center for Geographic Information and Analysis (NCGIA). His research and teaching focuses on the analysis of legal, ethical, and institutional issues affecting the creation and use of digital databases and the assessment of the social and societal impacts of spatial and tracking technologies. He is past president and current Executive Director of the Global Spatial Data Infrastructure Association (GSDI), past-president of the University Consortium for Geographic Information Science (UCGIS), and past Chair of the U.S. National Committee (USNC) on Data for Science and Technology (CODATA) of the National Research Council. He has participated in several U.S. National Research Council studies related to spatial data and services and has been funded as a Fulbright Specialist in Law with assignments in Australia and Germany.

Abbas Rajabifard is a Professor of Geomatics Engineering, Head of Department of Infrastructure Engineering and Director of the Centre for SDIs and Land Administration at the University of Melbourne. He is Past President of the Global Spatial Data Infrastructure Association (GSDI) and a member of Victorian Spatial Council (VSC). He was Vice Chair, Spatially Enabled Government Working Group of the UN supported Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). He has authored/co-authored over 240 publications including 8 books. He has been also consulted widely on spatial data management, SDI, land administration and spatial enablement, to many national government agencies and ministries.

CHAPTER 8

Developing Spatial Information Sharing Strategies across Natural Resource Management Communities

Dev Raj Paudyal[1], Kevin McDougall[2] and Armando Apan[3]

[1] Faculty of Health, Engineering and Sciences, University of Southern Queensland, Queensland 4350, Australia

[2] School of Civil Engineering and Surveying, University of Southern Queensland, Queensland 4350, Australia

[3] Australian Centre for Sustainable Catchments, University of Southern Queensland, Queensland 4350, Australia

paudyal@usq.edu.au; mcdougak@usq.edu.au; apana@usq.edu.au

Abstract

Spatial information plays an important role in many social, environmental, economic and political decisions and is increasingly acknowledged as a national resource essential for wider societal benefits. Natural Resource Management (NRM) is one area where spatial information can be used for improved planning and decision-making. Traditionally, national mapping agencies and government organizations have been the main spatial data providers for the natural resource management sector. Recent developments in spatial and information communication technology have provided a new opportunity for the NRM community to collect and manage spatial information. With this new environment, the access and sharing of spatial information between NRM communities and government agencies is emerging as an important issue. The aim of this chapter is to identify the key factors which influence spatial information sharing between state government organizations and regional NRM bodies/catchment management authorities in Australia and formulate strategies to facilitate spatial information sharing and hence support spatial enablement initiatives. A mixed method research approach was utilized to collect both quantitative and qualitative data from regional NRM bodies. A questionnaire survey conducted across 56 regional NRM

bodies provided the current status of spatial information access and sharing and explored the SDI development activities in the NRM sector in Australia. A detailed case study explored the effectiveness of spatial information and knowledge-sharing arrangements between regional NRM bodies and state government organizations. Using the mixed method design framework, the key factors which influence spatial information sharing between state government organizations and regional NRM bodies/catchment management authorities were identified and classified into six major classes as governance, economic, policy, legal, cultural and technical. The study suggests that the adoption and implementation of strategies can facilitate spatial information sharing and hence advancing spatially enabled communities across the NRM sector.

KEYWORDS: Spatial data infrastructure, spatial information sharing, natural resource management, catchment management, spatial enablement

1. Introduction

The issues related to climate change, urbanization, land use change, environmental degradation and sustainable development, are of global concern. For environmental sustainability and sustainable development, many initiatives have been undertaken which range from global to local scales including the Brundtland Report (1987), UN Rio Earth Summit-Agenda 21 (1992), Bogor Declaration (1996), Bathurst Declaration (1999), Millennium Development Goals (2000), Johannesburg World Summit (2002) (Dalrymple, 2005). According to Brundtland Report (United Nations, 1987), sustainable development means "meeting the needs of the present without compromising the needs of the future". The three dimensions of sustainable development include the economic, environmental and social dimensions which form the "triple bottom line" (Williamson *et al*., 2010). Sustainable development requires meaningful dialog between the economic, environmental and social aspects of life (Ting, 2002) and strong frameworks are required by which land and natural resources can be effectively managed. Reliable information infrastructure is needed to record the environmental, social and economic dimensions of natural resource management and to support appropriate decision making and conflict resolution (Paudyal *et al*., 2009).

Within the information infrastructure, spatial information may be considered a special type of information and is increasingly acknowledged as a national resource essential for sustainable development (Warnest, 2005). This speciality has resulted in the emergence of spatial data infrastructures (SDI) as part of, or independent of, information infrastructures (Van Loenen, 2006). SDIs are about the facilitation and coordination of the exchange and sharing of spatial data between stakeholders in the spatial data community. An SDI is a network-based solution which can provide convenient, consistent, and effective access to geographic information and services to improve decision-making in the real world in which we live and interact (Onsrud, 2011). The ultimate objectives of these initiatives, as summarized by Masser (1998),

are to promote economic development, to stimulate better government and to foster environmental sustainability. The principal objective of SDIs is to facilitate access to the geographic information assets that are held by a wide range of stakeholders with a view to maximizing their overall usage (Masser, 2011).

The spatial information sharing will increase the benefits to society through the reduction of duplication of effort in collecting and maintaining of spatial data. Further, the exposure of these data to a wider community of users may also result in improvements in the quality of the data. The sharing of spatial data is critical to the development of comprehensive and inclusive SDIs (McDougall, 2006). However, the sharing of spatial data between jurisdictions, and hence SDI development, continues to be problematic. Therefore, it is necessary to identify the key factors which influence spatial information sharing between organizations.

This chapter focuses on understanding the current mechanisms of spatial information sharing amongst regional NRM bodies/catchment management authorities (CMAs) and state government organizations for sustainable catchment management outcomes. Further, it identifies key factors which influence spatial information sharing between state government organizations and regional NRM bodies/CMAs within Australia, and formulates appropriate strategies to facilitate spatial information sharing and hence support SDI development**.**

2. Background

2.1 Catchment Management for Sustainable Development

Catchment management refers to the practice of managing natural resources using river catchment systems as the unit of management (Commonwealth of Australia, 2000). It involves integrating and managing ecological, economic and social aspects of land, water and biodiversity resources around an identified catchment system. Catchment management issues are characterized by multiple stakeholders and multiple goals which cut across traditional as well as administrative boundaries (Love *et al*., 2006). Catchment management requires an integrated management approach as different institutions and individuals need to work together towards sustainable catchment outcomes (Paudyal and McDougall, 2008). From theme perspectives, catchment management is about management of land, water, biodiversity, coast and marine theme (Paudyal *et al*., 2012). The term catchment management and watershed management are used interchangeably. In USA and Canada, the term watershed management is used, however in Australia and UK, the term catchment management is more widely accepted. Catchment management strategies need to support initiatives aimed at meeting the demands of our changing world particularly to serve sustainable development in the broader sense through environmental management. The four pillars of sustainable development are economic development, environmental management, social justice and good governance (Rajabifard *et al*., 2011).

2.2 Spatial Information for Natural Resource Management

Spatial information (also known as geographic information) is any information that can be geographically referenced, i.e. describing a location, or any information that can be linked to a location (ANZLIC, 2010). Spatial information is a key and integral component for the delivery of good governance, promoting efficiency in business and supporting sustainable development. It provides an enabling framework for modern societies and is recognized as fundamental for wealth creation and good decision making. As a result, policy makers and managers have begun to realize the value of spatial data to their business. They consider spatial data as a resource and also a part of fundamental infrastructure that needs to be coordinated and managed effectively (Ryttersgaard, 2001). Spatial information underpins decision-making for many disciplines (Clinton, 1994; Gore, 1998; Rajabifard *et al*., 2003) including natural resource management. Reliable, up to date and easy accessible spatial information is needed to support appropriate decision making and conflict resolution. Traditionally, government organizations and mapping agencies were the custodians of spatial information necessary for the catchment management whilst NRM community bodies were just the users of spatial information (Paudyal *et al*., 2011). The easily accessible and available spatial technologies and products like Google Earth, handheld navigation systems, Web 2.0 technologies, and social media can provide natural resource management communities with access to spatial data. However, with different organizations under different jurisdictions working towards natural resource management, the access, use and sharing of spatial information to support multi-stakeholder decision-making processes and policy development continues to be problematic.

2.3 Spatial Information Sharing: Research Gap

Calkins and Weatherbe (1995) defined spatial data sharing as "the (normally) electronic transfer of spatial data/information between two or more organizational units where there is independence between the holder of the data and the prospective user." Omran (2007) defined it as "those transactions in which individuals, organizations or parts of organizations obtain access from other individuals, organizations or parts of organizations to spatial data." McDougall (2006) clarified that the term "transaction" could be routine or non-routine, may be internal or external to the organization, but importantly it is an "arm's-length exchange or transfer."

Bregt (2011) reviewed the book "Building European Spatial Data Infrastructures" by Ian Masser (2010) and advised that the narrative anchor for SDI is "sharing spatial data". Spatial data sharing is recognized as one of the important components in spatial data infrastructure design and development. There are many studies done by scholars for sharing spatial data (Kevany, 1995; McDougall, 2006; Omran, 2007; Onsrud and Rushton, 1995; Warnest, 2005; Wehn de Montalvo, 2003), however, the studies were mainly based on the spatial data provider's point of view and do not recognize the power of spatial data users. Due to the advent of spatial technology and spatial

awareness, spatial information users are becoming more important for the spatial data infrastructure design and development and hence it is necessary to look from the users' perspectives.

Despite all these benefits, spatial data sharing is easier to advocate than to practice (Azad and Wiggins, 1995). There are many issues that hinder sharing spatial information between organizations. The issues can be categorized into organizational/institutional issues, technical and technological issues, economic issues, legal considerations and political issues (McDougall, 2006). McDougall (2006) undertook a critical analysis of the spatial information issues through a literature study and concluded that the growing importance of Internet connectivity, resourcing, trust and institutional frameworks (particularly policy), are key issues.

There has been limited previous research on spatial data infrastructure and data sharing in catchment management.

2.4 Motivations and Barriers for Spatial Information Sharing

The issues that impact on the sharing of spatial information are broad-ranging and include organizational/institutional issues, technical and technological issues, economic factors, legal considerations and political issues (McDougall, 2006). Nedovic-Budic and Pinto (2000) identified two factors that shape the processes involved in data-sharing activities and their outcomes: motivations for engaging in data sharing activities, and structural characteristics of the interaction mechanisms implemented by the data-sharing entities. Many researchers (Harvey, 2001; Harvey and Tulloch, 2006b; McDougall, 2006; Nedovic-Budic and Pinto, 2000; Nedovic-Budic *et al*., 2011; Omran, 2007; Onsrud and Rushton, 1995; Sebake and Coetzee, 2013; Wehn de Montalvo, 2003) tried to understand the spatial data-sharing issues and the benefits and constraints in spatial data sharing. McDougall (2006) categorized these issues into barriers (constraints) and the benefits (which will motivate). Table 1 summarizes the motivators and barriers for spatial data sharing (i.e. why organizations may or may not engage in spatial data sharing). These motivators and barriers for spatial information sharing were determined through the literature review.

Motivators
Cost saving through lack of duplication of data collection and maintenance efforts
Improved data availability and quality
Enhanced organizational relationships through promotion of cross organizational relationships
Reduction in risk if organizations are prepared to contribute to the costs or development time for a shared initiative
High returns on investment
Improved user satisfaction
Barriers
Cost recovery, copyrights and legal liability
Priorities of the organization, organizational disincentives and lack of support from management
Trust and unequal commitment from organizations
Insufficient staff, staff turnover and lack of technical resources
Networking costs; data confidentiality, liability and pricing
Differences in data quality
Lack of common data definitions, format and models
Conflicting priorities
Lack of leadership and coordination mechanism
Cultural (political and institutional)
Power disparities and differing risk perception

Table 1. Motivators and barriers for spatial information sharing (after Sebake and Coetzee, 2013)

2.5 Spatial Information Sharing Components

Various frameworks and components on data sharing are found in the literature. Amongst them are a generic model of the Mapping Science Committee of the National Research Council (National Research Council, 1993), taxonomy for research into spatial data sharing (Calkins and Weatherbe, 1995), antecedents and consequences of information sharing (Pinto and Onsrud, 1995), factors relevant to GIS data sharing (Kevany, 1995), a typology of six determinants of inter-organizational relationships (Oliver, 1990), typology based on inter-organizational relations and dynamics (Azad and Wiggins, 1995), an organizational data-sharing framework (Nedovic-Budic and Pinto, 1999) a model of willingness based on theory of planned behavior (Wehn de Montalvo, 2003), interaction between organizational behavior of spatial data sharing and social and cultural aspects (Omran, 2007), a collaboration model for national spatial data infrastructure (Warnest, 2005), local government data sharing (Harvey and Tulloch, 2006a; Tulloch and Harvey, 2008), the local-state data sharing partnership model (McDougall, 2006) and Geospatial one-stop (Goodchild *et al*., 2007). Most of these frameworks were based on the authors' experiences and have not been proven empirically except for Nedovic-Budic and Pinto's (1999), Wehn de Montalvo's (2003) Harvey and Tulloch's (2006a) and McDougall's (2006).

Australian Government Information Management Office (2009) has proposed some nine conditions for information sharing. They include provision of leadership, demonstrate value, act collaboratively, establish clear governance, establish custodianship guidelines, build for interoperability, use standards-based information, promote information re-use and ensure privacy and security. Pinto and Onsrud (1995) argued the factors to facilitate spatial information sharing between two or more GIS using organizations are superordinate goals, bureaucratization rules and procedures, incentives, accessibility, quality of relationships and resource scarcity. They demonstrated how these antecedent variables influenced the efficiency, effectiveness and enhanced decision-making ability of organization. This approach is based on organizational theory. The Office of the Director of National Intelligence (2008) has proposed a range of issues for information sharing that span governance, policy, technology, culture, and economic facets. Based on these three literatures five areas and their attributes are identified for spatial information sharing through collaborative networks. Table 2 describes these five key areas and their main attributes for spatial information sharing to improve NRM planning and decision-making process.

Components	**Attributes**
Governance (Sharing environment)	mission, goal, objectives, stakeholders (data producers and users), leadership, custodianship, roles and responsibilities, rights and restrictions, governance methods
Policy (Rules for sharing)	laws, rules and regulations, policies and procedures, protocols, accessibility, privacy, liability, copyrights, IPRs
Technology (Capacity to enable sharing)	data model, standards, software, security, tools/mechanism, data quality, metadata, resource, interoperability
Culture (Willingness to share)	trust, motivation, communication, adaptation during circumstances changes, reciprocity, relationship
Economics (Value of sharing)	funding, incentives, pricing, cost recovery, transaction cost

Table 2. Spatial information sharing components (Paudyal *et al*., 2010)

3. Methodology

3.1 Study Area Description

As catchment management issues are characterized by multiple stakeholders and multi-level governance cutting across traditional as well as administrative boundaries, the Australian case has been considered suitable for this study. Catchment management arrangements in Australia are implemented through the partnerships of government, community groups, private sector and academia. Under the Australian Constitution, the States are responsible for land and water management within their boundaries (Marshall, 2001). All states/territories have some form of catchment management authorities or natural resource management groups under their jurisdiction. There are both top-down and bottom-up approaches exist for catchment

management. Government organizations are leading from a top-down approach and the activities of regional NRM bodies /community organizations are bottom-up.

Regional NRM bodies/catchment management authorities (CMAs) have been established to address complex catchment management issues that involve many community groups and government agencies. There are 56 regional NRM bodies which are responsible for catchment management in Australia. The regional NRM bodies vary in their name, corporate structure, catchment management philosophy, and relationship to the state government organization. They are termed catchment management authorities in New South Wales and Victoria, catchment councils in Western Australia, NRM boards in South Australia, regional NRM groups in Queensland and Regional committees in Tasmania. CMAs comprise representatives of the major sectors of the community and government which are involved in, or influenced by, the management of land and water resources in the catchment. Their major role is to provide a forum for community input and discussion, prioritize the issues, and develop and promote the adoption of catchment management strategies. Figure 1 shows the location of case study area and boundary of 56 NRM regions.

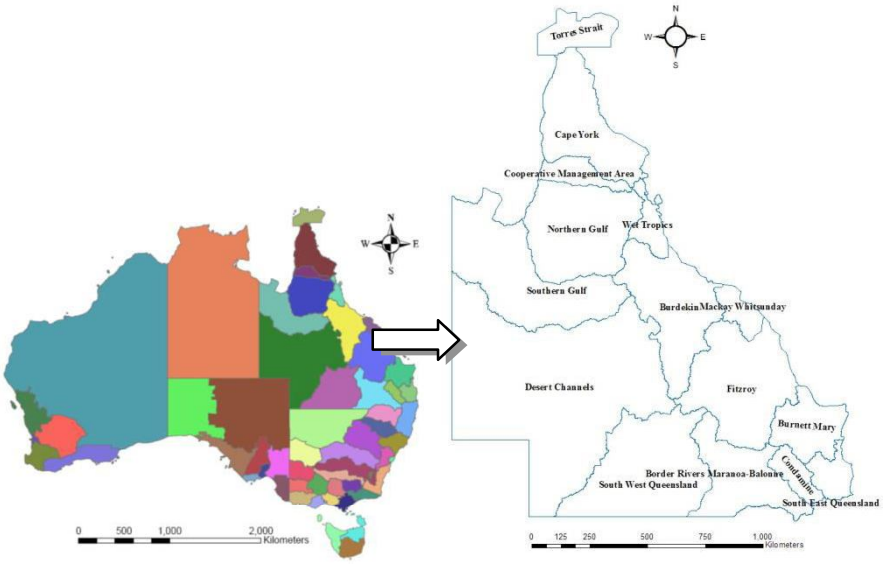

Figure 1. Location map of study areas

3.2 Research Method

This research has utilized mixed method strategy which involves collecting and analyzing both qualitative and quantitative data in a research study and mixing them. It has been argued by a number of researchers that the selection and use of appropriate data collection and analysis techniques are very important to the success of research (de Vaus, 2001; Marshall, 2006; Yin, 2009). Survey and case study were

considered to be the most appropriate method for data collection and analysis. The survey and case study data were collected and analyzed sequentially. Using the mixed method design framework as suggested by Creswell and Plano Clark (2011), the key factors which influence spatial information sharing between state government organizations and regional NRM bodies/catchment management authorities were identified and classified into six major classes as governance, economic, policy, legal, cultural and technical.

The survey was conducted with all 56 regional NRM bodies responsible for catchment management in Australia. The survey was undertaken from 15 June 2010 to 9 September 2010. A total of 56 valid responses were received to the online questionnaire giving an overall response rate of 100%. The questionnaire survey was distributed in two stages. Initially, the questionnaires were distributed to regional NRM bodies which belong to the Murray Darling Basin Authority (MDBA) and later to the remaining NRM bodies around Australia. The feedback and experience from the first distribution assisted in the second stage of the survey and assisted in achieving the high response rate. The online questionnaire was designed such that the data from questionnaire was automatically collected into an Excel spread sheet via a Web server. The raw data were reviewed and cleaned up before inputting into the statistical software. The statistical analysis was performed using SPSS statistics package. The profile of respondents is tabulated in Figure 2, with the largest group of respondents being GIS officers, with other respondents including staff who were directly or indirectly involved with spatial information management or the GIS operations of that regional NRM body. The majority of respondents were full-time staff.

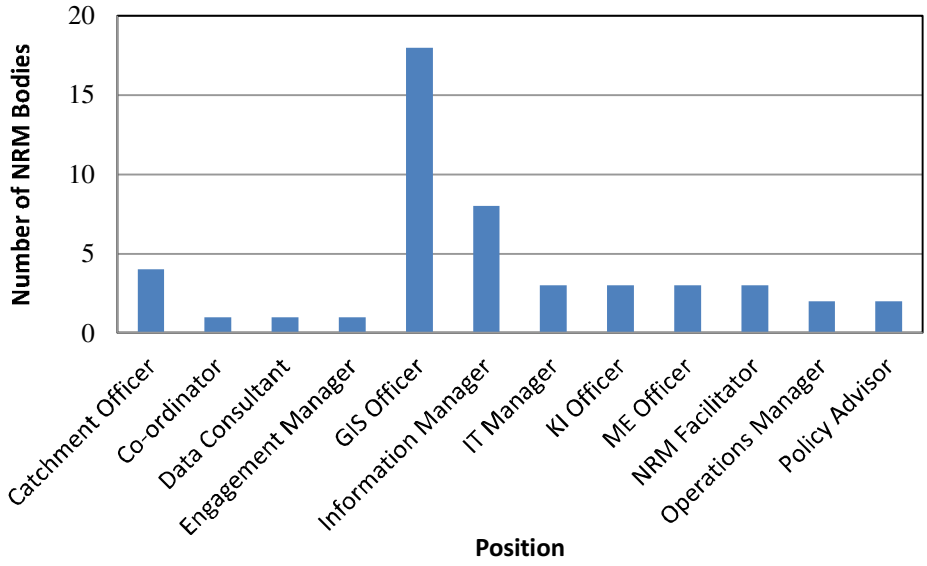

Figure 2. Profile of respondent (by position)

The case study approach was considered to be the most suitable approach for developing a deeper understanding about the motivation factors and constraints for spatial information sharing between regional NRM bodies and state government organizations, and confirm the issues related to spatial information management which were identified during the survey. The Knowledge and Information Network (KIN) project in Queensland was selected as a representative case to investigate spatial information and knowledge sharing process for catchment management. Queensland has 14 regional natural resource management (NRM) bodies and 74 local authorities spread from the far-northern region of Torres Strait to the New South Wales (NSW) border at southern end. These groups develop regional NRM plans and deliver sustainable catchment outcomes at grass-roots level.

The aim of case study was to determine the motivation factors and constraints for collaborating in the KIN project. Semi-structured interviews with all 14 regional NRM bodies, state government representatives and Queensland Regional NRM Groups Collective (RGC) were undertaken. The staff who were experienced in spatial and knowledge management activities were targeted for interview. A total of 15 staff from regional NRM bodies, two staff from RGC and three staff (both executive level and operational level staff) from state government agencies were interviewed. The responses were transcribed, analyzed and the main factors were determined.

4. Results

4.1 Results from Survey

4.1.1 Catchment Management Issues and Role of Spatial Information

There are disparities among regional NRM bodies regarding the catchment management issues on which they focus. However, we tried to explore the main catchment issues at national scale. Table 3 shows the top ten catchment management issues at the national level in Australia. The highest priorities include healthy habitat & biodiversity conservation, pest animal & weed management, community capacity building & indigenous engagement, disaster management, and water resource management. The grazing land & property management and Aboriginal NRM & cultural heritage are the less focused issue at national scale. This finding may assist federal and state government organizations for prioritizing funding and planning.

Rank	Catchment Management Issues	Frequency
1	Healthy Habitat and Biodiversity Conservation	38
2	Pest Animal and Weed Management	29
3	Community Capacity Building and Indigenous Engagement	27
4	Disaster Management (Fire Mapping, Floodplain, Land erosion, etc)	24
5	Water Resource Management	23
6	Land Use Planning and Soil Conservation	19
7	Climate Change	7
8	Coastal and Marine Management (estuarine and near shore)	5
9	Grazing Land and Property Management	4
10	Aboriginal NRM and Cultural Heritage	3

Table 3. Main catchment management issues

When asked to identify the role that spatial information can play in addressing the catchment management issues listed in Table 3, it was interesting to observe that approximately 60% of the regional NRM bodies responded that spatial information can play a very significant role, with the remaining 40% of the organizations responding that it can play a significant role. Not a single organization responded that it was not aware of the role of spatial information in addressing catchment management issues. This response indicates the importance of spatial information in supporting better catchment outcomes at the regional level (catchment level).

4.1.2 Spatial Data Providers and Identification of Spatial Information Requirement

The main spatial information providers to regional NRM bodies are the state government organizations. The majority (86%) of regional NRM bodies rated state government organizations as of high importance, whilst only 28% of regional NRM bodies rated commonwealth government organizations (e.g. Geoscience Australia, Bureau of Rural Sciences, etc) as of high importance. Local government organizations and private industries were identified as being of limited importance as a source of data. As spatial information is a critical component for improved catchment decision, the identification of the spatial information requirements is fundamental. Table 4 ranks the importance of spatial information for catchment management activities as identified by the NRM bodies.

Rank	Spatial information
1	Vegetation data
2	Cadastral data
3	Watershed/catchment boundary data
4	Land use/land cover data
5	Topography data
6	Aerial Photography and DEM
7	Satellite Imagery and LIDAR
8	Administrative boundary data
9	Infrastructure and utilities data (building, transportation etc)
10	Locally gathered data (GPS mainly) and Landholder data
11	Spatial project specific data
12	Geology and soil data
13	Open source data (Google Maps, OpenStreetMap, WikiMapia etc)
14	Mineral resources

Table 4. Spatial information needs for catchment management

Table 4 identifies that vegetation, cadastral and catchment boundary/watershed boundary, and land use/land cover data are the highest priority spatial data for catchment decisions. The regional NRM bodies were less concerned with geology and soil data, open source data or mineral resources data.

4.1.3 Spatial Information Sharing, Collaboration and Networking

The collaborative arrangements of regional NRM bodies with other organizations with respect to the exchange of resources, skills and technology were examined. The majority (83%) of the regional NRM bodies advised that they have a collaborative arrangement with other organizations. After investigation, it was found that data sharing and spatial information management were the main areas of collaboration. However, it was identified that the majority of regional NRM bodies had a silo approach to the spatial information management which did not encourage to spatial information sharing. The next most important area of collaboration was knowledge transfer (as illustrated in Figure 3).

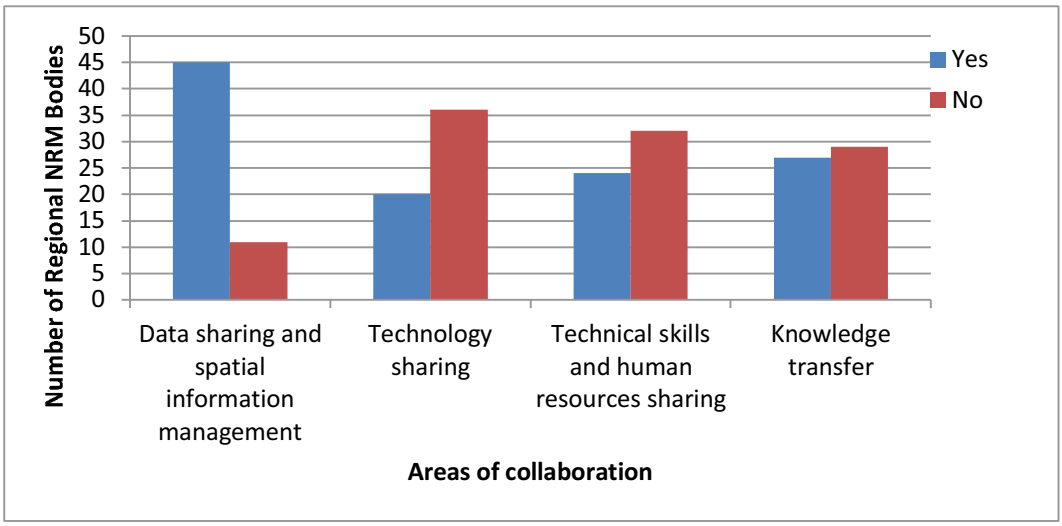

Figure 3. Areas of Collaboration

The main partners for these collaboration and networking activities were state government organizations with community organizations, including other regional NRM bodies, the next most common.

Spatial information sharing factors were identified and their importance in facilitating information sharing with other organizations was examined. Having a formal agreement, organizational attitude to sharing, individual attitude, ability and willingness to share, and leadership were found most important. Table 5 lists the spatial information sharing factors and their importance as rated by regional NRM bodies.

Spatial Information Sharing Factors	Importance
Formal agreement	Very High
Organizational attitude to sharing	Very high
Individual attitude, ability and willingness	Very High
Leadership	Very High
Networking and contacts	High
IT system and technical tools	High

Table 5. Spatial information sharing factors and their importance

4.1.4 Key Factors that Influence Data Sharing across Natural Resource Management Areas

A total of 21 factors were identified and classified into five broad groups: sharing environment (governance), rules for sharing (policy), capacity to enable sharing

(technology), willingness to share (culture) and value of sharing (economic). The five broad groups were identified during literature review (Section 2.5). The factors which were rated above 70% importance were classified as high, 50-70% are medium and less than 50% are low. The factors are shown in Table 6. The factors indicating the spatial capacity of the organization, spatial information policies and data sharing arrangements, spatial data requirements, access mechanisms, collaborative arrangements and willingness to provide data were the main factors which impacted on spatial information sharing between the regional NRM bodies and government agencies. The sharing environment, rules for sharing and willingness to share were the most important conditions for spatial information sharing.

Individual Factors	Conditions for sharing	Importance
Organization type	Sharing environment (Governance)	High
Spatial information use by staff	Sharing environment (Governance)	High
GIS maturity	Sharing environment (Governance)	High
Organizational capacity	Sharing environment (Governance)	High
Volunteer activities	Willingness to share (Cultural)	Low
Scale of spatial data	Sharing environment (Governance)	Low
Spatial information policy	Rules for sharing (Policy)	High
Funding sources	Value of sharing (Economic)	Medium
Spatial data requirements	Value of sharing (Economic)	High
Spatial data access medium	Rules for sharing (Policy)	Medium
Importance of spatial data providers	Sharing environment (Governance)	High
Ease of access to spatial data	Rules for sharing (Policy)	High
Frequency of supply	Capacity to enable sharing (Technical)	Low
Spatial data receiving medium	Capacity to enable sharing (Technical)	Medium
Restrictions on spatial data	Rules for sharing (Policy)	Medium
Integration issues	Capacity to enable sharing (Technical)	Low
Pricing of spatial data	Value of sharing (Economic)	Low
Collaborative arrangements	Sharing environment (Governance)	High
Data sharing agreement	Rules for sharing (Policy)	High
Social media, Web 2.0 technology	Capacity to enable sharing (Technical)	Medium
Willingness to provide spatial data	Willingness to share (Cultural)	High

Table 6. Factors that influence spatial information sharing

4.2 Results from Case Study

4.2.1 Motivational Factors for Collaborating and Data Sharing

The motivational factors for collaborating in the KIN project were determined through a semi-structured interview with all 14 regional NRM bodies, state government representatives and Queensland Regional NRM Groups Collective (RGC).

The motivation for collaborating in the KIN project was to better organize information and knowledge, to reduce cost, avoid duplication, and to enhance better collaboration and networking. However, the motivational factors varied between stakeholders. Basically, three types of organizations were involved in the KIN project and the motivations for these organizations are shown in Table 7.

Motivational Factors	
Regional NRM Bodies	State-wide project
	To enhance collaboration and networking
	To better organize knowledge and information
	To create an improved information portal
	To reduce cost, avoid duplication and optimize the use of resources
State Government Organization	To maximize the use of spatial information
	To improve collaboration and networking
	To achieve better regional NRM outcomes
Regional NRM Groups Collective	To avoid duplication
	To reduce cost and resources
	To encourage collaboration and networking
	The project was aligned with the organizational mandate and strategic goal

Table 7. Motivation factors for collaborating and data sharing

The main motivational factors for collaborating in the KIN project were to organize information and knowledge better, to reduce cost, avoid duplication, and to enhance better collaboration and networking. These motivational factors are also supported by previous research (Harvey, 2001; Harvey and Tulloch, 2006; McDougall, 2006; Nedovic-Budic and Pinto, 2000; Nedovic-Budic *et al.,* 2011; Omran, 2007; Onsrud and Rushton, 1995; Wehn de Montalvo, 2003).

4.2.2 Constraints Managing KIN Project and Spatial Information Sharing

There were a number of constraints in managing the KIN project and the spatial information sharing. The constraints were categorized into five broad areas as policy issues, organizational/governance issues, cultural issues, economic issues and

technical issues. The main organizational issues included concern about losing authority, and data sharing not being an organizational priority. The policy issues included the lack of spatial policy, pricing issues, and the lack of policies to return the data to the state repository. The legal issues included the licensing arrangements and privacy/confidentiality. The continuity of funding and incentives for sharing were identified as the key economic issues, whilst lack of trust and confidentiality were identified as cultural issues. Finally, lack of metadata and no single gateway to access spatial data were the main technical issues. From case study, it has been identified that the non-technical issues such as policy, governance, cultural and economic issues were found to be more significant for the success of the KIN project in comparison with the technical issues. The constraints managing KIN project are shown in Table 8.

Constraints	
No state government policy to include the spatial information back to the state repository	Policy
Spatial data has different scales, contents, qualities and standards and does not match with state government standards	Policy
Access policy, pricing and licensing arrangements	Policy
Lack of common standards or specification during data collection	Technical
National standard developed by Geoscience Australia is not suitable for catchment level data	Technical
Lack of single gateway to access NRM related spatial information	Technical
Data integration difficulties	Technical
People in state government organizations concerned about lose their power and control	Governance
Privacy issue with landholders' information	Cultural
Lack of trust and fear of data misuse	Cultural
Funding	Economic

Table 8. Constraints managing KIN Project and spatial information sharing

The KIN study identified the importance of improving the institutional and cultural component of the data sharing mechanism.

4.3 Integration of Survey and Case Study Results

This research followed the embedded mixed method design. In the embedded mixed method design, different datasets are connected within the methodology framed by other datasets at design phase to help in interpretation of the results (Creswell and Plano Clark, 2011). The case study results provided a supportive role and enhanced the findings from the national survey. A summary of the spatial information sharing issues identified during the survey and case study are presented in Table 9. Table 2 was used to classify the factors into five broad groups. The factors which were identified during survey or case study were indicated by (√).

Spatial Information Sharing Factors	Survey	Case study	Factor's group/Class
Organization type	√		Governance
Spatial information use by staff	√		Governance
GIS maturity	√		Governance
Organizational capacity	√		Governance
Spatial information policy	√	√	Policy
Data custodianship	√	√	Governance
Funding	√	√	Economic
Incentives	√	√	Economic
Spatial data requirements	√		Governance
Spatial information access medium	√		Technical
Importance of spatial information providers	√		Governance
Ease of access spatial information	√		Policy
Spatial information receiving medium	√		Technical
Restrictions on spatial information	√		Legal
Collaborative arrangements	√	√	Governance
Data sharing agreement		√	Legal
Licensing		√	Legal
Social media, web 2.0/3.0 technology	√	√	Technical
Willingness to provide spatial data	√	√	Governance
Trust		√	Cultural
Willingness to share spatial data	√	√	Cultural
Data integration	√	√	Technical
Data portal	√		Technical
Networking/contact	√	√	Governance
Leadership/champion	√		Governance

Table 9. Factors that influence spatial information sharing

4.4 Relationship between NRM Sectors and Identified Factors

The common findings from survey and case study were interpreted and the conditions which influence data sharing across catchment were categorized into six groups, namely governance (sharing environment), policy (rules for sharing), technical (capacity to enable sharing), cultural (will to share), legal and economic (value of sharing). The governance, policy/legal, cultural and economic factors were the most important conditions for spatial information sharing. The technological capacity to share spatial information was available, however, the governance, policy, cultural and economic issues need to be addressed to improve spatial information sharing. This

research identified that non-technical factors were more important than technical factors, which was also supported by previous research (de Man, 2011; McDougall, 2006; Mohammadi, 2008; Nedovic-Budic and Pinto, 2000).

The six main governance factors that influence the spatial information sharing between regional NRM bodies and state government organizations include leadership/champion, collaboration arrangement, organizational capacity, networking/contact, organizational mandate and willingness to provide spatial data. Spatial information policy, data custodianship and ease of access were the three main policy factors. There were no or limited policies/guidelines in regional NRM bodies to manage spatial information. Specifically, there was no policy to return the spatial information collected by regional NRM bodies to the state repositories or to utilize that spatial information for updating statewide NRM databases. Spatial information sharing was not considered a part of the organizational mandate and was always considered a lower priority. The continuity of funding and incentives for spatial information sharing activities were the two main economic factors, whilst the data sharing agreements, licensing and restrictions were identified as the legal factors. Regional NRM bodies were used to multiple licensing arrangements with state government organizations and showed interest in sharing data under the Creative Commons Framework. Trust, willingness to share and attitude were cultural factors. The landholders' data contained information that was considered private and they feared that the information could be used against them by government. The data portal, standards and data integration and the lack of a single gateway to access NRM related spatial information, were identified as technical factors.

5. Developing Spatial Information Sharing Strategies

The strategies were developed to address the spatial information sharing factors. The adoption and implementation of these strategies can assist to improve spatial data sharing. Further, these strategies can accelerate the progress in the development of catchment SDI initiatives. Each strategy has been presented in Figure 4 and discussed in more detail below.

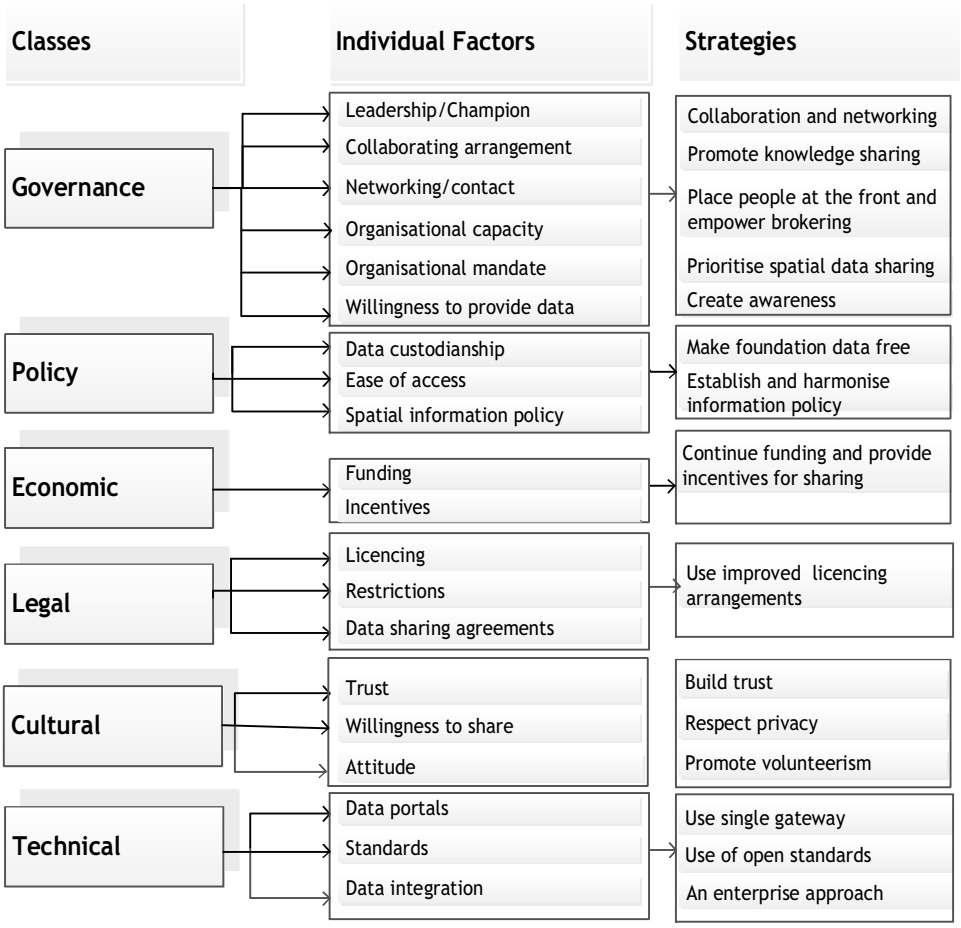

Figure 4. Spatial information sharing strategies

5.1 Collaboration and Networking

Collaboration and networking was identified as an important strategy to improve spatial information sharing. A particular issue that was identified was the poor relationship between regional NRM bodies and state government organizations in the provision of data. Various regional collaboration and networking activities already exist for natural resource management and lessons from their development can be gleaned and transplanted for spatial information sharing.

5.2 Promote knowledge sharing

Knowledge sharing is one activity where community organizations such as Landcare, Watercare, Bushcare, and Coastcare are achieving better natural resource management outcomes. The current focus of regional NRM bodies is for spatial data

and information sharing. The raw spatial data can be translated into meaningful knowledge resources for the wider benefits of society using spatial technology and web tools. Therefore, knowledge sharing is an emerging area to be considered when developing spatial data infrastructure (SDI).

5.3 Place people at the front and empower brokering

There are many technical solutions in place and it was found that a technology-based approach was not likely to make a significant difference for spatial information access and sharing. The real need was to place people at the front. The people part of SDI was found to be critical for sharing spatial information. It was found from the case study that the role of the classic librarian should be formalized and placed at the front within the institutional framework either as a knowledge broker or a focal person. The role of librarian will provide both energy and focus to enable better cataloging, indexing, interpretation and publication of NRM information. It was also found from the case study that the function of the librarian should not be housed in any regional NRM body but should be independent.

5.4 Prioritize Spatial Data Sharing as an Organizational Activity

Spatial information sharing is not an organizational mandate for regional NRM bodies. The organizational mandate should be revised and spatial data sharing should be included as a priority area.

5.5 Create Awareness

There is a need to create awareness regarding spatial data sharing. Awareness is not simply the knowledge about spatial information sharing benefits; it also involves the appreciation, recognition and engagement of regional NRM bodies and other community organizations for spatial information management. The organizational attitudes and individual willingness to share data can be improved through improved awareness.

5.6 Make Foundation Data Free

There is growing pressure for state government organizations to make foundation data free. Seventy five per cent of regional NRM bodies argue that foundation data should be made free as it is a public good and paid for by the public through their taxes. This will also maximize the use of spatial information. Additionally, private organizations such as Google Earth and OpenStreetMaps have already placed their spatial products free in the market place. In this competitive market, there is pressure on state government organizations and mapping agencies to make foundation data free. The Commonwealth Government and the Victorian Government have already recognized the benefits of improved access and availability of public sector information (PSI). The

findings from case study showed that making foundation data free will also encourage regional NRM bodies to utilize foundation data and to better organize their data.

5.7 Establish and Harmonize Information Policy

It was found that there was a lack of information policy in regional NRM bodies and so it is important to establish an appropriate information policy in these bodies. The main areas for the preparation of spatial information policy include spatial information access, pricing, data custodianship, licensing arrangements, utilization of open-source information and social media, and should include an arrangement for the spatial information collected by regional NRM bodies to be returned to the state repositories.

5.8 Continuous Funding and Provide Incentives for Information Sharing

One of the major constraints for spatial information sharing and SDI development for catchment management activities was funding. The key funding sources for regional NRM bodies are the commonwealth government, state government, landowner's "in-kind" contribution and local government. There is a need for more reliable and continuing funding for spatial information management area for NRM bodies.

Spatial information sharing is not the core business of regional NRM bodies. There is little motivation for regional NRM bodies to share spatial information as they are busy with their core business. Incentives should be put in place to encourage further sharing of spatial information. The incentives could be economic incentives or some form of acknowledgment, recognition or appreciation so that the individual's willingness to share spatial information will be increased.

5.9 Improved Licensing Arrangements

It is recommended that regional NRM bodies use a single licensing arrangement rather than multiple licensing with state government organizations. The Queensland licensing framework used by the RGC when sharing spatial information between regional NRM bodies and state government organizations is a useful model to follow for other states. This could be facilitated through utilizing the Creative Commons licensing framework or the Australian Government Open and Access Licensing (AusGOAL) framework. Creative Commons licenses are designed to facilitate and encourage greater flexibility in copyright. A single licensing arrangement will improve efficiency in accessing and sharing of spatial information between regional NRM bodies and government agencies.

5. 10 Respect Privacy and Build Trust

The data which is collected by Landcare groups and landholders often have privacy/confidentiality issues. It is necessary to respect the privacy of spatial information during data sharing. The community groups and farmers should be

assured that the collected data regarding their properties will not be misused. This will also help to build trust and enhance collaboration in the future.

5.11 Promote Volunteerism

The volunteer participation and engagement of community groups and citizens for natural resource management has a long history in Australia. These community volunteer activities have been successful in achieving improved environmental outcomes and are acknowledged by government agencies. The local environmental knowledge of these groups can also be used for spatial information collection and management. Recent developments in ICT tools and spatial technology have provided community groups with a new opportunity to collect and manage the spatial data and facilitate spatial information access, sharing and SDI development.

5.12 Utilizing a Single Gateway for Access

Many IT solutions and spatial portals exist; however, NRM bodies are confused about where to go and how to access the data they need. It was identified by regional NRM bodies that a single gateway (access point) for natural resource information would improve discovery and access to spatial data.

5.13 Use of Open Standards

A continuing technical difficulty for spatial information sharing and spatial data infrastructure development at sub-national level is interoperability. The spatial information collected or generated by regional NRM bodies are generally local and have various standards and formats. Because it is very difficult to integrate and utilize spatial data gathered from different sources, spatial portals need to be built using open source and OGC standards to encourage interoperability. If open standards are embraced, the integration, access and sharing of spatial data can be improved.

5.14 An Enterprise Approach

The regional NRM bodies have a silo approach to spatial data management. The silo approach does not encourage the sharing of spatial data. The enterprise approach is more reliable and stable. It consolidates 'silos' of information, standardizes existing technologies, and minimizes the duplication of information services. As catchment management issues cross the administrative boundaries the adoption of an enterprise approach for data management is recommended.

6. Conclusions

This chapter has contributed to the current body of knowledge by exploring the spatial information sharing arrangements in natural resource management areas and

formulating strategies to facilitate spatial information sharing between NRM communities and government agencies. Natural resource management in Australia are implemented through the partnerships of government, community groups, private sector and academia. The national survey provides a unique nationwide perspective on the spatial information access and sharing for catchment management. The output from the survey will help to identify priority catchment management issues, national NRM datasets and information infrastructure in Australia. Though there are disparities among regional NRM bodies regarding the catchment management issues on which they focus, we identified the top ten catchment management issues at national level. This may assist federal and state government organizations for prioritizing funding and planning. The main catchment management issues at national scale were healthy habitat & biodiversity conservation, pest animal & weed management, community capacity building & indigenous engagement, disaster management, and water resource management. Spatial information plays a significant role in addressing these catchment management issues and majority of regional NRM bodies agreed this statement. Vegetation, cadastral, catchment boundary and land use information were the highly used spatial data by regional NRM bodies for catchment decisions. Spatial information and knowledge sharing were identified as the main areas of collaboration with the main collaboration partners being state government agencies and community organizations.

The main motivational factors for collaboration were to better organize information and knowledge, to reduce cost/resources, to avoid duplication, to maximize the use of spatial information and to achieve better regional NRM outcomes. These motivational factors are also supported by previous research. Lack of spatial policy, lack of trust, privacy/confidentiality, and continuity of funding were identified as KIN framework implementation issues.

The critical factors for improving data sharing across catchment management authorities were identified through triangulating the findings from the literature review, the results of the national survey of regional NRM bodies and the KIN project case study. Eighteen issues were identified as being highly significant and classified into the six major classes of organizational, policy, economic, legal, cultural and technical. The non-technical factors (organizational, policy, economic, legal and cultural) were found to be more significant in comparison with the technical factor. Based on these findings, information-sharing strategies were developed. Fourteen major strategies were formulated and suggested that the adoption and implementation of strategies can assist in overcoming the spatial information sharing issues and will contribute to the development of catchment SDI. The findings and strategies from this research have the potential to improve spatial information sharing between regional NRM bodies and government organizations to support better catchment management decisions.

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