Relocation of Intensive Agriculture to Northern Australia: The Case of the Rice Industry

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Contents

List of Tables

List of Figures

Executive summary

Development of new agricultural industries in northern Australia is seen as a way to provide food security in the face of reduced water availability in existing regions in the south. This report aims to identify some of the possible economic consequences of developing a rice industry in the Burdekin region, while there is a reduction of output in the Riverina.

Annual rice production in the Riverina peaked at 1.7 M tonnes, but the long-term outlook, given climate change impacts on that region and government water buy-backs, is more likely to be less than 800,000 tonnes. Growers are highly efficient water users by international standards, but the ability to offset an anticipated reduction in water availability through further efficiency gains is limited. In recent years growers in the Riverina have diversified their farms to a greater extent and secondary production systems include beef, sheep and wheat.

Production in north Queensland is in its infancy, but a potentially suitable farming system has been developed by including rice within the sugarcane system without competition and in fact contributing to the production of sugar by increasing yields and controlling weeds.

The economic outcomes are estimated a large scale, dynamic, computable general equilibrium (CGE) model of the world economy (*Tasman Global*), scaled down to regional level. CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. When an economic shock or change is applied to a model, each of the markets adjusts according to the set of behavioural parameters which are underpinned by economic theory.

In this study the model is driven by reducing production in the Riverina in accordance with relationships found between water availability and the production of rice and replacement by other crops and by increasing ride production in the Burdekin. Three scenarios were considered:

- Scenario 1: Rice is grown using the fallow period between the last ratoon crop of sugarcane and the new planting. In this scenario there is no competition between rice and sugarcane
- Scenario 2: Rice displaces sugarcane production
- Scenario 3: Rice is grown on additional land and does not compete with sugarcane.

Two time periods were used, 2030 and 2070, which are the conventional time points to consider climate change impacts. Under scenario 1, real economic output declines in the Riverina by $45 million in 2030 and by $139 million in 2070. This is only partially offset by the increased real economic output in the Burdekin of $35 million and $131 million respectively.

When rice is relocated to the Burdekin in competition with sugar cane there is only a modest change compared to the Scenario 1 in the Riverina, but there is a decline in the Burdekin of $50 million in 2030 and $237 million in 2070 due to displacing the higher per hectare value sugarcane. This represents a loss of $14,000 per person in 2070 for the projected population at that time. The

movement of labour associated with this change has an impact on the rest of Australia output of -$38 million in 2030 and -$181 million in 2070.

This case study illustrates some of the expected issues in relation to the relocation of agricultural production. The main conclusions from this study are:

1. Rice farmers, as with other primary producers, face on-going adjustment pressures from the deregulation of agriculture over the last 20 years, competition from overseas producers, climate change, costs of production and, most recently, competition for water, including from governments buying on behalf of the environment.

2. Industry policy reforms and buybacks will combine to reduce the average area of rice production because water allocation reductions of 25-35 percent cannot be offset by productivity gains given current production techniques and increasing temperatures and rainfall variability.

3. Southern rice farmers are comparatively diversified already and so they will be able to change the production systems to some extent, but alternative enterprises are also limited by a reliance on rainfall, which is largely restricted to the winter season. The loss of water will reduce the net number of farm businesses in the Riverina (and Australia), because of the additional pressures to adopt less intensive and larger-scale farming.

4. The reduction in output will also reduce net exports and have some impact on GDP, especially because of the extensive value-adding that occurs in Australia. An increase in wheat production will not compensate for the reduction in the higher value rice. The supply chain for rice could still be run from Australia, but more of it would be located overseas, to cope with the reduction in domestic production. This will be a cost to the economy over and above the direct cost of the environmental water.

5. There could be very large effects on some regional economies, especially if one or more mills close or operate only occasionally, as the employment effects multiply through the community. This study has not taken account of threshold effects, such as school or service closures, which may additionally affect some towns and other forms of economic and social analysis would reveal more.

6. There is some interest within the industry and from potential new corporate entrants, in the relocation of some rice production to the north. Concerns include:

    The lack of suitable varieties for the north that would sustain Australia's market niche;

    Lack of, or risks of investing in, processing infrastructure;

    Transport costs;

    Pest and disease problems;

    Concern about local reactions to land use change; and

Attracting new or existing landholders into the rice industry, sufficient to develop a regional industry.

Previous experience with grand schemes in the north generally tends to encourage caution.

7. Based on limited agronomic and financial data, rice production in the Burdekin area could be profitable, depending on land and water values. However, it does appear to be less profitable than in the south because of lower yields.

8. This also means that if there is roughly the same amount of additional northern production as is lost in the south then there would still be a net loss of national output and income, even with the minimal impact option, whereby rice production is introduced to a sugar-based rotation. The displacement of an existing intensively-produced crop, such as sugar, will result in a much larger net national loss, also meaning that there would be a net reduction in GRP.

We conclude that there is unlikely to be a rapid and spontaneous increase in rice production in the north, because of a lack of infrastructure, wariness in relation to the agronomic issues and the opportunity cost of turning away from sugar. We have not yet examined the social preference for traditional crops and landscapes but our interviews and field observations suggest a strong local attachment to sugar production. This means that the rice in rotation is likely to be the most appealing in the short run. This at least would minimize the net national and regional economic effects. This may be economically and agronomically feasible, but the distribution of work, especially possibly increasing work in high summer, might not be appealing to some farmers, as suggested in some of the interviews with key informants.

In regard to the policy implications of this study, the findings raise some questions for governments. The returns from rice, per hectare, are likely to be less in the north than in the south, at least until there is further developments on varieties and production techniques. The relative profitability might be moderated if it was clear that land and water was cheaper in the north. There will be some further investigation on land prices but the market for water in the north is much less developed. Setting aside any capital cost differences, the lower profits, agronomic uncertainties and a local attachment to existing crops mean there is unlikely to be any major autonomous expansion of a northern rice industry, which raises the question of whether or not governments should provide additional support to accelerate industry development. The three main arguments for support would be: cushioning the impacts on the national economy of reducing southern production; helping to support the maintenance of rice processing infrastructure in Australia, which assists with local value-adding; and boosting the Burdekin regional economy.

Forms of government intervention could include:

Providing the additional infrastructure for an expansion of the Burdekin irrigation scheme without necessarily aiming to recoup full capital costs;

Providing social infrastructure (roads, power etc) to support private irrigation developments;

Providing structural adjustment funding to support the development of a value-adding part of the value chain, though there would obviously need to be some clear expansion before such an investment;

Research projects dedicated to increasing rice productivity in the north; and

Extension officers to support prospective producers.

This all presumes that the environmental consequences of such an expansion were not too severe. There would be no point in buying back 'environmental' water in the south, only to incur additional environmental costs in the north, and so this is recommended for further research.

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1. Introduction

1.1 Background

Under climate change projections it is expected that the southern part of Australia will generally become drier, while there is a likelihood of increased rainfall and the frequency and intensity of extreme events in parts of the north (IPCC, 2007). The possibility of climate change leading to less rainfall in the south-east of mainland Australia triggered renewed interest in northern irrigation projects, with proposals to reconfigure the geography of intensive agriculture (ABC News, 2008; Camkin *et al.*, 2007; Northern Australia Land and Water Taskforce, 2009b; Shanahan, 2007). In December 2008, the Commonwealth government, committed $200 million to an expansion of the Ord River Irrigation Area (ABC News, 2008), the first real expansion of the scheme associated with the main dam since the mid-1970s, while there have been investigations of expanded crop production possibilities in other areas of the north (Petheram *et al.*, 2008; Northern Australia Land and Water Taskforce, 2009b). One driver of this renewed interest in northern agriculture was to secure a 'potential new food basket' in the face of climate change (Shanahan, 2007; The Sydney Morning Herald, 2007). This expansion would then offset possible decreases in the irrigated area and output of the Murray Darling Basin as a result of decreased inflows, buybacks of environmental water under the Murray Darling Basin Plan (Murray-Darling Basin Authority, 2010), and possible trading of water to other uses (National Water Commission, 2009).

Approximately 39 percent of Australia's agricultural production comes from the Murray-Darling Basin (MDB) (Murray-Darling Basin Authority, 2010, xv). The MDB has been under varying forms of administrative bioregionalism since the River Murray Commission (RMC) was established in 1917, primarily to manage water allocations (Walker, 1994). In 1967 the RMC examined salinity in the river system (Kellow, 1992) and in 1973 the Federal Government convened a meeting to discuss the River Murray, with special emphasis on salinity (Kellow 1992). From the 1973 meeting, there was some agreement on an action plan between four of the governments involved (NSW, Victoria, SA and the Commonwealth) but this was not translated into an agreement until 1981. In 1985 the Murray-Darling Basin Ministerial Council was formed and the Murray-Darling Basin Commission (MDBC), the advisory body, in 1988, and the MDBC was to explicitly consider salinity and drainage beyond the immediate rivers (Walker 1994). With the increasing involvement of the Commonwealth in water management, the 2001 National Action Plan for Salinity and Water Quality (NAP) confirmed three policy directions: a system of regional natural resources management organisations jointly funded by the states and the Commonwealth; a focus on riparian ecosystems; and a focus on 'over-allocation' of water. In 2004, the National Water Commission (NWC) was formed, with the aim of addressing over-allocation and of securing sufficient environmental flows to create 'sustainable' river systems. In 2008, the Murray-Darling Basin Authority (MDBA) took over from the MDBC and is required by the *Water Act 2007* to '… protect, restore and provide for the ecological values and ecosystem services of the Basin' (Murray-Darling Basin Authority 2010, p. xii).

The regional impacts of a reduction in irrigation in the MDB could be significant, especially given that agricultural production was for many years a mainstay of regional development (Davison, 2005)and there are many communities highly dependent on irrigation schemes. Water-dependent communities have been dealing with adjustment pressures for many years as a consequence of climate variability, volatile commodity prices, shifting exchange rates, government policies and social trends (National Water Commission, 2009). The combination of future expectations of reduced total water availability and the national imperative to provide a greater share of the available water for the environment, particularly in the MDB, means that the irrigation sector faces significant additional pressures. There is evidence of a great deal of uncertainty in the community in regard to potential implications of major structural reforms in irrigation sector and there is a risk of over investment in infrastructure renewal if the likely extent of future structural adjustment is not adequately recognised (National Water Commission, 2009).

Some industries are already looking to establish production centres in the north, for example the Peanut Company of Australia (PCA) planned to produce 13,500 tonnes of peanuts and 25,000 tonnes of corn and other crops from two newly established Katherine properties by 2012, requiring an investment of over $20M[1]. For such investments to succeed, it is imperative that sustainable and profitable rotational systems are identified and adopted. There have however, been many attempts to develop intensive crop production in northern areas with a number of notable failures (see for critical reviews Davidson, 1966; Graham-Taylor, 1982; Wooding, 2008) leading to a great deal of caution in regard to recent proposals for more development, considering that concerns about previous developments did not include environmental considerations to the extent that they are a contemporary concern. There are then, four questions in relation to northern irrigation developments:

- Are there the natural resources (soil and water) to support irrigated agriculture?
- Are there suitable crops and crop varieties?
- Will it be profitable?
- What are the social impacts?

Some work has been undertaken to identify suitable soils and available water in the northern areas (Northern Australia Land and Water Taskforce, 2009a; Camkin *et al.*, 2007) and this work is recommended to continue (Northern Australia Land and Water Taskforce, 2009b). We focus mainly on the last two questions, with assumptions that there are suitable soils and crops and available water, which will be the work of others to determine. These are heroic assumptions and all recommendations should be seen as confined only to consideration of the private and public benefit if those resources are available. This project will research and provide information to support decisions on the incremental and transformational changes that are already happening in northern Queensland, by looking at rice production systems in the Burdekin and the development of sustainable and profitable rotational systems. This will be investigated at a number of spatial (paddock, farm, region) and temporal (baseline, 2030 and 2070) scales. We also consider the net effects of shifting agricultural production by examining possible structural adjustment in the southern rice areas, given a reduction in available water. This work can also contribute to discussions about the future of the Murray-Darling Basin in that the on-farm and regional impacts of reducing water allocations are examined.

[1] This looks to be on hold at the time of writing due to the changed commercial focus of PCA.

1.2 Aims and objective of the report

This report is part of a larger project which aims to identify likely private, social and community costs and benefits, in terms of production, farm business profitability, economic risk, and environmental impacts, of relocating irrigation industries to northern Queensland.

Project objectives: The project activities include to:

- Develop a methodology for examining the regional economic impacts of changing agricultural land use under climate change;
- Develop a coordinated approach to analysing options for intensive rice cropping systems in northern Australia, and provide relevant local and regional information with regards to the increased risks and opportunities from climate change;
- Assess the likely impact of relocating rice production systems and associated industry to northern Queensland using both productivity and economic metrics;
- Map the social and value chains (non-farm) and identify changes in related business activity and community services, infrastructure and resilience; and
- Provide advice on effective Government policy that supports the sustainable growth of Australian primary industries by increasing the preparedness of farmers from vulnerable regions to mitigate impacts and identify opportunities from expected changes in climate.

This is case study focuses on the rice industry as the industry likely to be most immediately affected by the current policy and climate changes. Rice production is highly concentrated in a long-established irrigation area, highly dependent on irrigated rice and likely to be affected by climate change,

1.3 Outline of the report

This report is structured as follows: Section 2 sets out a conceptual framework for considering the relocation of agriculture as part of an industry policy. Section 3 provides an overview of climate change and its implications for water availability for rice. Section 4 discusses the significance of the rice industry, particularly the area and production of rice over time, southern (Riverina) and northern Queensland (Burdekin) rice productivity and profitability, the rice value chain and the contribution of rice industry to the Australian economy. Section 5 describes empirical assessment methodology, including conceptual and empirical models. It also provides a brief overview of regional economic modelling while presenting an empirical assessment of structural adjustment in a rice farming system. It tests various hypotheses on structural adjustment in rice using ABARE data sets. Section 6 discusses challenges and opportunities and industry viewpoints related to relocation in northern Queensland while section 7 assesses the structural adjustments in rice farming systems and empirical validated hypothesis related to structural adjustments. Section 8 provides details of rice relocation scenarios and their rationale, and presents the results of the regional general equilibrium modelling outcomes. Section 9 is the conclusions from the study.

2. The relocation of agriculture as industry policy

In this section we develop a conceptual model of policy developments, based on some basic economic principles, as a means of organizing the discussion of the research. The contention is that governments in developed countries, including Australia, have moved through three broad stages of industry development policy for agriculture. By industry policy we mean '…*collective action aimed at building up new industries and firms, and restructuring old ones*' (Stewart, 1994, 15) with the ultimate goals of such policy including economic growth (Stewart, 1994, 15), general welfare (Freedman and Stonecash, 1997, 170) and even social stability (Freedman and Stonecash, 1997, 173). The goals of agricultural industry policy in Australia have at various times included: the reform of emancipated convicts (Connors 1970; Ward 1975); the civilisation of the frontier (Pike 1962; Waterson 1968; Johnston 1988); offsetting the effects of an economic depression (Connors, 1970); supplying resources to the industrial hub of the British Empire (Schedvin 1988); and managing social unrest after the gold rushes and the first world war (Callaghan & Millington 1956; Connors 1970; Ward 1975; Lake 1987), but into the twentieth century, the primary aims were usually national economic growth and regional development.

The four policy stages proposed as the means of organising this review of policy change are: establishment; and stabilisation (of an industry); self-sufficiency, competitiveness and structural adjustment; and post-productivist adjustment. The stages are not discrete with policy legacies and path dependency and various reversals but the model serves to illustrate dominant trends. In regard to *establishment*, this has been well-documented in Australia with colonial and then state governments distributing land and providing subsidized finance in return for requiring particular development outcomes, such as clearing and grain production (Connors, 1970; Lake, 1987; Roberts, 1924). The 'stabilisation' mechanisms developed during the 20th century included at various times: input subsidies, such as machinery and fertilizer bounties; tariffs on competing imports; and the creation of centralized marketing systems, such as the Rice Marketing Board (see Table 1 for a summary). The commodity boards shifted market power to the collective sellers and also enabled governments to provide underwriting arrangements. In addition, for public irrigation schemes, water costs were often effectively subsidized with, at best, recovery of the distribution costs.

Hence, the initial subsidies encouraged producers to enter the market, shifting the supply curve further to the right (S to S_s in Figure 2) than would have been the case with no government intervention. Assuming there are limits to the number of producer who can or wish to enter the market, those and/or other subsidies encourage growers to stay in the industry because of a high price (P_s) relative to the cost of production (C_s), because subsidies effectively reduce marginal costs (MC) relative to prices. This policy approach was however, criticized, notably by some agricultural economists, from the 1960s on (for overviews see Gruen, 1986; Cockfield, 2009) as being against the liberal principles of efficiency and competitiveness, foreshadowing the second stage of industry policy: *self-sufficiency, competitiveness and structural adjustment*. From the early 1970s, there was a general move to reduce agricultural (and secondary industry) support with the winding back of tariffs, a reduction in subsidies and the privatization of marketing boards (for an overview see Cockfield and Botterill, 2006).

Table 1 Assistance for Australian Agriculture: Industry Establishment and support

Policy	Elements
Production subsidies	Land (through ballots and allocations below market value); Water 'rights' (at little or no cost); Finance; production inputs (e.g. machinery; fertiliser)
Funding for research and development	State agricultural agencies; agricultural colleges; commodity-based research centres; research corporations; regional natural resources management bodies
Infrastructure provision	Silos; railways; roads; social services; dams and water distribution systems
Industry protection	Tariffs on imported substitutes Non-tariff barriers such as quarantines rules
Market adjustments	Marketing board monopolies; commodity price averaging and guarantees
Export facilitation	Export corporations and trade networks
Safety nets	Drought assistance; exceptional circumstances
Industry adjustment	Farm build-up loans; exit grants; innovation grants; farm business advice; regional adjustment packages (e.g. Dairy industry)

The argument was that Australia did not have the resources to match the US and EEC (later EU) subsidization or market power so the only option was to encourage competitive and efficient industries (Hawke and Kerin, 1986; Hawke, 1989; Kerin and Cook, 1988; Kerin, 1989). For irrigated agriculture, the consequences were: the phasing out of input subsidies on machinery and fertilizer (1970s on); increasing water prices to cover infrastructure (1990s on); and the deregulation of water pricing and trading, which would reflect the opportunity cost (1990s-2000s). There was also the removal of the marketing boards (1980s-1990s) but at the time of writing, there was still a monopoly for export rice, which dominates the market (see later discussion), so this is set aside to simplify the conceptual discussion.

With these policy changes, the market would become more competitive and the tendency would be for production to move towards Q. This is because costs would tend to move from C_s towards P, prompting producers to consider other crop options or to exit the industry, thereby shifting the supply curve towards S. This would include an increase in the opportunity cost of water as markets develop for alternative uses for that water. There are in reality offsetting developments that help maintain production levels, such as increased farm size for economies of scale and the constant innovation that is a feature of agriculture, whereby producers are always battling cost increases with little control over prices. In addition, production decisions are highly correlated with water availability, as opposed to just price of water, and water availability can vary considerably, as will be discussed later in the report. To aid the processes of structural adjustment, such as farm amalgamations, technological innovations and industry exit, governments created a range of rural adjustment schemes that have gone through a number of incarnations, from the Rural Reconstruction Scheme (1970s) to Advancing Agriculture Australia. There could be more changes for the rice industry that result from this policy stage, including deregulation of the export market and the removal of limits on trading water out of regions and agriculture. On top of that, there is a case for arguing that a third stage of industry policy has commenced which is likely to bring more major change.

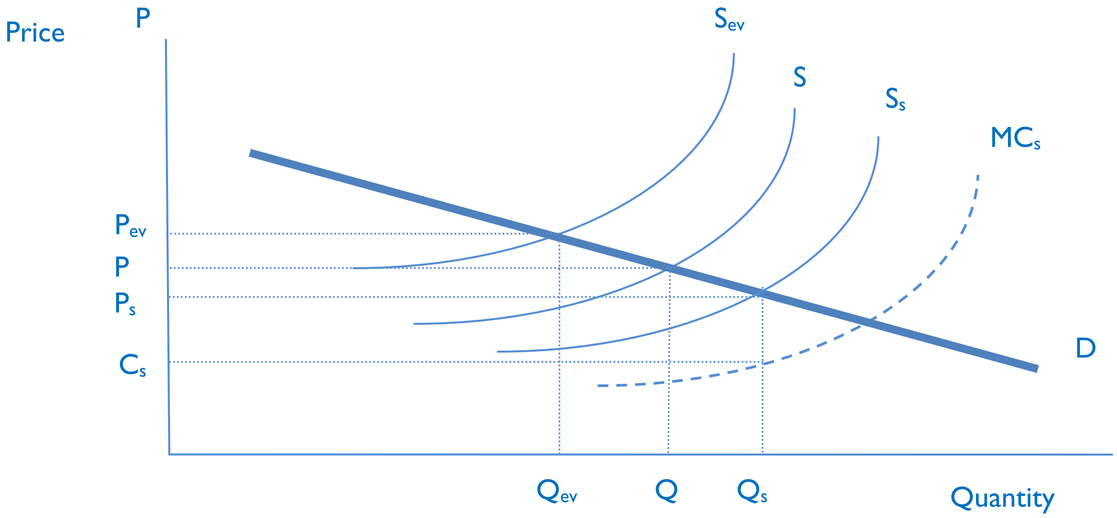

Figure 1 A model of the Australian rice market with 2 stages of policy adjustment

The demand schedule is probably relatively flat because Australian production hardly affects the world market and exports comprise 80% of Australian sales, though there is some differentiation by the style of rice (see later discussion). The supply curves eventually become almost vertical because of natural resources limits and the increasing cost of shifting capital from other industries.

We suggest that all irrigation industries, especially those in the Murray-Darling Basin, are likely to undergo what might be termed *post-productivist adjustment* as implicit environmental and social 'subsidies' are removed. With an increased focus on externalities, the costs of agricultural production are now considered to include environmental and social (post-productivist) values such as clean water and air, environmental flows, habitat for non-human species and the recreational and existence value of non-agricultural vegetation. Examples of post-productivist revocations in other industries include: limits on industrial and effluent discharges into waterways; the restriction of logging in native forests; and the proposed carbon tax, or emissions trading. All of these initiatives require producer adjustments with the adoption of waste management or emissions control technology, the purchase of sequestration offsets, the switch to commercial plantation timber, or exit from the industry. In the case of irrigators in the Murray-Darling Basin, governments have decided that water was 'over-allocated' at the expense of the environment and therefore some needs to be bought back for that purpose. This will further decrease supply to where environmental values are considered (S_{ev}), and net production will also decrease, as will be discussed in a later section.

Table 2. Timetable of Major Rice Industry Events

	Policy and Industry Events	Market implications
1910-1912	Construction of MIA scheme for horticulture and allocation of land*	Reduced costs through subsidised land, water, finance & infrastructure
1913-1920	Industrial Undertaking Act*: Requirement for scheme self-sufficiency	Cost recovery (higher costs) Autonomous adjustment
1925	Irrigation (amendment) Bill*: Structural adjustment; Debt write-off & reduced rates Formation of growers cooperative & Millers Association in response to the co-op.	Implicit subsidy Moral hazard Potential for quasi-monopoly Explicit buyer collusion
1927	Import duty (later tariffs)** Production limited to MIA** (effectively area quotas)	Domestic price above 'world' price Kinked supply curve
1928	Formation of NSW Rice Marketing board (Voluntary pooling)	Moving to monopolistic competition
1930	Collapse of cooperative but MIA Rice Growers (later Rice Growers of Australia) formed	Increased power to buyers
1933-49	Multiple mills built	Regional value-added
1950-68	Formation of new cooperative; purchase of existing mills; construction of new mills; wholesale distribution	Grower control of supply chain Higher on-farm prices
1969	Increased production area* (government 'permits')	Supply increases
1970-80	World demand falls and US 'dumping' Tariff reductions** User pays water pricing*	Prices fall Increased competition from imports Increased costs
1986	US/EC trade war (export subsidies) Cooperative product diversification	World prices fall New markets
1990-95	Trade wars cool; Japan accepts Australian rice National Competition Policy review recommends domestic market deregulation	Some price recovery
2005	Cooperative converts to company	End of direct marketing assistance
2006	Domestic rice market deregulated (permits to sell outside the system)	Increased number of buyers
2007-08	Water Act and formation of MDBA** (water buy-backs start)	Reduced water and reduced rice supply
2010-12	MDB Plan and regional targets**	

* NSW government action ** Commonwealth Government

The four stages can be seen in some milestones in the development of the rice industry (Table 2) though with some unusual disjunctions. Soon after the Murrumbidgee Irrigation Area was developed, the NSW government sought full cost recovery, which then contributed to an early round of structural adjustment. By the mid-1920s, the MIA growers were producing sufficient rice for the domestic market but, as with other producers of the time, they were concerned about 'predatory' and 'collusive' commodity buyers and therefore formed the first cooperative. The rice millers responded by forming their own association and from the 1930s to 1949, there was an increase in processing capacity to match the increasing rice production. The two other key interventions were: the Federal and NSW Government agreeing to license production areas, effectively limiting supply; and imposing 'duties' (later tariffs) on imports. State manufacturing tariffs had been used since the late 1800s (Logan 1966) and these were centralised after Federation and agriculture was eventually included in 'protection all round'.

In the post-war period a new rice growers' cooperative was formed, supported by the NSW Government, and this became, effectively, a monopoly buyer and distributer, acquiring all major processing plants and building additional ones. The cooperative was also given sole control over exports. This effectively increased prices for producers, since cooperative profits were kept within the industry. These market arrangements were however threatened by external market forces and changes in domestic policy ideas. Production was increasing in Asian countries and the US and EU were increasingly subsidising agricultural production and Australia chose to opt out of that protectionist arms race.

The rice industry was, however, one of three tardy deregulators, the others being sugar and dairy products. There are several possible contributing reasons for this. First, all these industries especially sugar and rice had strong cooperatives which facilitated the political organisation of the producers. Second, all these industries, especially sugar and rice, were regionally concentrated, as were producer and industry votes. Third, both sugar and rice were one-state industries and were less susceptible to multi-government negotiations. This did not stop the general movement towards national policy settings. In 1995 a National Competition review recommended the deregulation of the domestic rice market but the NSW Government resisted this until the Commonwealth withheld 5% of the 2004-05 competition payments ($13million). The NCP's ambit also included 'reforms' to the management of water in Australia, with some relevant goals being to:

- Ensure prices for water cover the full cost of maintaining the asset;
- Separate land and water entitlements;
- Provide water for environmental purposes (recognising over-allocation);
- Facilitate water trading to maximise the 'return to Australia'; and
- Better integrate natural resource management activities to account for interaction of resource condition within a basin or region. (National Competition Council, 2003, ix-x)

These principles or aspirations have to a greater or lesser became increasingly evident in subsequent policy, as described in Chapter 1, culminating in the MDB plan which, along with climate change, is expected to result in a decrease in the area of rice in the southern region.

The question being examined within this project is then, should producers be encouraged to consider rice production in non-traditional areas, so as to offset some of the expected decrease in the southern area? Further to that, should governments be supporting relocation of production and if so, by what means? The purpose of this section was to set out a conceptual framework for organizing the overall discussion but in particular, to use the concept of the three stages to highlight some potential dilemmas for governments. If this study were to find that rice production in a northern area, in this case the Burdekin region, was relatively profitable, then government roles could reasonably be confined to research and extension on crop production techniques, the expansion of the water distribution system and perhaps some additional roads and communications infrastructure. All of these are standard government roles and the costs of the additional the infrastructure could be recouped through full cost charges. If however, there is not a clear case that rice is competitive with other land uses, then governments have to decide if there is to be additional support to facilitate this expansion. This would mean that just as the southern irrigation area is going through fourth-stage adjustment, there would be some first stage support in order to encourage the establishment of a northern rice (geographically infant) industry. This would not necessarily be a return to colonial agricultural policies but forms of assistance could include special efforts to develop northern varieties that would have market appeal, marketing assistance, reduced water costs, subsidized social infrastructure, grants to establish processing infrastructure and so on. This would be somewhat contrary to the general trend of third stage (self-sufficiency and competitiveness) industry policy that prevails in most agricultural industries.

3. Climate change and water availability for rice

There are significant concerns about the longer term impact of climate change and climate variability on water availability. It is expected that with climate change, future average water availability will decline and that the frequency of extreme events such as the current drought will increase (Sanders et al., 2010). In addition, there are the policy changes that will further restrict water available for irrigation, as discussed in the previous section. The purpose of this section is to show the future constraints on the southern rice industry.

The CSIRO predicted long-term water availability in the Murray–Darling Basin (MDB) under a number of climate change scenarios (CSIRO 2008). The projections were based on extensive basin-wide hydrological modelling as well as historical data from 1895 to 2006. While acknowledging the uncertainty in these predictions, surface water availability across the entire MDB is more likely to decline than to increase. The median is projected to be 9-11 percent in the north of the MDB and 13 percent in the south. For the Murray Region, under the best estimate 2030 climate average, annual runoff would be reduced by 10 percent. The extreme estimates (from the high global warming scenario) range from a 37 percent reduction to a 7 percent increase in average annual runoff (Table 3). The results from the low global warming scenario range from a 12 percent reduction to a 2 percent increase in average annual runoff (CSIRO, 2008a).

Table 3 Percentage change in mean annual rain and runoff under future climate 2030 for Murray Region, Riverina

Parameters	Historical		Future climate					
	Historical 1895–2006	Recent 1997–200	Current development			Future development		
	mm		Dry	Best estimate	Wet	Dry	Best estimate	Wet
			percent change from Historical					
Rainfall	340	313	-19%	-3%	6%	-19%	-3%	6%
Runoff	24	19	-37%	-10%	7%	-38%	-11%	6%
Evapotranspiration	316	294	-18%	-3%	6%	-18%	-3%	6%

Source: CSIRO, 2008a

The 'millennium' drought illustrates the problem if there are to be more extended dry periods and constrained water supply. There was significantly reduced rainfall and above average temperatures from 2001-02 to 2009-10 and Basin inflows have been much lower than average and allocations to irrigators have declined, resulting in an irrigation drought (Sanders et al., 2010). As indicated in Table 4, the general security allocations have significantly decreased since 2005-06 and were almost zero during 2006-08 in NSW Murray region.

Table 4 Irrigation general security water allocations in major areas of the southern Murray–Darling Basin, 2000-01 to 2009-10

System	Allocation %					
	2000-01	2005-06	2006-07	2007-08	2008-09	2009-2010
South Australian Murray	100	100	60	32	18	48
Victorian Murray (high security)	200	144	95	43	35	60
Victorian Goulburn (high security)	100	100	29	57	33	50
NSW Murray (high security)	100	97	69	25	95	97
NSW Murray (general security)	95	63	0	0	9	10
Murrumbidgee (high security)	100	95	90	90	95	95
Murrumbidgee (general security)	90	54	10	13	21	14

Source: (Sanders et al., 2010; State water authorities).

To address over-allocation of water, particularly in irrigated agriculture, the Murray–Darling Basin Authority (MDBA) is developing a 'Plan, in second draft at the time of writing. The centre-piece of this plan is the establishment of environmentally Sustainable Diversion Limits (SDLs) on surface and ground water use. The purpose of the SDLs is to achieve a more sustainable balance between consumptive water uses and the environment. The first draft plan outlined three SDL scenarios, involving reductions in long-run average consumptive diversions of between 22 and 29 per cent (or 3000 to 4000 GL). For the Murray region this would equate to a reduction in the current long-term average surface water diversion limit from 4,219 GL/y to between 3,126 GL and 2,756 GL per year (reduction of 1,093-1,464 GL per year or 26-35%) (Murray-Darling Basin Authority, 2010), though there has since been significant debate about 'balancing' the environmental, economic and social effects of the Basin Plan. Nonetheless, rice is a major irrigated crop in the southern areas so cuts to allocations, along with reduced flows and higher temperatures will have a significant impact on production.

Rice is a summer crop, sown in windows according to variety from mid-September to mid November (usually between 120 to 180 days). The rice production system in Australia is fully irrigated usually in a rotation system involving other crops and livestock, in contrast to the mono-cultural rice systems employed elsewhere. Almost all of Australia's rice is grown in shallow (10cm) ponded water. The growing season is approximately 6 months, with a mean annual average rainfall ranging between 350 – 450 mm in the Riverina and with rice requiring water throughout this period (Stokes and Howden, 2008), there is a high demand for stored water. The long term average evapotranspiration at Griffith is 1160 mm over the rice season, which means that on average rice requires 1000 mm of irrigation water to meet net evaporative demand (Humphreys, 1999). Rice water use and areas planted are given in Table 5. Water use varies from 11-14 ML/ha, depending on temperatures and soil conditions. Falling water tables due to drought may also result in increases in rice irrigation water requirements, particularly on more marginal rice soils where the presence of shallow water tables, rather than low soil hydraulic conductivity, limit percolation (Stokes and Howden, 2008).

Table 5 Rice area and water use in Australia

Year	Water use (ML)	Area (ha)	ML/ha
1993/94	1,349,391	125,000	10.80
1994/95	1,436,105	119,000	12.10
1995/96	1,437,369	137,000	10.50
1996/97	1,643,306	152,367	10.80
1997/98	--	147,000	--
1998/99	--	148,000	--
1999/00	--	131,000	--
2000/01	2,418,000	178,000	13.60
2001/02	1,978,000	145,000	13.60
2002/03	615,375	44,000	14.00
2003/04	813,812	65,000	12.50
2004/05	630,872	51,200	12.30
2005/06	1,240,626	101,000	12.30
2006/07	237,214	20,000	11.90
2007/08	26,664	2,072	12.90
2008/09	101,474	7,194	14.10
2009/10		19,000	

Source: ABS: Australian Water Accounts (various versions) -- data not available

Total rice area in Australia has a strong linear relationship with total irrigation water allocations (Figure 2). Most rice is grown by general security irrigators who receive their water last in the hierarchy of allocations. They are also the first to have allocations reduced in times of water shortages. Drought and water shortages have also reduced the number of farms actually growing rice (Figure 3). Despite the fact that the Australian rice industry improved its water efficiency considerably, using 50% less water than the world average (RGA 2011), there is further pressure for structural adjustment because of the continuous declines in water availability. This will affect farm profitability and also the regional economies where rice production is concentrated.

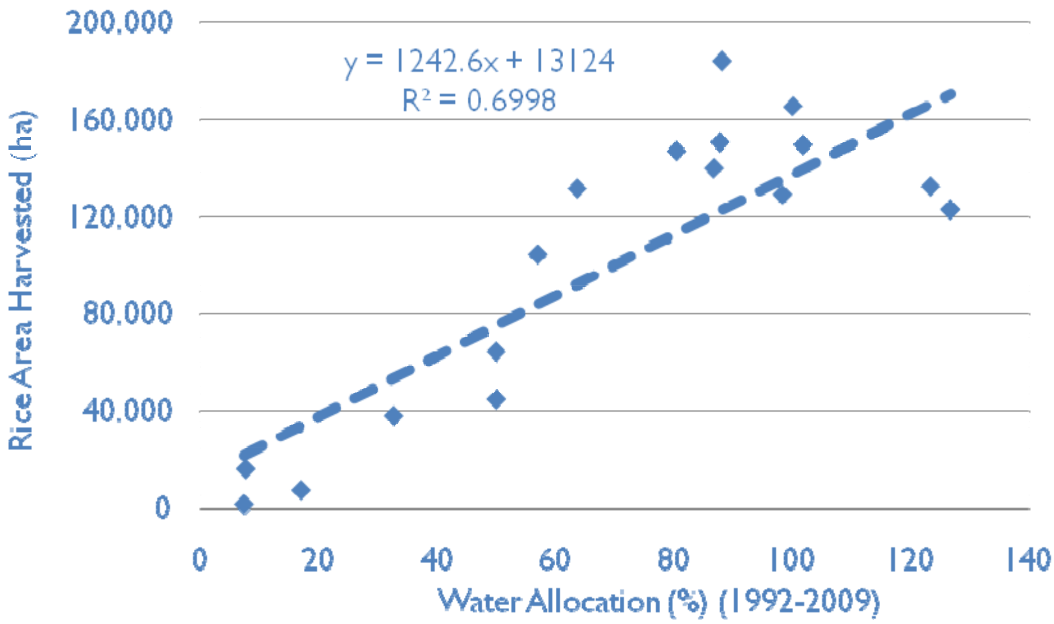

Figure 2 Relationship between annual water allocation and rice area in the Riverina (Murray, Murrumbidgee and Coleambally Irrigation areas), NSW

Source: Rice Marketing Board; NSW Water Information.

Note: The detail water allocation in each of the irrigation area is given in Appendix 1.

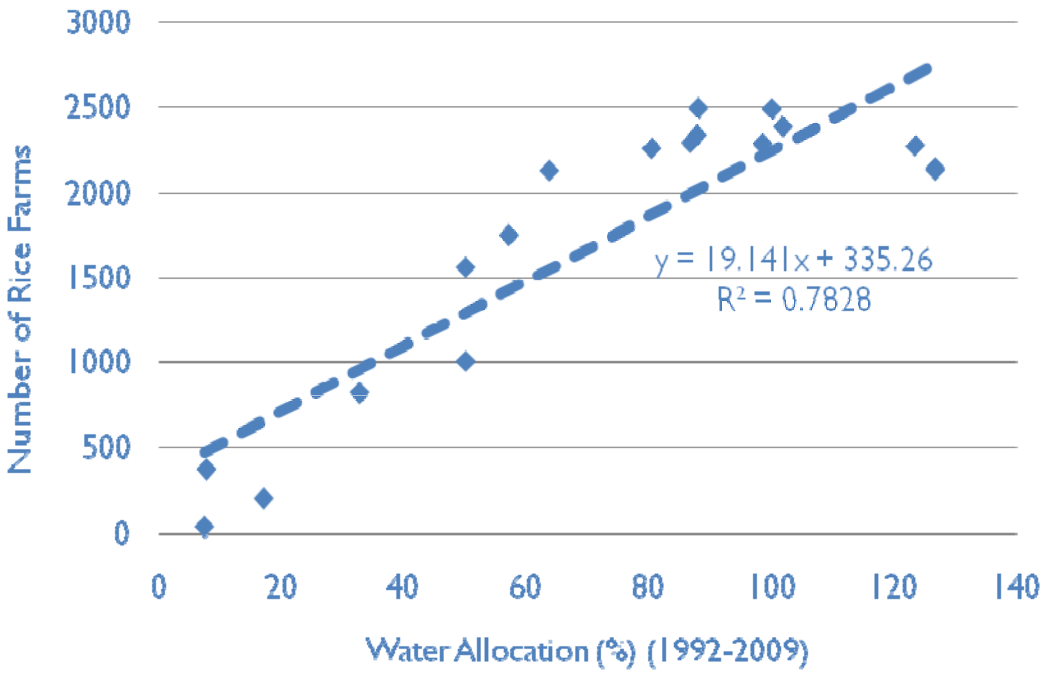

Figure 3 Relationship between annual water allocation and number of rice farms in the Riverina (Murray, Murrumbidgee and Coleambally Irrigation areas), NSW

Source: Rice Marketing Board; NSW Water Information.

4. Rice industry significance

Rice is one of the world's most important staple foods and is the main source of nutrition for more than three-quarters of the World's population. Several factors combine to make rice production in Australia successful: the high quality of grain owing to the climate, which provides a plenty of sunlight and suitable temperatures; excellent water quality; good soils; expert producers who obtain an average around 10 tons per hectare while increasing water use efficiency (RGA, 2011); and the tight integration of the production, commercial, and research arms of the industry. The Australian industry has a relatively small number of producers generating considerable export income, as well as value added production. During the 1990s, with generally increasing yields and area planted, 2000-2500 farms in the Riverina region produced 1-1.2 million tonnes of rice a year. This routinely contributes about $300m at the farm gate and $800m value added to Australian economy (Lacy et al. 2009). Rice growers have invested over $2.5 billion in land, water, plant and equipment and around $400 million in mill storage and infrastructure through Ricegrowers' Limited (SunRice) and the Rice Marketing Board of NSW (RMB) (RGA, 2011). Taking into account processing and packaging operations, the rice industry directly employs over 8,000 people and supports over 60 towns. Indirectly, the industry further supports 33,000 people, mostly in regional Australia (SunRice, 2010) and mostly in the Riverina region.

4.1 The Riverina (southern) rice area and production

Rice was first commercially grown in Australia in the early 1920's near the townships of Leeton and Griffith in the Riverina region. Since then there has been considerable development in rice varieties and farming techniques as Australian farmers have adapted to unique climate conditions (Marsden Jacob Associates et al. 2010). Australian rice varieties are different to those grown in monsoonal wetland countries such as Thailand and Indonesia and were specially developed to suit the hot, dry conditions of southern NSW. Most of the rice grown is of the Japonica type, which includes relatively soft-cooking, medium and short-grain varieties as distinct from Indica (predominantly firm-cooking long-grain) varieties which are grown throughout the tropical world. Japonica rice is suited to the temperate climate of the Riverina, though cold-induced spikelet sterility remains one of the major constraints to yield in the region (Humphreys et al., 2006). Since, the establishment of first commercial crop of rice in 1924, there has been a gradual increase in rice area and yield (Figure 4, Figure 5, and Figure 6).

The rice area peaked at 177,000 ha, yielding 1.7 million tonnes, during 2000/01. However, the main production areas have been severely affected by drought since 2002-03. A rebound crop of more than one million tonnes was produced in 2005-06, but since then production has remained below 170,000 tonnes with the low point in 2007-08 of 2,200 ha planted and 18,000 tonnes harvested. There was another rebound in 2008–09 with 7,000 ha and 61,000 tonnes but these figures are still markedly below the levels of ten years ago. Figures for 2009-10 were not finalized at the time of writing but are expected to show another bounce-back, though still well short of the peak production, as there has been considerable on-farm adjustment over the last decade (see later discussion).

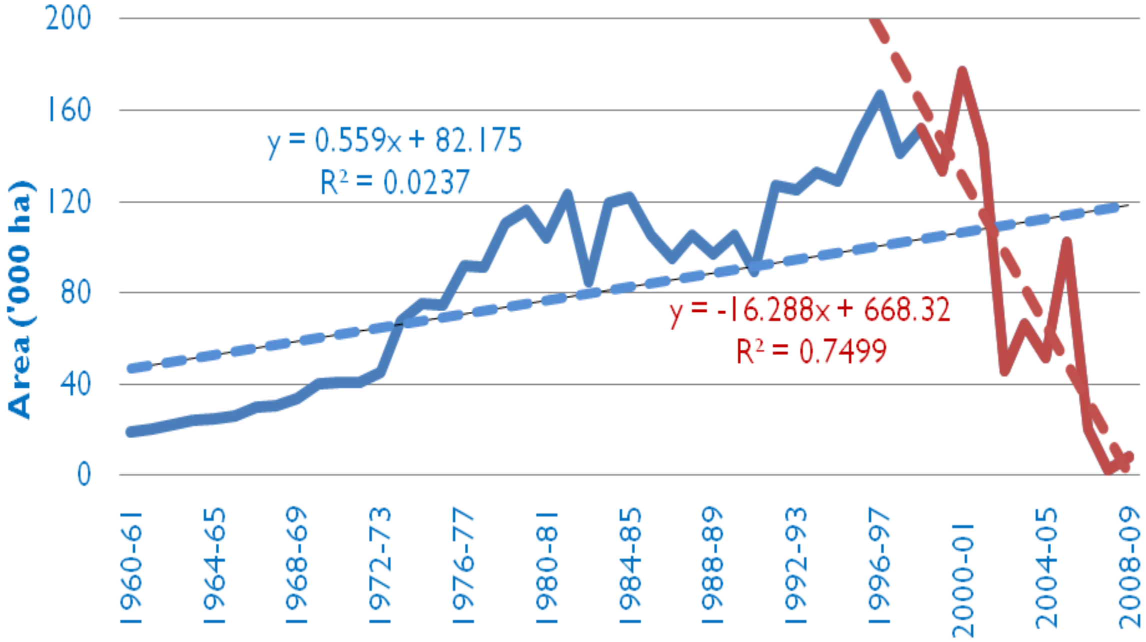

Figure 4 Historical rice area

Source: ABARE: 2010

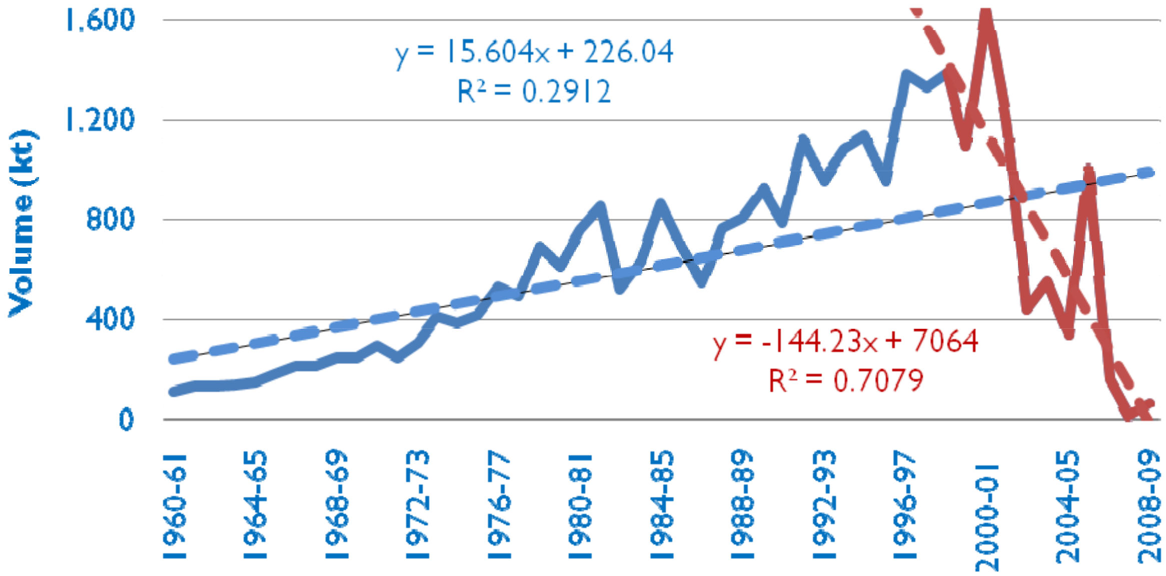

Figure 5 Historical rice production

Source: ABARE, 2010

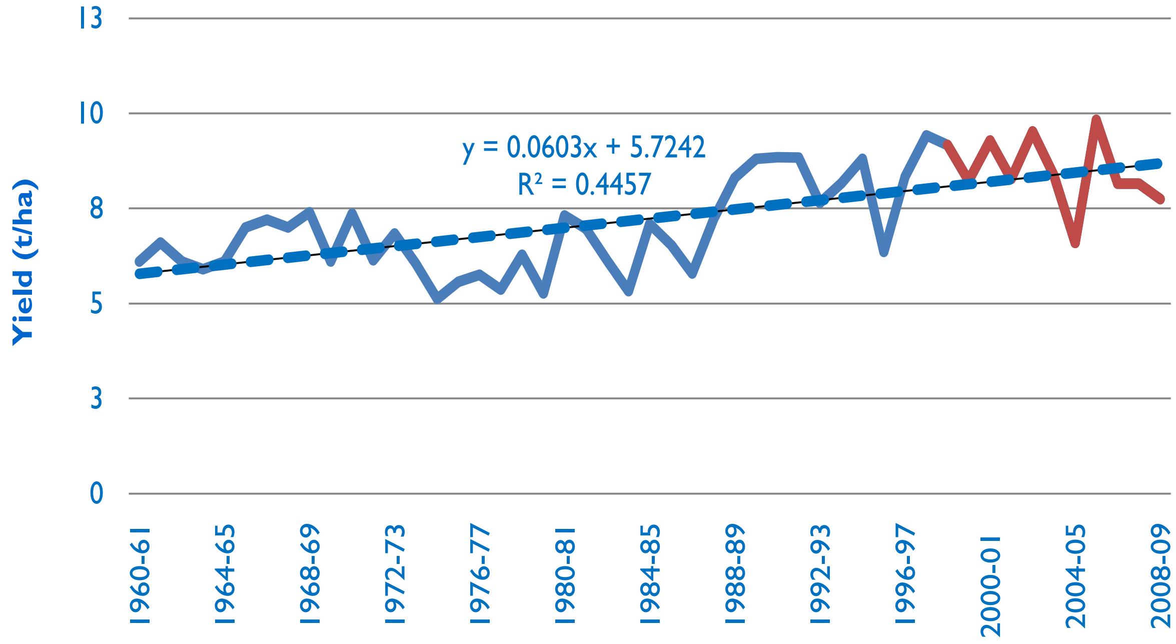

Figure 6 Historical rice yield

Source: ABARE, 2010

4.2 Rice Water Productivity

Australia has one of the highest yields of rice per hectare in the world. Over the past thirty years there have been substantial increases in irrigation and total water productivity (rice yield per ML applied irrigation water) in Australia (Figure 7). The long term Water Productivity (WP) for rice from the Murrumbidgee Irrigation Area increased by more than 60% from the 1980s to 2008 (Lacy et al., 2009). This is largely due to improved varieties and management of water, nutrients, weeds, pests and diseases and partly due to reduced water use (Humphreys and Robinson 2003) brought about by a range of industry-imposed restrictions and regulations (Humphreys et al., 2004). There are, however, likely to be diminishing returns from pursuing more water use efficiency with the current systems, although there may be gains through: the adoption of new irrigation practices, such as Alternate Wetting and Drying (AWD) and Aerobic rice (Humphreys et al. 2006); reduced water use in rice production through more accurate determination of the least permeable soils using revised rice soil suitability criteria (Beecher et al. 2002); the development of new cultivars; optimising sowing dates which move ponded periods outside peak evaporation periods (Humphreys et al. 2005); and investments in more water efficient irrigation methods such as lateral move and centre pivot irrigators (personal communication with Blue Ribbon Rice and Pulse Exporters). Nonetheless, these are unlikely to offset a reduction of available water of the order of 26-35%, so the Australian industry will generally contract based on current parameters and there will be changes in regional output in the Riverina.

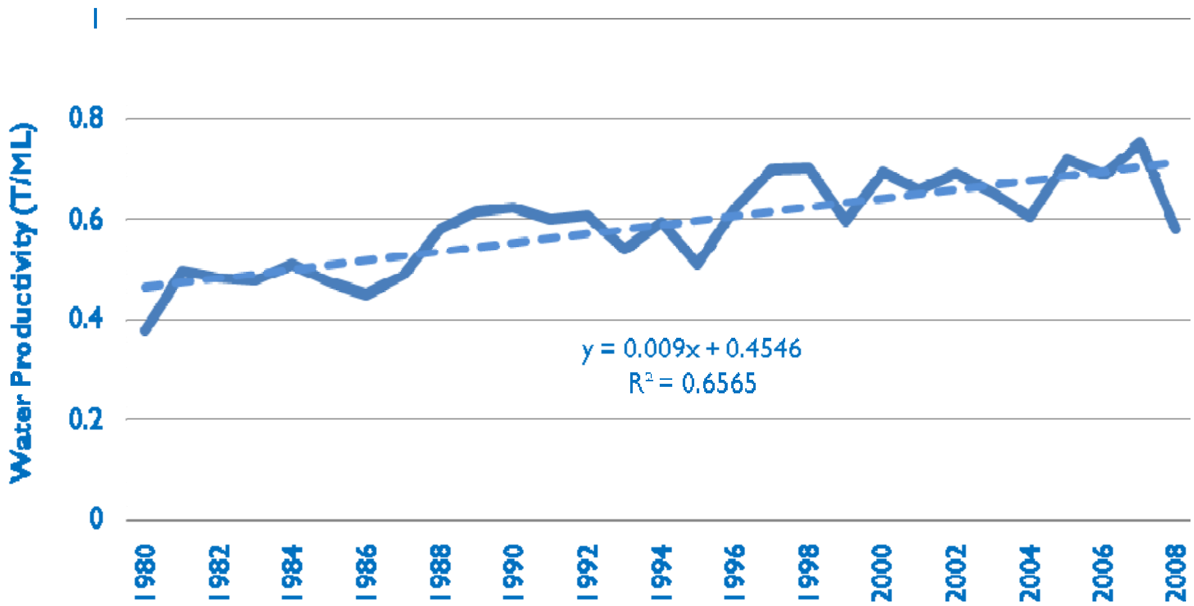

Figure 7 Rice water productivity (tonnes/ML) in the Murrumbidgee Irrigation Area, Riverina

Source: Lacy et al. (2009); Humphreys and Robinson (2003)

4.3 Rice farming system in Riverina

Rice farms are generally diversified and so farmers, if need be, can shift towards any or all of the other enterprises they have, including wheat (both irrigated and dryland) and sheep (Hughes et al., 2009 and Table 6). Table 6 shows that farms where rice is the primary enterprise, field crops or livestock activities are secondary activities. Sheep numbers are decreasing partly as a result of lower water availability, affecting pasture production, over time (ABARE Farm data - not shown here), while the area of wheat, is increasing with the increase in water scarcity (See Figure 12 and Figure 13 in section 6). Based on Hughes et al (2009), rice contributed 37 percent of total cash receipts during 2006-07 but the contributions of rice receipts are highly variable, depending on the water availability. Hence, net farm and regional income would likely decrease with the on-farm adjustments. Second, the profitability of farms would decrease with less rice. In 2006-07 for example, water availability was exceptional low and overall, and the average rate of return to capital was 1.9 percent. There is evidence (discussed in section 6) that farm size is increasing, which would help offset farm business profitability but regional and national output could still be reduced, though the latter could be offset through industry expansion in the north.

Table 6 Commodity production on rice farms in the Riverina

Primary	Secondary	Percentage of farms

Rice	--	100
--	Sheep	74
--	Beef	26
--	Irrigated wheat	65
--	Dryland wheat	13
--	Others (Grape wine, Cotton and Vegetables)	22

Source: Hughes et al. (2009)

4.4 Northern Queensland rice production

There have been number of investigations by rice industry bodies, including SunRice and Blue Ribbon Seed and Pulse Exporters, to assess the feasibility of rice production as an effective drought management strategy. There was experimentation in the NSW northern rivers around Lismore and in Queensland around Dirranbandi, Emerald, Mareeba and Burdekin. The Northern Rivers is a relatively high rainfall zone, while Dirranbandi is at the top of the Murray-Darling Basin and therefore water allocations will be limited or even reduced. Emerald in central Queensland is still likely to have a rainfall reduction under climate change and cotton is dominant. The Ord shows promise (see later industry comments) but the land area is currently quite limited. For this case study, we consider the Burdekin where there is already a significant irrigation dam and distribution system and rainfall is expected to be at least maintained, though seasonal distribution may change. To test the possible profitability of rice, we adapted Blue Ribbon Seed and Pulse Exporter's suggested approach, rice as a secondary crop in a rotation with sugar, as the main alternative to business as usual land use. This is chosen as the option most likely to maximize regional economic gains since sugar is not displaced. Direct substitution of rice for sugar was also examined in another scenario (see later discussion).

Previous attempts to grow rice in north Queensland were based around ponded systems, however, this method requires much greater work to set up the field and then to return the land to sugar cane. The approach being undertaken by Blue Ribbon Seed and Pulse Exporters is to exploit the availability of fallow land during the 3-5 year planting cycle and to use center-pivot irrigation in a system known as alternate wetting and drying (AWD) or saturated soil culture. This system has been used very successfully overseas and it means that returning to sugar cane is not so labour and machinery intensive as with ponded rice. Making use of the fallow period also means that rice would not be seen as an alternative to sugar cane but as a rotation crop that provides an income rather needing to control weeds during the fallow period. Continuously replanting to sugar cane leads to yield losses and the fallow period can mean extra costs are incurred for weed control. Improved sugar yields of ~20t/ha have been reported by growers undertaking the early trials in the Burdekin.

To alleviate the yield loss in subsequent new sugar cane crops the fallow can be planted to crops such as pulses, legumes (peanuts are being trialled)[2] and rice either as a winter or summer crop and potentially both as shown in Figure 8.

[2] Pulses, legumes and peanuts are not considered in regional economic modelling.

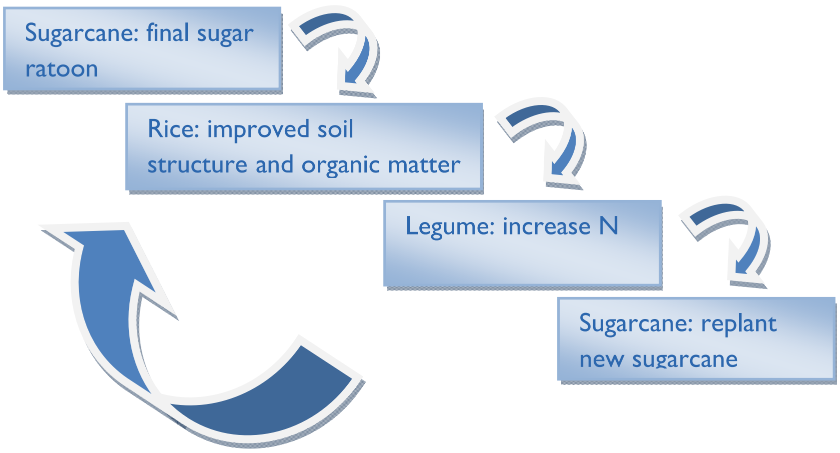

Figure 8 Possible rice production system in sugarcane landscapes in Burdekin

Cotton is also being trialled in this region but there are some advantages to rice over cotton as an additional crop within the sugar-dominated landscape. There are two planting windows for rice, a summer crop and a winter crop whereas only summer plantings of cotton appear viable. At this stage rice production in north Queensland is very small and aimed at building grower confidence, working out agronomic issues and building up seed stocks but there is potential to expand to more than 50,000 t per year. As with cotton, there is no processing infrastructure in the region and it would require a capital investment in the order of $8–10 million in order to establish a processing plant. Shipping to export markets could be via Townsville.

4.5 Rice profitability

Rice is a globally traded commodity and a financially attractive crop due to relatively high net returns. Returns are heavily influenced by the prices from the international market for rice. Unlike other globally traded commodities, the rice trade is based on customer specifications encompassing quality, packaging and delivery. Net returns (gross returns – total costs) of rice grown in Riverina are estimated using NSW DPI farm budget handbooks 2011 while net returns for the Burdekin are estimated from the data provided by Blue Ribbon Seed and Pulse Exporter and authors assessments based on NSW DPI farm budgets (Table 7). The details of the yield, inputs and associated costs are presented in Appendix II. The net returns for the Riverina (Murrumbidgee) indicate that all types of rice are profitable, generating close to $2,000 per ha for medium grain. The regional differences are mainly due to higher yields in the south, although the Burdekin rice, particularly summer rice, is still profitable. The medium grain rice grown in winter can generate up to $1,180 per ha because of the lower volumes of water use and associated water costs. The net return can also be expressed as a return to resource inputs. The net returns per ML of water, depending on the type of rice grown, indicate that Riverina (Murrumbidgee) rice will generate up to $148/ML while in the Burdekin summer rice will generate up to $80/ML and winter rice up to $118/ML (Table 7). This indicator could be re-examined in the future were water to be of different value from one region to the other, reflecting southern scarcity and demand.

Table 7 Rice profitability analysis in Riverina and Burdekin

	Long grain (Areal Sown)		Medium Grain (Areal Sown)		Medium Grain (Sod Sown)	
	Summer	Winter	Summer	Winter	Summer	Winter
Riverina (Murrumbidgee)						
Yield (T/ha)	9.25	--	10.0	--	10.0	--
Net Return ($/ha)	$1,755	--	$1,534	--	$1,920	--
Net Return ($ML)	$135	--	$110	--	$148	--
Burdekin						
Yield (T/ha)	4.5	6.5	5.0	7.0	5.0	7.0
Net Return ($/ha)	$443	$1,028	$496	$862	$641	$1,183
Net Return ($ML)	$55	$103	$50	$86	$80	$118

Source: DPI NSW, 2011; Blue Ribbon Seed and Pulse Exporter

4.6 Rice value chain

The value chain of rice includes the intermediary phases of production, delivery to final consumers in domestic and international market. Importantly it highlights the interaction of actors along each step of the production system (from producer to consumer) as well as the linkages within each set of actors (Kaplinsky, 1999). Two types of value chains have been identified in the literature – *Producer-driven* and *Buyer-driven* (UNCTAD, 2000; Kaplinsky, 1999). *Producer-driven* chains are those in which companies that produce the product control the networks within the chain. Producer-driven chains are most common in capital and technology intensive industries where high barriers to entry exist in production. *Buyer-driven* chains, by contrast, are controlled by groups that market the product. The Australian rice value chain is mainly Producer-driven as a result of the way the cooperative took over most processing (Chapter 2) and the barriers to entry including start-up costs, resource limitations centralised control specifications and standards determined by the domestic, international markets and environmental regulations. The value chain map is given in Figure 9.

The Australian rice industry has single-desk marketing arrangements for export. The Rice Marketing Board (RMB) controls sales of all rice grown in NSW and all consequent milled products and has licensed its powers to Ricegrowers' Limited (Rice Strategic Plan 2006-2011). Ricegrowers' Limited, also known as SunRice, has moved from a cooperative to a company structure, recently being sold to overseas owners. Rice growing, milling and transport normally provides direct employment for approximately 8,000 people and a further 37,000 jobs are generated in flow-on activities (Rice Strategic Plan 2006-2011). Both the industry and growers have adopted risk-averse approaches. During low water availability years, rice growers trade water and shift to low water intensive or dry land farming, even though SunRice tries to offer guaranteed minimum prices, so that production in the southern areas is likely to be highly variable, as noted above.

In response to this variable domestic supply, SunRice buys rice for milling purposes and for sale in domestic and international markets, using a well integrated global trading system. (Global supply alliances e.g. with SunFoods in California) and global trading activities are instrumental in ensuring rice supply in the most critical markets and even during the recent drought years, SunRice made a profit (SunRice, 2010). There are three rice processing mills in the southern Basin at Leeton, Coleambally and Deniliquin with a combined processing capacity of approximately 1.2 million tonnes a year. The Leeton mill has a capacity of 200,000 to 250,000 tonnes a year produces smaller packed products mainly for the domestic market. The Deniliquin mill is the largest rice processing mill in the southern hemisphere, and has a capacity of 600,000 to 630,000 tonnes a year, although it was 'mothballed' during the worst of the drought years. It processes rice mainly for the export market (Hone et al., 2010).

Only 20 percent of the rice, mostly in the form of long grain and medium grain packet rice products, is sold in Australia, though this comprises about 66 per cent of the domestic retail grocery market volume (Figure 9). Australian rice is only 0.2% of world production but exports (80% of the rice produced) are more than 4% of world trade. Rice is Australia's third largest cereal grain export, and the ninth largest agricultural export. Export success has been driven by innovation and clearly differentiated value propositions based on quality, service, logistics and price. The share of the retail sales dollar earned by the retail sector has increased over the past several years. This is largely due to a combination of increasing retail prices, increasing use of private labelled products and a greater investment in trade spending and promotional activities by marketers. Based on the apparent average net wholesale selling of long grain rice, producers are earning 40% market margins, processors are making 22% profit margins while retailers are earning 38% of the profit margin (DAFF, 2004). The gross value of rice (Table 8) confirms the expected high correlation between water availability and value, following from the correlation between water and production discussed in the previous section. In 2007/08 as a result of very low water availability (almost zero), the gross value of rice was as low as 7 million.

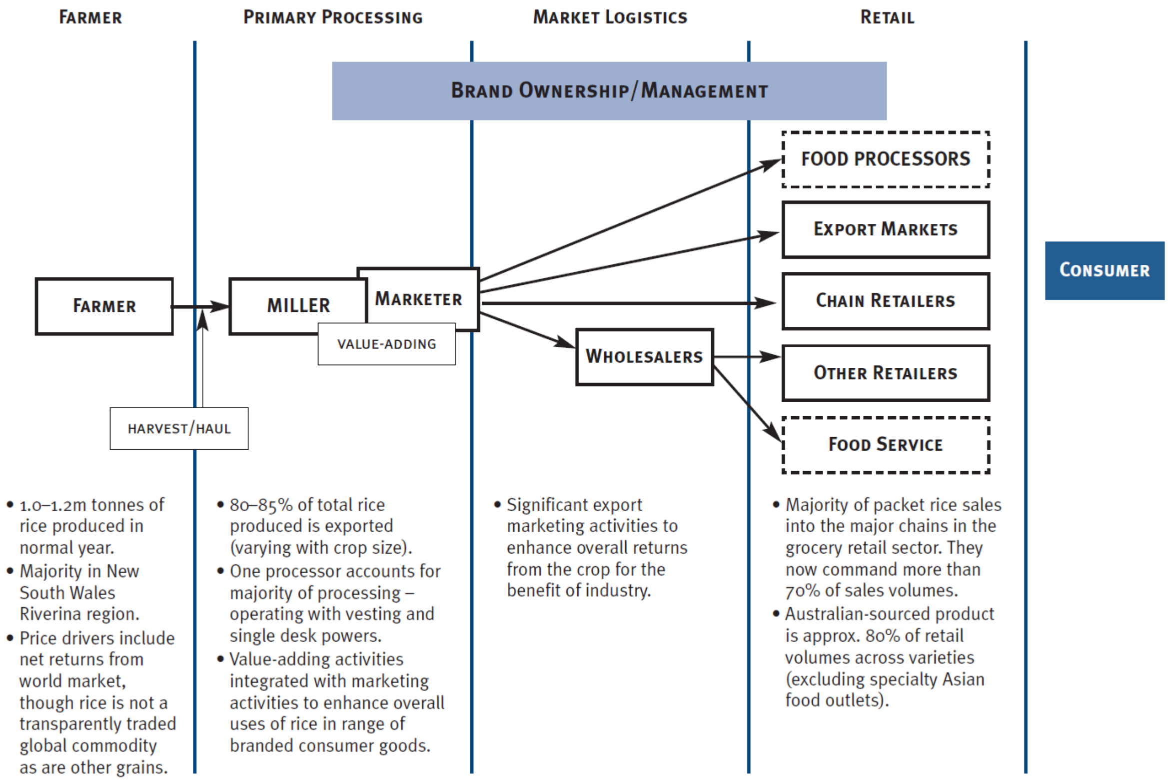

Figure 9 **Rice Value Chain of Riverina Rice**
Source: DAFF, 2004

Hence, the structure of the market is such that the processing and distribution sectors could remain in operation, even if domestic supply remained low, although the incentives to remain in regional areas would be diminished, resting mainly on historical affiliations and the current location of production capital. The global networks have helped to maintain the processing and retail sectors but this also means that parts of the value chain are and could be more so, located off-shore. It can therefore be hypothesized that less water available in the southern area will reduce Gross Domestic Product (GDP) but there will be significant reductions in the Gross Regional Product (GRP) of some regions, especially if and where there are mill closures. The number of rice mills in the growing regions has decreased over time with rationalisation and centralisation.

Table 8 Gross value of rice and value of export of rice industry

	Unit	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Number of rice farms	No.	2291	2392	2494	2296	2342	2129	2499	2261	817	1564	1004	1753	371	38	203	--
Production	kt	951	1388	1331	1390	1101	1760	1192	438	553	339	1003	163	18	61	205	270
Farm gate prices	$/t	207	195	226	213	233	190	274	348	325	297	283	346	414	582	528	517
Volume of commodity exports	kt	605	561	661	637	694	587	580	591	234	271	258	491	78	32	83	142
Value of commodity exports	$m	333	318	402	417	436	369	354	371	145	173	171	347	71	31	78	117
Gross value of rice	$m	197	270	300	296	256	335	327	153	180	101	284	56	7	36	108	140

Source: ABARE, 2010; Rice Marketing Board

5. Methodology

5.1 Project Conceptual Framework

The conceptual framework to examine the impacts of relocation of production at the farm, regional and national levels is set out in Figure 10. The methodology involves crop and farm level estimates of productivity and responses to water scarcity linked to structural adjustment models. The framework recognises that the decisions made by farmers can impact on industries (and vice versa) and local and regional communities. Basically, relocation decisions are driven by expectations about the future profitability of rice farming based on a range of market, social, technological, government policy and environmental considerations. At the regional level the project uses the ACIL Tasman General Equilibrium model. *Tasman Global* is an analytical tool that can capture these linkages on a regional, state, national and global scale. The model enables the analysis of issues at the industry, global, national, state and regional levels and the determination of the impacts of various economic changes on production, consumption and trade at the macroeconomic and industry levels. In the case of the regional rice model, a reference case simulation will be developed (business-as-usual) with which various scenarios will be compared.

5.1.1 Structural adjustment assessment

The empirical analysis for this report evaluates the evidence of structural adjustment in rice farming with increasing water scarcity and a number of hypotheses have been tested using simple regression modelling involving ABARE Farm Survey data. The hypotheses include that water scarcity is is positively correlated with farm size and the area of dryland wheat and negatively correlated with the area of rice. It is also expected that there will be an increase inwater trading in low water availability year when prices are high to support income and an increase in the proportion of off-farm income. Limited data availability on key factors such as water use volumes and trading activity, and for water charges and other costs incurred in the use of irrigation water and length of data sets (only last 20 years of data), restricted the scope of more rigorous modelling.

5.1.2 Regional modelling approach

Tasman Global is a large scale, dynamic, computable general equilibrium (CGE) model of the world economy that is a powerful tool for undertaking economic analysis at the regional, state, national and global levels. CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, starting with individual markets, producers and consumers and building up the system via demands and production from each component.

When an economic shock or change is applied to a model, each of the markets adjusts according to the set of behavioural parameters[3] which are underpinned by economic theory.

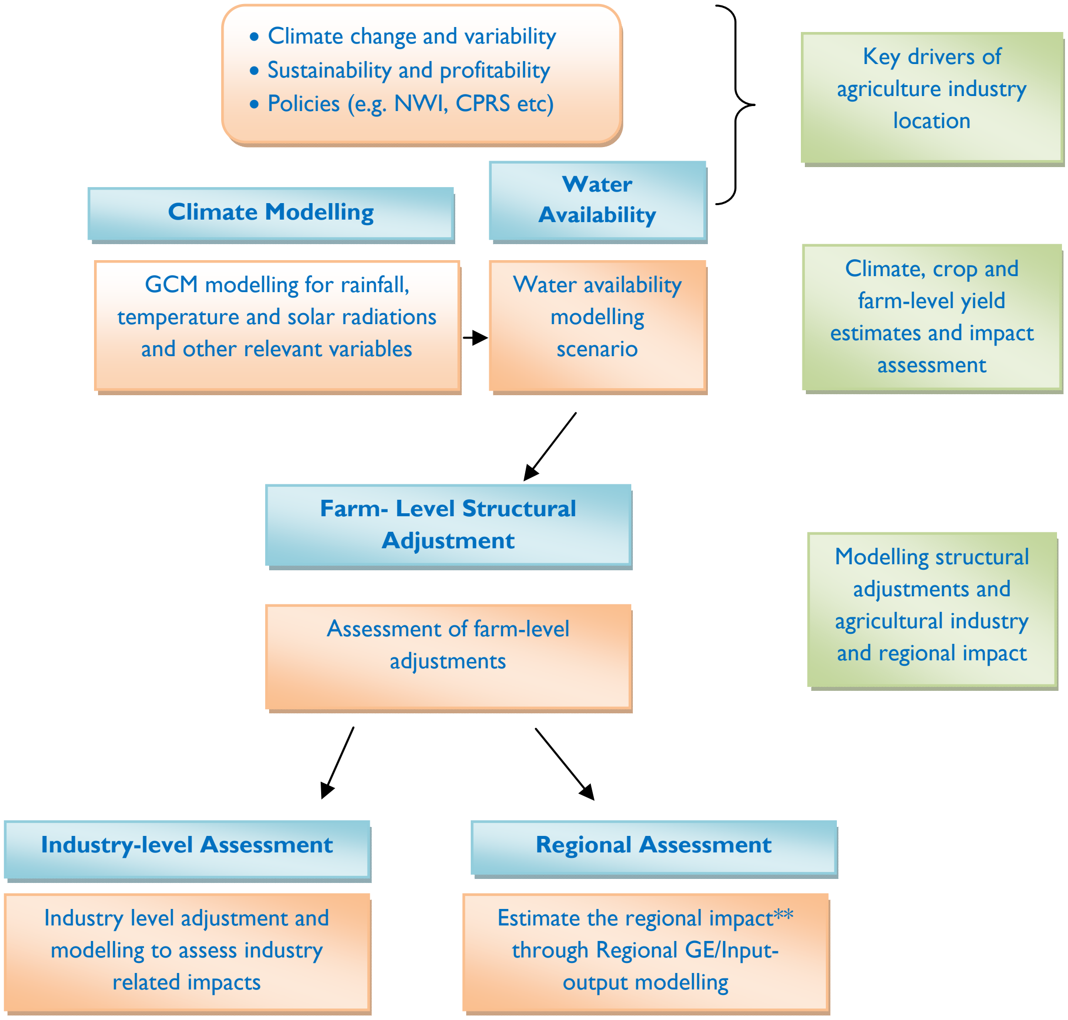

Figure 10 Project conceptual framework

* Net farm level impact = current farm level income ($)-income from next best alternate enterprises

** Net industry impact (e.g. rice) = Direct Economic Impact (Direct value added by rice industry- value added from next best alternative 'dryland' enterprises) + Indirect Economic Impact (Value added by rice industry processing net change in output + All other net indirect effects- Value added by alternate industry processing net change in output + All other net indirect effects)

[3] An example of a behavioural parameter is the *price elasticity of demand* – the responsiveness of demand for a commodity to a change in the price of that commodity.

The generalised nature of CGE models enables a much broader range of analyses to be undertaken (generally in a more robust manner) compared to input-output multiplier techniques, which are also used for economic impact assessments. In addition to recognising the linkages between industries in an economy, general equilibrium models also recognise economic constraints. For example, an increased demand for labour may increase real wages if there is full employment. A key advantage of CGE models is that they capture both the direct and indirect impacts of economic changes while taking account of economic constraints. For example, *Tasman Global* captures the expansion in economic activity driven by investment and at the same time accounts for the constraints faced by an economy in terms of the availability of labour, capital and other inputs. Another key advantage of CGE models is that they capture a wide range of economic impacts across a range of industries in a single consistent framework that enables rigorous assessment of a range of policy scenarios. More detail of the *Tasman Global* model is provided in Appendix III.

5.1.3 Farm level data

The ABARE survey data for Riverina, used in this analysis, provides a broad range of information on the economic performance of farm business units in the rural sector since 1990. Information collected from each farm in the survey included details of area sown, area harvested, quantity produced, quantity sold, gross receipts and the volume of water used for each crop (with dryland and irrigated crops identified separately). Unit prices received per hectare were calculated for each crop from these data. The details of the survey and methods are available at http://www.abare.gov.au/publications_html/surveys/surveys/surveys.html. Apart from the ABARE farm survey and ABS, data from Industry publications such as the Rice Growers'Association (RGA) of Australia and SunRice, Blue Ribbon Seed & Pulse Exporters and irrigation company publications are used in the analysis.

6. Challenges and opportunities: rice industry perspectives and perceptions

In future, water will be more expensive, scarcer and allocations will be less secure, particularly for water intensive industries such as rice. The production capacity of the rice industry will be significantly influenced by droughts and environmental water buy-backs. The rice industry and rice growers have adopted a risk-averse approach. At industry level, the rice industry has global partnership that insures continuous rice supplies during critical periods. At the farm level, during the low water availability years, rice growers trade water as a tactical response and shift to low water intensive or dry land farming. This has resulted in highly variable rice supplies. Opportunities exist however, in further diversifying rice production in northern Queensland and to scope the possibilities, we first talked to key informants in the rice industry.

A semi-structured questionnaire was developed to support discussion with key rice industry personnel regarding (see Appendix IV). The key personals interviewed from the rice industry were:

- Ruth Wade, Executive Director, Rice Growers Association;
- Mike Hedditch, General Manager Grower Services, SunRice;
- Robert Brown, Secretary, Rice Marketing Board, NSW; and
- Stephen Donnelly and James Hunt, Blue Ribbon Seed & Pulse Exporters, Pty Ltd, Brisbane.

The main points of the rice industry perceptions regarding rice relocation include:

Rice industry informants:

- The long-term outlook for the rice industry is around 800 000 tonnes a year. This is based on an expected reduction in long-term water availability because of climate change and water policy reform. This is down from an average of around 1.2 million tonnes during the 1990s, and is similar to the level of production that occurred in the 1980s.
- There is cautious support for considering the relocation of some rice production. Among the two possible areas currently being investigated, Burdekin and Northern Australia (mainly the Ord area), the Ord is considered a slightly better opportunity because of the available water and lack of competition with other crops such as sugarcane.
- Any northern Australian rice would be 'complementary production', with different types of rice, growing seasons and markets.
- Key constraints would likely include insect pests, magpie geese and transportation and production costs. Currently the transportation cost from the north back to the Riverina is about $150/tonne, which is affordable during reasonably high rice market prices but

not so when prices are lower. Similarly, there are reasonably higher transportation costs for fertilisers and other inputs.

- The rice industry may be willing to invest in milling facilities provided sufficient production level (10,000 ha or more) can be maintained over some periods. There are however, interim responses, such as the use of portable mills for first-stage processing.

- There are some concerns regarding medium and long grain rice. Currently, the rice industry is established around medium grain rice, which has plenty of demand in the Middle East and other areas and is different to that produced in areas such as Thailand and India. However, northern area rice production, based on long grain, would have to compete in the international market with rice from Thailand, India and Vietnam etc. Demand for quality medium grain rice has risen in recent years in markets such as Japan.

- The informants are also concerned about skills level and the relevant machinery involved in rice industry, which may not be available when shifting rice production or substituting rice with other crops.

- Organising rice milling facilities and relevant infrastructure involves significant investment therefore direct/indirect subsidies could facilitate the relocation.

Blue Ribbon Seed and Pulse Exporters:

- The regulation of rice production within New South Wales and the occurrence of rice blast (*Magnaporthe grisea*) disease means that production within the Burdekin will need to be self-contained, especially if it is undertaken by growers that are not members of SunRice.

- Rice milling can be conducted in the Burdekin region with export of the finished crop via Townsville. In this way there is no transport of material that may be carrying rice blast conidia. However, this implies a significant capital investment.

- A similar need for infrastructure was discussed, however, there are limited avenues to explore with government and so the development of the industry will have to be done in smaller stages and funded by the growers and exporters.

- There was perceived lack of agronomic knowledge about rice production within the Burdekin region.

- Previous attempts at rice production in the Burdekin used ponded rice which also provides a habitat for magpie geese during the summer. This is largely avoided using overhead irrigation and such systems are well understood by many growers. By contrast, sugar cane production in the Burdekin generally uses furrow irrigation, so there would be additional investment required on some farms.

- Apart from the advantage of having the extra income of a crop during the fallow, rice, cotton and legume crops within the sugar cane production system provide an increase in yield for subsequent sugar cane crops, provide weed suppression, and decrease nitrogen applications.

7. Structural Adjustments in Rice Farming

Structural adjustments reflect the decisions by farmers to continually adjust the size and the nature of their farming operations to improve efficiency and profitability and these decision may contribute to economic growth and raise living standards (Harris, 2006; Nelson et al., 2006; McColl and Young, 2005; Frontier Economics, 2010). These adjustments occur from the interaction over time of a wide variety of natural, social and economic forces. As described by Musgrave (1982), structural change is the aggregate response, at the regional, industry and national level to the myriad of adjustment decisions made at the firm or individual level. The changes are often incremental and can lead to a gradual reduction in the number of farmers and increase farm holding size. Economic principles suggest risk management (including climate risks), competition, productivity changes, reduction in market support, and world price signals create incentives for farmers to make rapid changes that will maintain or improve their profitability. Structural adjustment is an essential ingredient for improvements in farm performance and the movement of resources between industries (Harris, 2006).

Australian long term trends show structural change is an integral part of the rural sector. Australian farmers, as a whole, and Australian rural communities have demonstrated great skill and capacity in adjusting to changing circumstances. Harris (2006) has evaluated key developments aspects associated with structural change in Australia. They include:

- Farm numbers have declined by about 13% over the past 10 years;
- About 45% of farms have an off-farm income – up from 30% in the early 1990s;
- The average farm size has increased by 23% over the past 20 years; and
- Productivity growth has increased by almost 3% a year over the past 30 years.

There have been, at least, ten rural structural adjustment schemes since the 1930s, each building upon the knowledge gained from those that came before them (McColl and Young, 2005) but most structural change in Australia is autonomous (undertaken by the farm business without external assistance).

7.1 Characteristics and drivers of structural adjustment in rice farms

Rice farmers are continually faced with pressures to adjust to changing environmental, climatic and economic conditions. The external drivers of structural adjustment in Australian agriculture include declining terms of trade, technology induced productivity changes, and productivity changes associated with changes in the natural resource base including climate (Hyder Consulting, 2010). Frontier Economics (2010) has summarised water and non-water related key pressure points relevant to structural adjustment major crops, including for rice (Table 9). Among others, prolonged drought, climate change, the new MDB plan and commodity and water markets rank very high/high as major driver to adjustments in rice farming systems.

Table 9 Water and non-water related pressure points relevant to structural adjustment for rice

Pressure Factors	Background discussions	Ranking
Commodity prices	Highly variable due to changes in world production and exchange rates.	High
Production costs	A major driver of structural change since farmers are generally price takers. Cost management drives technological change and property aggregation.	High
Social, technological and legacy factors	The relative importance of the agricultural sector in regional economies is declining. There is an overall decrease in agricultural employment, aging of farmers, young people leaving rural areas and a general movement of people and services from small towns to regional centres.	Medium/ Low*
Other government policy	Drought assistance distorts and delays adjustment decisions. Land use planning and policy will be important in managing the impacts of change, including the need for further farm consolidation and pressures from competing land uses.	Medium*
Prolonged drought	Major reduction in rice production	Very high
Climate change	Uncertain but potentially very high impact, due to water availability impacts, severe weather events and market impacts due to changes in global agricultural commodity markets.	High*
Competing uses	Demand from urban users depends on climate change and drought.	Medium
Buyback	The buyback will have a significant impact on water availability for irrigation. Irrigators are given a financial injection, which may not be available under a planned reduction in water availability	Medium/ High
The Basin Plan	Uncertain. The impact depends on additional reduction in water availability due to SDLs, in addition to the buyback program, and how this is shared in wet and dry sequences. The extent of market, drought and climate change driven adjustment before the Basin Plan is adopted will also be important. Risk assignment provisions are uncertain and could influence adjustment outcomes.	High*
Water markets and trade barriers	Water markets have been critical in reducing the impacts of drought. The overall movement of water out of irrigation districts in the southern system (i.e. from dairy and rice to horticulture) is much less than the reductions due to drought.	High/Medium*
Irrigation charges and termination fees	Generally expected to be of less importance compared to other factors, but major increases in prices will increase farm costs and competitiveness. Where triggered, termination fees effectively decrease the net return from water entitlement sales or the underlying value of the land that is ceasing to be irrigated.	Low*
Public investment in irrigation renewal	Uncertain but potentially high. There are risks that these projects will: distort private investment, result in inefficient / inappropriate irrigation infrastructure that fails to recognise the impacts of reduced water availability, be inappropriately sequenced with buyback, restrict buyback in renewal areas, force adjustment, and result in poor adjustment decisions by irrigators due to information asymmetries.	High/ Medium*

Metering policy	Lack of clarity about cost-sharing and implementation creates uncertainty.	Low*

Source: Frontier Economics (2010)
Ranking: very high, high, medium, low, very low
* Authors Assessment

Hyder Consulting (2010) has conducted a detailed investigation of adaptation options for rice farmers managing lower water allocations in the Central Murray area. Through face-to-face interviews, a diverse range of responses were generated from rice growers when asked about what they saw as the major changes to the industry over the last 10 years (Table 10). The most common observed change was reduced water availability/allocations, which was not surprising considering the direct effect water availability has had on rice production (CSIRO 2008). Development of more suitable rice varieties was also identified as major challenge. None of the respondents identified improvements in technologies such as laser levelling and water recycling as major changes. Interestingly, a range of social changes, including population decline, declining community morale, labour scarcity and loss of businesses and community services ranked highly as being a change in the rice industry.

Additionally, through the questionnaire, Hyder Consulting (2010), Sanders et al. (2010) and Marsden Jacob Associates et al. (2010), observed the following adjustments in the key rice growing regions over the last 10 years:

- Seven out of 13 respondent stated they had increased farm size. This included the purchase of additional land (both dryland and irrigated land);
- Eight out of 13 do not grow rice during low water availability years;
- When water is not available for rice farming other sources of income are generated. During 2009/10, only 4 respondents used their entire water allocation to grow rice while others sold water. Overall, out of 13 respondents, 10 sold temporary water allocations and three permanent water entitlements;
- Alternative crops are generally planted during winter. These include cereals such as wheat and barley. Six respondents also used livestock, particularly sheep, as an alternative source of income. However, in general sheep flocks are also declining;
- A number of respondents to the rice survey also had off-farm sources of income. These included investments in the share market, off-farm employment, contract sowing and harvesting and operating a produce store;
- One broadacre rice farmer altered his crop mix by reducing the amount of (water intensive) rice planted from 49 hectares to 16 hectares, while another completely changed his crop mix from predominantly rice and grain to a less water intensive mixture of rockmelons and pumpkins (Sanders et al., 2010); and
- Marsden Jacob Associates et al. (2010), found that with reductions of 20% in water availability relative to the long-term average, a quarter of rice farmers would exit and a further quarter would change their activity, but half would not change their activities. Furthermore, with reductions of 40% in water availability from the long-term average, more

than half would seek to exit. Those rice farmers who remained on farm would effectively exit rice production and shift to less water demanding cereal crops. In addition, at the 20% scenario about 20% of farmers would increase borrowings, and at the 40% scenario about 10% would seek more off-farm income.

Table 10 Major changes in the rice industry, as identified by local rice growers

Major changes	Number of responses
Reduced water availability/allocations	10
Development of more suited rice varieties (e.g. cold tolerant & use less water)	4
Population decline (young people leaving the area; aging population)	4
Loss of businesses in rural centres	3
Decreasing community morale (increasing suicide rates, less optimistic)	2
Labour scarcity	2
Loss of services – community & industry (e.g. DPI agronomists)	2
Drought	2
De-regulation of marketing arrangements (removal of single desk)	2
Rising input costs (e.g. fertilisers)	2
Limited research & development (government & industry)	2
Increased dependency on other revenue streams; diversification of revenue sources	2
Timing of announcements of water allocations	1
Mill closures	1
Lack of rice crops	1
Over-importance of climate change	1

Source: Hyder Consulting, 2010.

The rice industry, as with all agricultural industries is subject to considerable structural adjustment pressures. The monopoly marketing arrangements may have contributed to some degree of price stabilisation but the industry is highly exposed to world markets, with many competitor countries that have low wage costs. The Australian competitive advantage is in scale of production, natural resources and efficient water use.

7.2 Empirical evidence of structural change in rice farming

In this section, we use the production data to test the proposition that rice production is sensitive to water availability.

7.2.1 Farm sizes, irrigated area and rice area

As noted earlier, rice farms are relatively more flexible in farm adjustment and structural change compared to purely dry land farms. This flexibility allows them to reduce rice area and shift to less intensive crops. It is hypothesised that increased water scarcity in the Riverina leads to an increase in farm size while reducing total rice and irrigated area. Figure 11-15 validate the hypotheses. On the other hand, the total operated farm area is increasing significantly. The increase in farm operated area could be easily attributed to the decreasing number of farms (including rice farms – see Figure 3) and temporary and permanent water trading. The results are similar to the general findings of the literature and as observed by Hyder Consulting (2010).

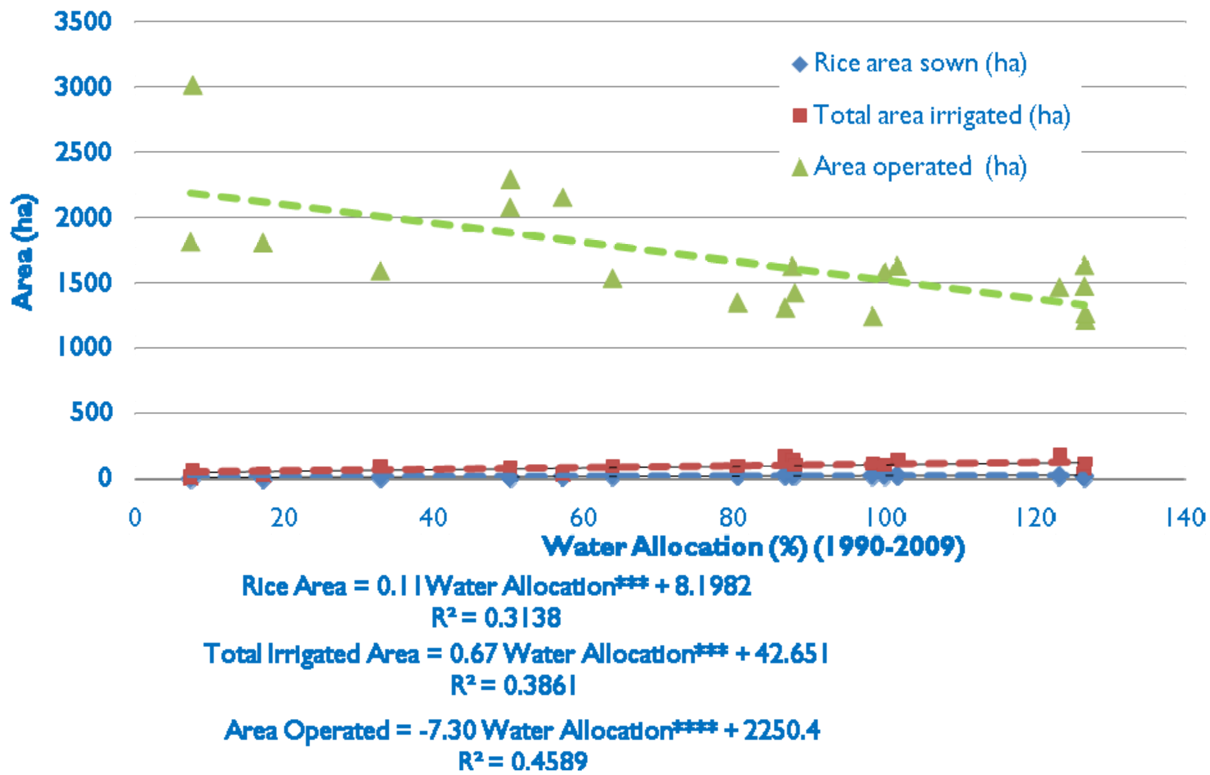

Figure 11 **Water Availability, Rice Area, Total Irrigated Area and Area Operated (per farm) Riverina, NSW**

Source: ABARE Farm Survey

*** shows significant at P <0.01

7.2.2 Crop shifting: rice to wheat

An assessment of crop shifting (e.g. rice to wheat) for the Riverina (as shown in Figure 12 and Figure 13) indicates that farmers are continuously adapting to climate variability and climate change (and as a result reduced water availability) through changing crop mixes and farm restructuring. The regression results indicate that rice area per farm is generally declining and being replaced by winter dryland wheat. Some farmers have adjusted their farming operation by shifting from rice to dryland wheat. The reduction in rice (and the increase in wheat area) will have some broader level industry related impacts. For example, rice industry mills and storage depots were left stranded and shut down as a result of lower level of rice supply during 2007/08 and there was an increase in use of rice from overseas to keep SunRice output up, with some of that processing occurring in overseas locations.

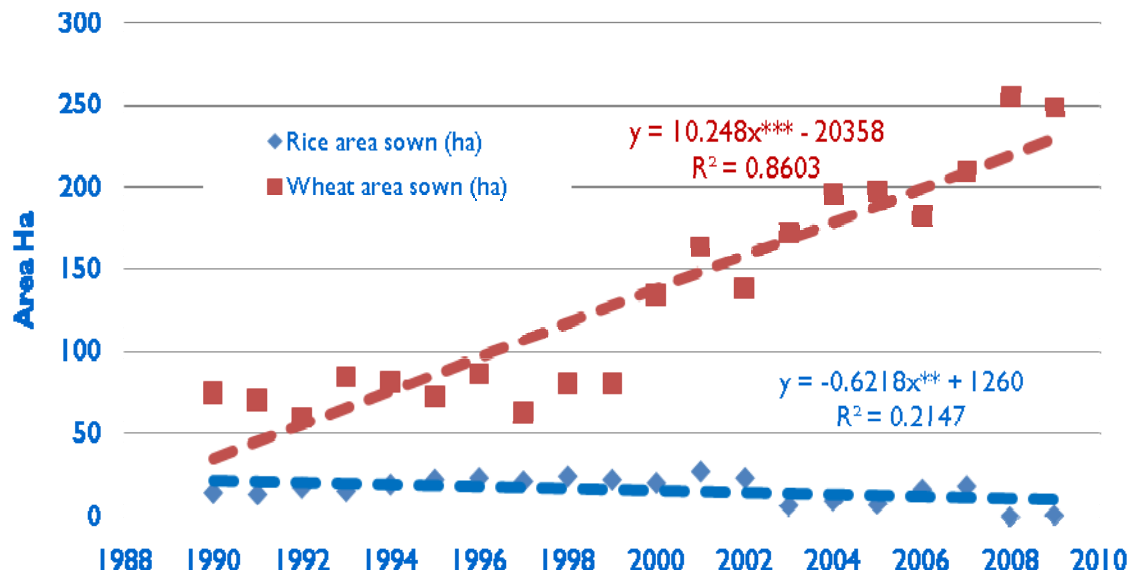

Figure 12 Rice and wheat production by area per farm in the Riverina from 1988-2010, NSW

Source: ABARE Farm Survey

*** shows significant at P <0.01; ** show significant at P<0.05

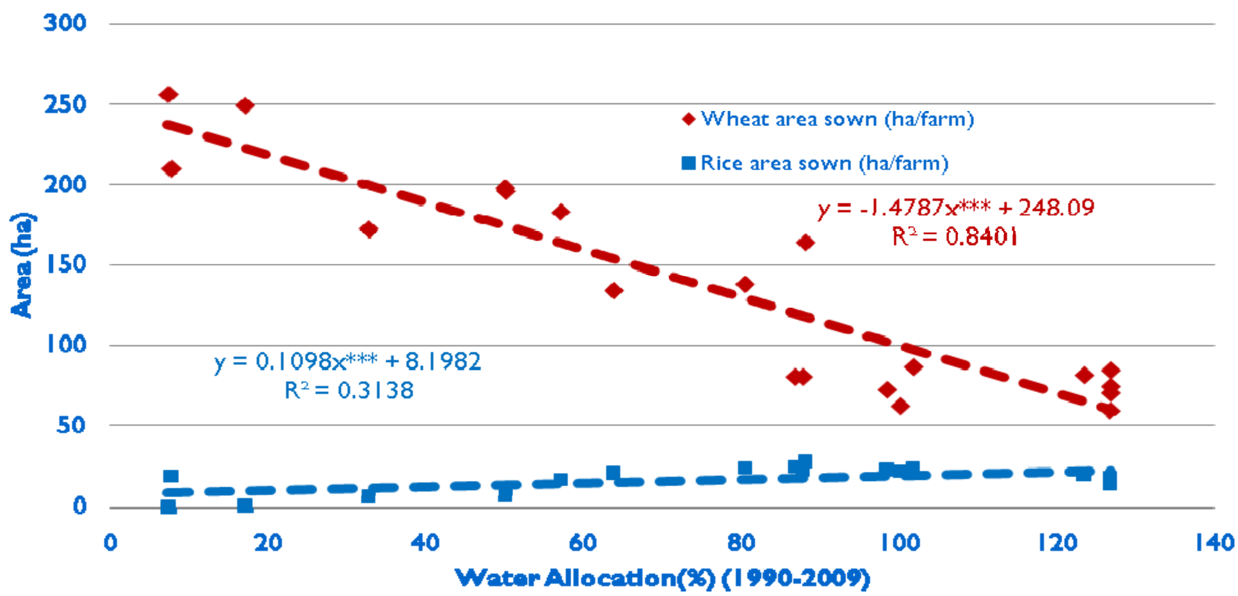

Figure 13 **Water allocation and wheat and rice production by area per farm in Riverina from 1992-2009, NSW**
Source: ABARE Farm Survey
*** shows significant at P <0.01

7.2.3 Rice area and water trading

Policy changes during the 1990s, including water pricing reforms and the introduction of water markets, have resulted in increased pressure on farm adjustment and structural change (Blackmore & Keyworth, 1994). Bjornlund and McKay (1999) showed that water markets facilitate the ongoing process of farm adjustment and structural change within the irrigation industry. Water has moved to more efficient and higher value producing properties and is consolidating into farming units of more viable sizes without showing evidence of a corporate takeover of the industry. To maintain a liveable income during drought periods, when water allocations are low and prices are relatively high, some farmers adjust their operations by temporarily trading water to take advantage of higher water prices. There are also farmers who have traded water permanently to take advantage of *Water for the Future* program that has set aside AU$3.1 billion over 10 years to buy environmental water from irrigators in the Murray-Darling Basin. Figure 14 shows water market behaviour in the Murray Irrigation Area. During 2007/08, water trading prices were high compared to other years because of drought; during this year general security seasonal water allocations were 0% of the total water entitlements.

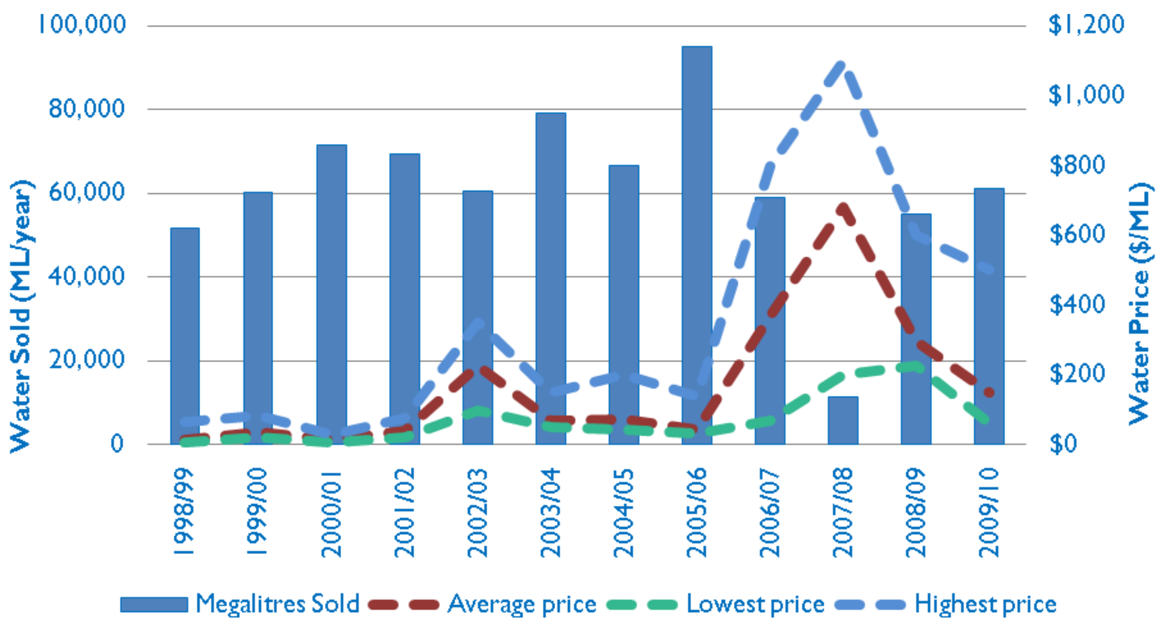

Figure 14 **Temporary water trading price dispersion and water sale.**
Data source: Murray Irrigation Limited (2010)

Figure 15 shows the relationship of water trading to rice area in the Coleambally Irrigation Area (CIA), Riverina (NSW); rice area is significantly influenced by the trading in of water. However, over the last 5 years CIA is trading-out water to satisfy the demand of high value crops. In some instances, farmers have purchased temporary groundwater in order to continue growing relatively water intensive crops, including rice (Sanders et al., 2010). This could be perhaps to satisfy forward contracts.

7.2.4 Rice area and price

Rice prices provide important signals to farmers to make rapid adjustment to their farming operation to maintain or improve their profitability. The rice area and price relationship was modelled using change in area against lagged changes in rice prices from the previous year involving longer term ABARE data and ABARE Farm Survey data[4] (Figure 16 and Figure 17). The relationship was not found to be significant but the positive coefficient of lagged rice price shows a direct relationship with rice area, and indicates that price does influence rice area. Hence, if water becomes scarce and therefore more expensive, either in actual or opportunity costs, this suggests that producers will still consider rice if and when the price is high enough.

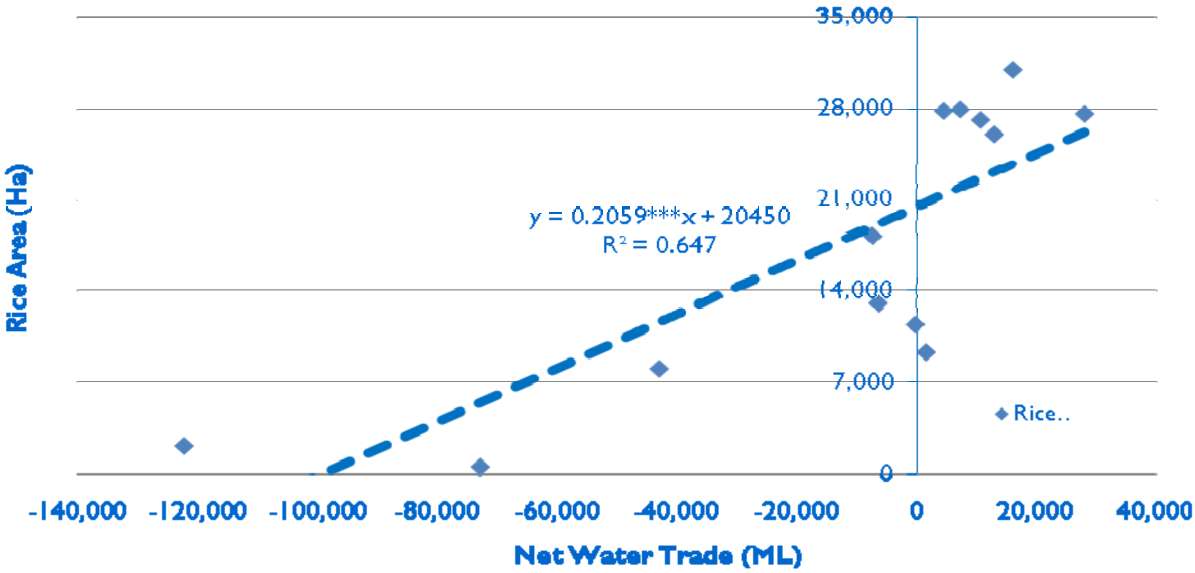

Figure 15 Relationship of net water trading (water trading in-water trading out) and rice area in the Coleambally Irrigation Area, Riverina (NSW)

Source: Source: ABARE Farm Survey

*** shows significant at P <0.01

[4] Due to relatively small farm sample, and as result high variability, only those observations with low standard error were included

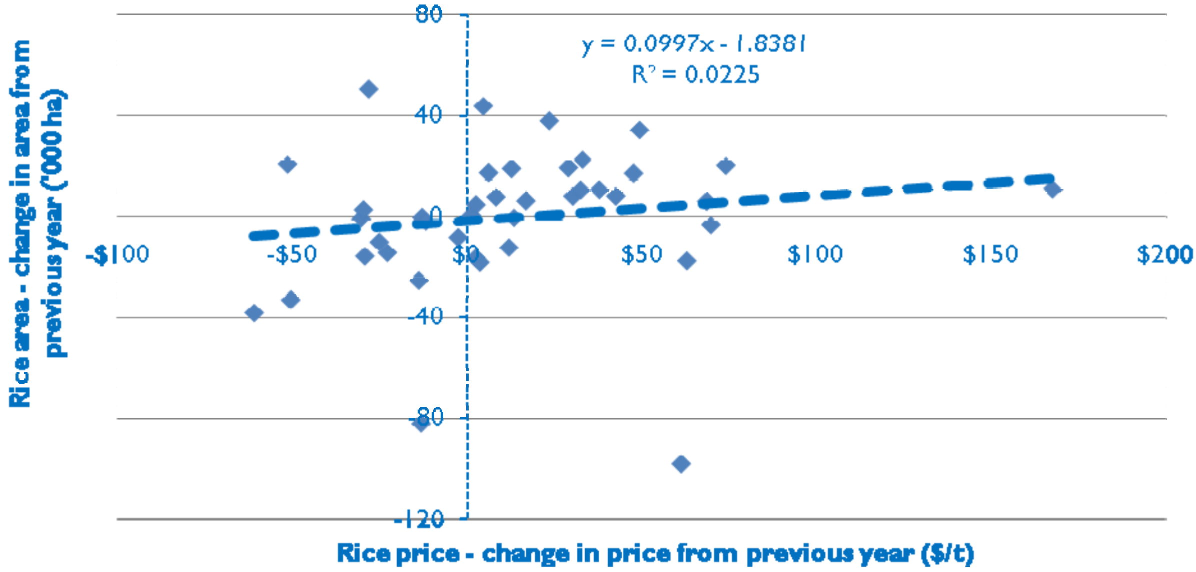

Figure 16 **Relationship of rice area to price**

Source: ABARE, 2010

Model used: $\Delta A = \alpha 0 + \alpha 1 \ \Delta(Price^{-1})$

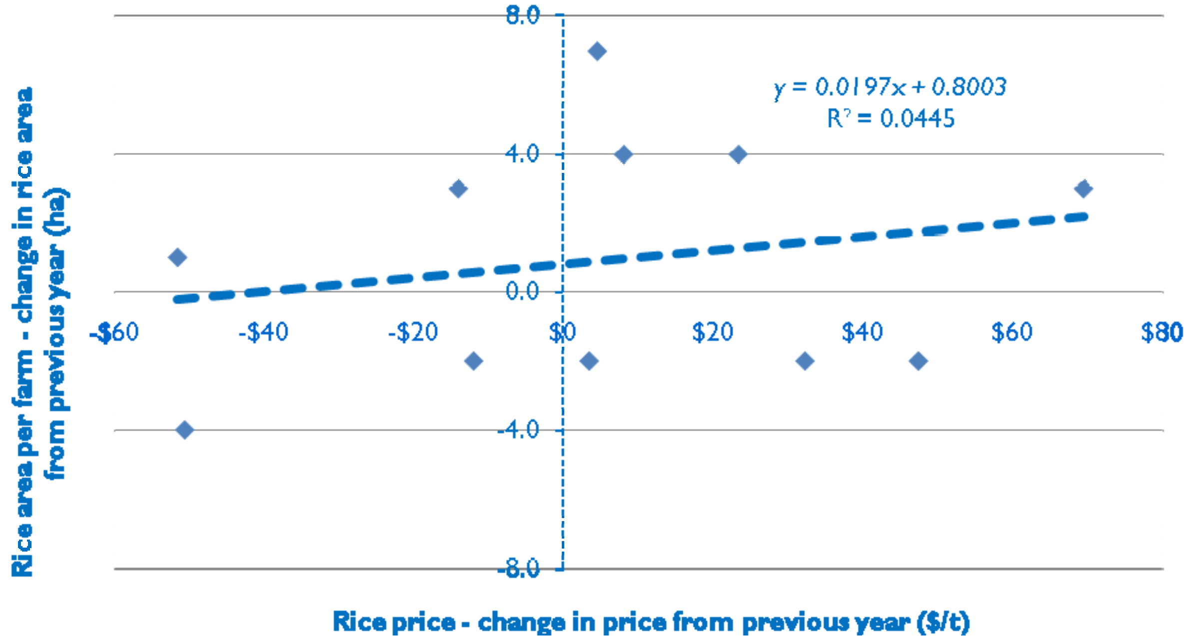

Figure 17 **Relationship of rice area per farm to price**

Source: ABARE Farm Survey, 2010

Model used: $\Delta A = \alpha 0 + \alpha 1 \ \Delta(Price^{-1})$

7.2.5 Financial impact

The reductions in the available water have significantly influenced farm business profit and overall family income. Figure 18 indicates that farm businesses are no longer making economic profits. Farmers have managed to sustain family income through off-farm activities but a sheer decline in agricultural profit is reducing overall family income. During 2007-2008, average family income per farm was –$16,982 and –$27,883, respectively. Clearly, this is not sustainable in the long-run, considering climate change and considerable adjustment (in terms of cropping pattern or off-farm activities) will be required to sustain reasonable family income.

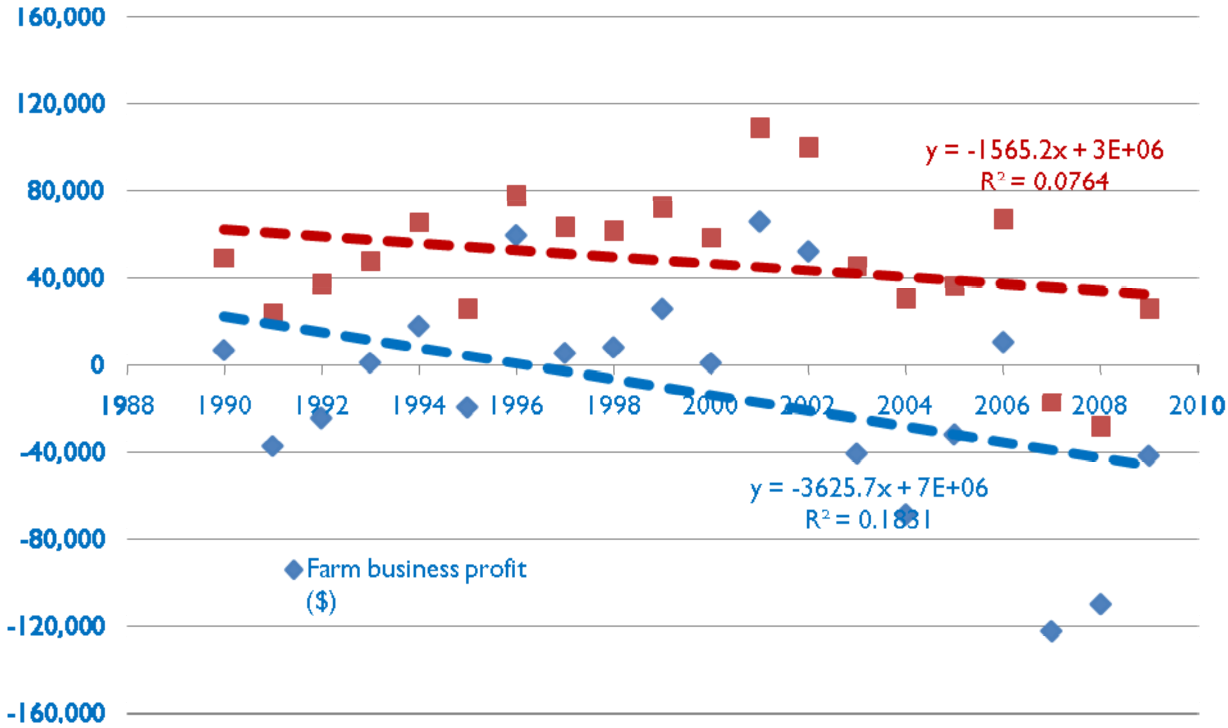

Figure 18 **Average Farm Business Profit and Total Family Income, Riverina, NSW**

Source: ABARE Farm Survey

Where: Farm business profit ($): Farm business profit equals farm cash income plus buildup in trading stocks, less depreciation expense, less the imputed value of the owner manager, partner(s) and family labour. Total family income ($):Family share of farm cash income less family share of depreciation plus all off- farm income of owner manager and spouse

8. Regional impact of relocating rice farming to northern Queensland

8.1 Rice relocation scenarios

In this section, the regional impacts of decreasing rice production in the MDB and increasing it in the Burdekin, are estimated using a CGE model. Scenarios are developed to simulate climate change and water buy-backs (in the MIA).

8.1.1 Baseline scenario:

For the baseline scenario, 2004 water availability was selected with no reduction in rice. Over the last decade water availability fluctuated significantly in Riverina so the baseline scenario assumes, an average water availability (50% allocation) with irrigators operating close to their historical average levels of production.

8.1.2 Scenario 1: Rice grown in fallow sugarcane land with no competition with sugarcane

In this scenario, it is assumed that rice is grown as a break or fallow crop for sugarcane every 4 years. That is, between each planting of a new crop of sugar cane there is a rice crop, since sugar can ratoon several times. As noted earlier, this may have benefits in regard to disease control and soil condition, as is often the case with crop rotations, however this would need more research, as recommended later.

There is an additional possibility, in that the Burdekin (Falls) Dam system could be further developed to expand the area of irrigated land, most likely to the inland of the current system. A 'Stage Two', whereby the current dam wall height is increased has been a subject of discussion since the existing structure was completed, Thus, this might provide the opportunity for opening up areas to new crops, where sugar would not be displaced. On the other hand, it may be that landowners would still select sugar. Nonetheless, we include the scheme expansion in one scenario to show the regional impacts.

Finally, we examine the impacts of displacing sugar for rice to show the effects of competitive, as opposed to complementary industry development. This scenario is designed to provide an indication of the potential competition for land that could occur if the Australian rice industry is preferentially maintained at the expense of other activities, especially given that on a 'dollars per hectare' basis, a hectare of land dedicated to sugar cane production is generally of higher value a hectare dedicated to rice.

Part A: 2030 climate with new MDB CAP in place

- ***For the Riverina:*** Based on Sustainable yield project's (CSIRO 2008a) best estimates with future development scenario) runoff will decrease by 11 %. Assuming a further 4% reduction in water availability as a result of new MDB cap, it is expected that a total of 15% reduction may occur, compared with baseline scenario (50% water availability). Usually, rice production tends to decline at a greater rate than the respective decline in water availability (Marsden Jacob Associates et al., 2010). Using a simple regression model involving rice areas as function of water availability, a 15% reduction in water availability will reduce rice area by about 18,500 ha, from an average of 75,255 ha, a 24.7% reduction. For simplicity, is it assumed that similar area will be converted in to irrigated and dryland wheat—10,000 ha to irrigated wheat (with 1-2 irrigations) and 8,500 ha to dry land wheat.

- ***For the Burdekin:*** Based on the information from the Blue Ribbon Seed and Pulse Exporter (Rice Company), about 17,000 ha of sugarcane fallow is available each year, which is about 25% of the average total sugarcane area in Burdekin (ABS (2010). Therefore, it is assumed that 20,000ha of fallow land will be available each year for rice. Furthermore, we assume 25% of this additional rice will be grown in winter (dry season rice) and 75% in summer (wet season rice). The expected yield (trial yield) of winter rice is about 7-8 tons while summer rice yield is about 4-5 tons.

Part B: 2070 climate with new MDB CAP in place.

- ***For the Riverina:*** Based on CSIRO 2008 under median global warming, runoff will decrease by ~26-27 % and with a further 4% further reduction in water availability from the MDB cap, a total of 30% reduction may occur, compared with baseline scenario. Using a simple regression model involving rice areas as function of water availability, a 30% reduction in water availability will reduce rice area by about 37,200 ha (a 49.4% reduction). For simplicity, is it assumed that similar area will be converted into irrigated and dryland wheat—20,000ha to irrigated wheat (with 1-2 irrigation) and 17,200 ha to dry land wheat.

- ***For the Burdekin***. It is assumed that 20,000ha of fallow land will be available for rice. Also another additional 17,200 ha of land will be available for rice crops (without competition). That is, additional land is opened up in Stage Two of the irrigation scheme. Furthermore, we assume 25% of this additional rice will be grown in winter (dry season rice) and 75% in summer (wet season rice). The expected (trial) yield of winter rice is about 7-8 tons while summer rice yield is about 4-5 tons.

8.1.3 Scenario 2: Rice grown in displaced sugarcane land with competition with sugarcane

In Scenario 2, there is competition between rice and sugarcane with no additional land available. Any additional rice grown will displaces sugarcane crop.

Part A: 2030 climate with new MDB CAP in place

- ***For the Riverina:*** same as scenario 1.

- ***For the Burdekin:*** There is competition between rice and sugarcane. As a result, assuming additional water availability, 20,000 ha of rice will displace 20,000 ha of sugarcane. The yield assumptions remain the same as scenario 1.

Part B: 2070 climate with new MDB CAP in place.

- ***For the Riverina:*** same as scenario 1

- ***For the Burdekin:*** There is competition between rice and sugarcane. As a result, assuming additional water availability, 37,200 ha of rice will displace 37,200 ha of sugarcane. Yield assumptions remain the same as scenario 1.

8.1.4 Scenario 3: Rice grown in additional available land with no competition with sugarcane

This is the opposite of Scenario 2, which assumed no competition for the irrigated land in the Burdekin. This scenario explores the other 'extreme' of full competition for irrigated land. As discussed in previous scenarios, yield and water availability assumptions remain the same.

8.2 Regional economic impact analysis: application of a General Equilibrium Model

8.2.1 Framework of analysis

For this analysis, ACIL Tasman's CGE model, *Tasman Global*, was used to estimate the economic impacts at the regional level. CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, starting with individual markets, producers and consumers and building up the system via demands and production from each component. When an economic shock or change is applied to a model, each of the markets adjusts according to the set of behavioural parameters[5] which are underpinned by economic theory. The generalised nature of CGE models enables a much broader range of analysis to be undertaken (generally in a more robust manner) compared to input-output multiplier techniques, which are also often applied in economic impact assessments. In addition to recognising the linkages between industries in an economy, general equilibrium models also recognise economic constraints. For example, increased demand for labour may increase real wages if there is full employment.

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[5] An example of a behavioural parameter is the *price elasticity of demand* – the responsiveness of demand for a commodity to a change in the price of that commodity.

A key advantage of CGE models is that they capture both the direct and indirect impacts of economic changes while taking account of economic constraints. For example, *Tasman Global* captures the expansion in economic activity driven by an investment, and at the same time accounts for the constraints faced by an economy in terms of availability of labour, capital and other inputs. Another key advantage of CGE models is that they capture a wide range of economic impacts across a wide range of industries in a single consistent framework that enables rigorous assessment of a range of policy scenarios.

8.2.2 Database aggregation

The database which underpins the model contains a wealth of sectoral detail. The foundation of this information is the input-output tables that underpin the database. Industries and regions in the model can be aggregated or disaggregated as required for a specific project. For this project the model has been aggregated to:

- Four levels, namely the 'Southern Rice region', the Burdekin local government area (LGA), the Rest of Australia and the Rest of the World. The Southern Rice region is an amalgamation of the Murray statistical division (SD) and the Murrumbidgee SD[6] which encompasses all current rice growing and rice processing areas in south-eastern Australia. Maps of the Southern Rice region and the Burdekin LGA are provided in Figure 19.

- 34 industries/commodities as presented in Table 11. This aggregation was chosen to provide the maximum detail possible for the key industries related to this analysis.

Riverina **Burdekin LGA**

[6] The closure of the Echuca rice mill in 2003 has been assumed to be permanent and therefore the Campaspe-Echuca SLA was not included in this analysis. The rice mills at Coleambally, Deniliquin and Leeton are all within the Southern Rice region.

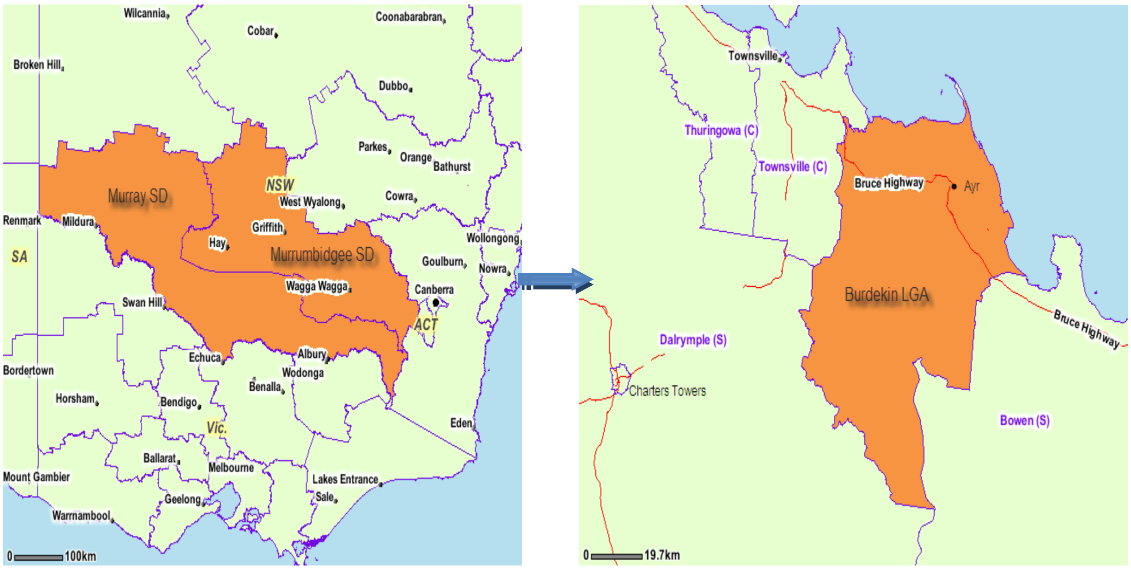

Figure 19 **Maps of the key regions for this analysis**

Source: Data source: ABS and ACIL Tasman

Table 11 Industry/Commodity aggregation used in Tasman Global modelling

	Industry/Commodity		Industry/Commodity
1	Paddy rice	18	Oil
2	Wheat	19	Gas
3	Cereal grains nec	20	Other mining
4	Vegetables, fruit, nuts	21	Electricity
5	Oil seeds	22	Petroleum and coal products
6	Sugar cane, sugar beet	23	Iron and steel
7	Plant-based fibres	24	Nonferrous metals
8	Crops nec	25	Nonmetallic minerals (including cement, plaster, gravel)
9	Bovine cattle, sheep and goats, horses	26	Chemicals, rubber, plastics
10	Animal products nec	27	Manufacturing
11	Raw milk	28	Water
12	Wool, silk-worm cocoons	29	Construction
13	Fishing and forestry	30	Trade services (includes all retail and wholesale trade, hotels and restaurants)
14	Processed rice	31	Transport services
15	Processed Sugar	32	Other business services
16	Other processed food	33	Government services (including public administration and defence)
17	Coal	34	Dwellings

Note: nec = not elsewhere classified

8.2.3 Reference case assumptions

An important element of the CGE analysis is the development of a reference case, against which the impact of alternative policies can be modelled. The outcomes of this modelling are then reported as deviations from the reference case – as shown in Figure 20.

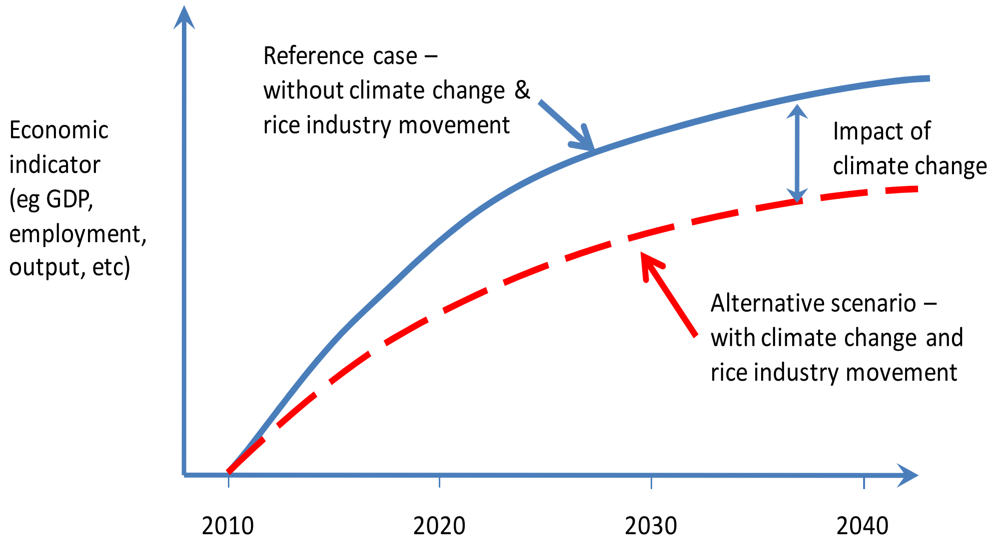

Figure 20 Estimating the impact of alternative policies (illustrative example)

To eliminate the impact of price movements in the results, economic variables such as the change in economic output are reported as deviations from their real rather than nominal values. Similarly, all aspects not directly related to the assumed changes in the rice industry have been kept constant across all the scenarios (including, for example, productivity growth, national population and all demand and supply elasticities).

In the reference case, the pattern and rate of real economic growth is a function of assumptions about:

- changes in population – including changes in the number of people of working age (15 years old and over)
- changes in workforce participation rates
- changes in the unemployment rate
- changes in average hours worked
- growth in labour productivity – defined here as the average output per hour worked.

These factors underlie the projected change in State real GSP and Australian real GDP. The projection of each of these elements is discussed in the following sections.

8.2.4 Population growth

Population growth is an important determinant of economic growth through the supply of labour and the demand for final goods and services. Population growth for 112 international regions and the 8 states and territories of Australia represented in the *Tasman Global* database has been projected using ACIL Tasman's in-house demographic model. The demographic model projects how the population in each region grows and how age and gender composition changes over time. It is an important tool for determining the changes in regional labour supply and total population over the projection period.

For each of the 120 regions, the model projects the changes in age-specific birth, mortality and net migration rates by gender for 101 age cohorts (0-99 and 100+). The demographic model also projects changes in participation rates by gender by age for each region, and, when combined with the age and gender composition of the population, endogenously projects the future supply of labour in each region. Changes in life expectancy are a function of income per person as well as assumed technical progress on lowering mortality rates for a given income (for example, reducing malaria-related mortality through better medicines, education, governance etc). Participation rates are a function of life expectancy as well as expected changes in higher education rates, fertility rates and changes in the work force as a share of the total population.

For this analysis, global population is projected to increase over the study period by 0.83 per cent a year, increasing the global population, for example, from around 6.7 billion in 2008 to 8.03 billion in 2030. Most of this growth occurs in the next decade, with the average annual growth projected to be 0.95 per cent a year to 2020, falling to 0.67 per cent a year between 2020 and 2030. The slowing rate of growth is due to continuing declines in fertility rates across developing countries coupled with ageing population effects across developed economies and some developing economies such as China. For example, Japan's population is projected to decline from the 2009 calendar year while the population of the European Union over the period is projected to increase moderately before falling back to current levels around 2022.

Population growth for the eight Australian states and territories incorporates all the latest ABS information on population levels, fertility, mortality and migration rates. The total Australian population in 2020 and 2030 is projected to be 26.8 and 30.2 million, respectively. The annual population growth rate projections used for each Australian state and territory are presented in Figure 21.

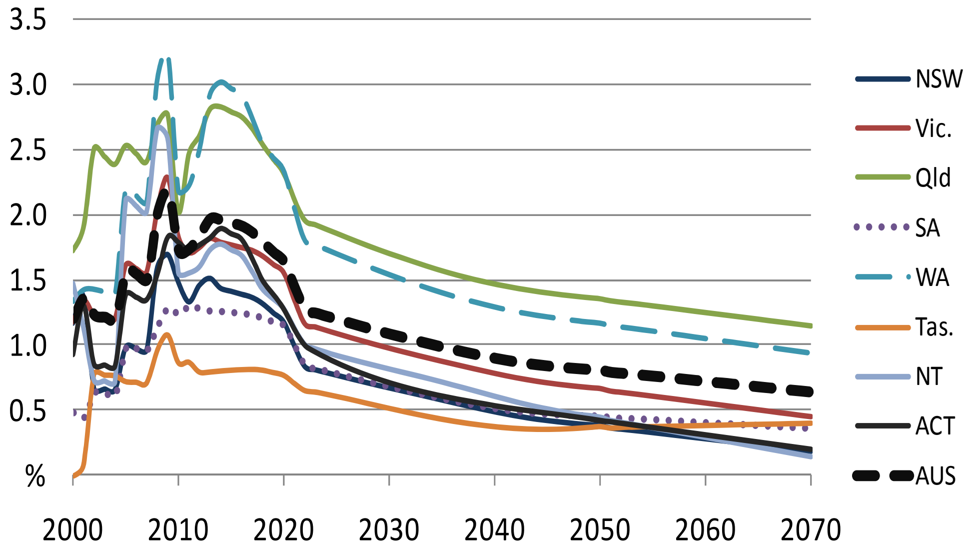

Figure 21 **Projected growth in population, Baseline scenario (per cent, year on year)**

Note: All years are financial years ending June 30.

Source: ACIL Tasman projections

For the Burdekin and Southern Rice regions, recent state government regional population growth rates have been applied to the latest ABS estimates of regional population. More specifically, total population in the Burdekin is projected to fall slightly from around 18,405 in 2009-10 to 18,238 by 2029-30 while the total population of the Southern Rice region is expected to grow from around 278 thousand in 2009-10 to 291 thousand in 2029-30 (Table 12). The declining population growth in the Burdekin region is projected to reverse as Queensland continues to grow such that by 2069-70, the total population in the region is projected to reach 18,576. The Southern Rice region is projected to continue to grow moderately reaching 294,671 people by 2069-70 (Table 12).

Table 12 **Regional population forecasts**

	2005-06	2008-09	2009-10	2019-20	2029-30	2069-2070
	people	people	people	people	people	people
Southern Rice region	269,483	277,133	278,075	285,853	290,515	294,671
Burdekin LGA	18,085	18,431	18,405	18,319	18,238	18,576

Data source: ABS estimates for 2005-06 and 2008-09, catalogue number 1379.0 released 22 November 2009. Other years are ACIL Tasman estimates using growth rates from NSW Department of Planning (2008) and Queensland Department of Infrastructure and Planning (2008).

8.2.5 Labour supply

Labour supply is derived from the combination of the projected regional population by age by gender and the projected regional participation rates by age by gender. Over the projection period labour supply in most regions is projected to grow more slowly than total population as a result of the ageing population. The labour supply growth projections used for the Southern Rice region, Burdekin LGA and Australia are shown in Figure 22. For this analysis, the Burdekin LGA and Southern Rice region have been assumed to experience the same changes in participation rates as the state averages (see Figure 23).

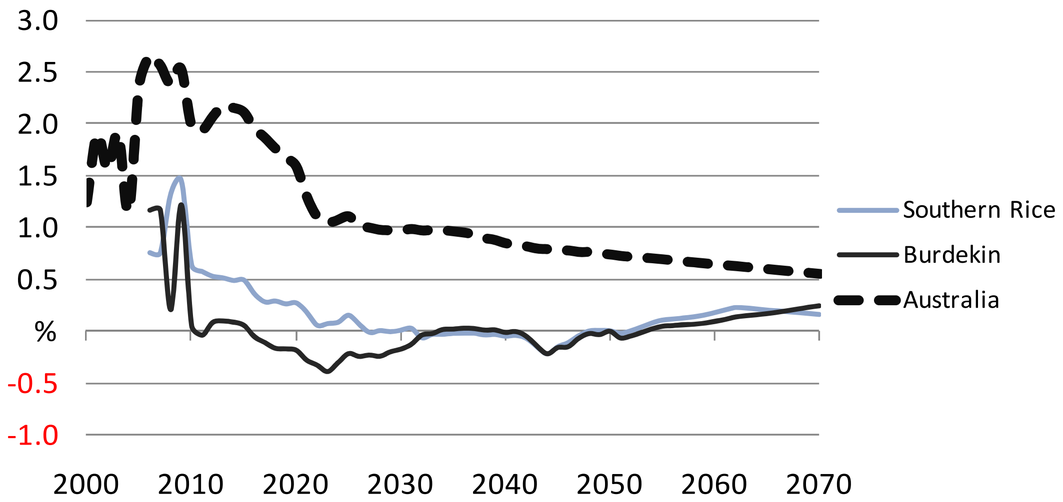

Figure 22 Projected growth in labour supply, Baseline scenario (percent, year on year)

Note: All years are financial years ending June 30.
Source: ACIL Tasman projections.

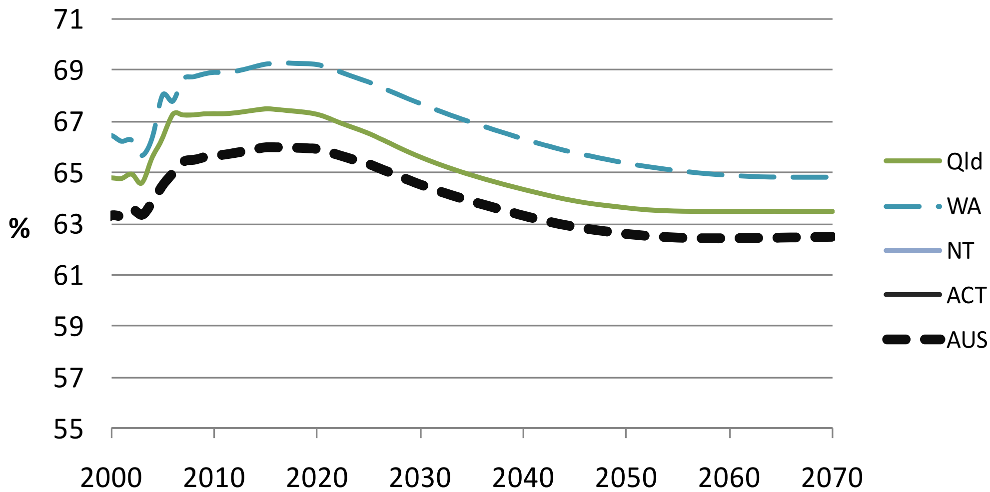

Figure 23 Projected average participation rates by region, Baseline scenario

Note: All years are financial years ending June 30.
Source: ACIL Tasman projections.

8.2.6 Unemployment

In addition to tracking the available workforce through the changes in population demographics and participation rates, *Tasman Global* also tracks unemployment rates. Unemployment and participation rates are largely interchangeable in affecting the number of people available for work in the model. The components are separately identified to allow a better representation of the labour market. In general, when unemployment is high, increases in labour demand can largely be supplied by reducing the unemployment rate but when unemployment is low, increases in labour demand will largely be met by increasing participation rates (and/or hours worked). For this analysis the average unemployment rates across all regions were assumed to move gradually from current levels to 5.0 percent by 2014-15, whence they were assumed to remain constant.

8.2.7 Labour productivity growth

Labour productivity is a measure of the quantity of goods and services per unit of time worked. Growth in labour productivity is highly variable on a year to year basis and is influenced by many developments in the economy, including changes in capital intensity and the composition of the work-force (Treasury, 2008).

Over the past 30 years Australian labour productivity growth has averaged 1.75 per cent a year and 1.8 per cent over the past 40 years (Treasury, 2007). Near term labour productivity growth is based on projections of labour supply and real GDP. In the reference case, the annual growth in Australian labour productivity is assumed to gradually slow from around 1.6 at the end of the current decade to 1.5 per cent a year by 2050 as the composition of the Australian economy continues to shift toward the services sector, which has historically had lower rates of productivity growth compared to the rest of the economy (Figure 24).

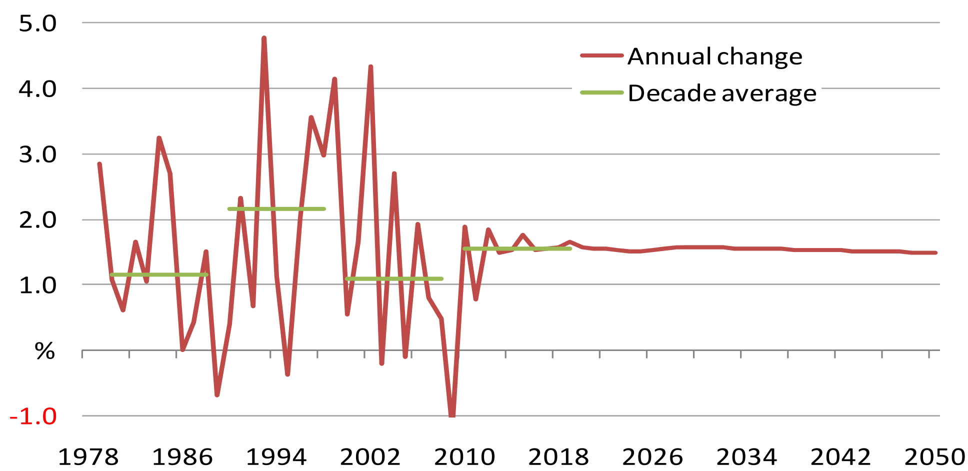

Figure 24 Historical and assumed Australian labour productivity growth, Baseline scenario (per cent change, year on year)

Note: All years are financial years ending June 30.
Source: ACIL Tasman projections.

8.2.8 Real economic output growth

The combination of the factors discussed above results in the projections for real GDP. The projections for the rest of the World are sourced from the latest IMF World Economic Outlook. Projections for economic growth past these points are determined using ACIL Tasman's projections of population, working age population, participation rates and labour productivity.

As a result of the projections of the factors underlying growth in economic output, the level of Australia's real GDP in the baseline scenario is projected to rise from $1.28 trillion[7] in 2009-10 to $2.26 trillion in 2029-30. Similarly, the real economic output of the Burdekin LGA is projected to rise from around $730 million in 2009-10 to approximately $925 million in 2029-30 while the real economic output of the Southern Rice region is projected to rise from to $12.3 billion to $16.4 billion over the same period.

8.2.9 Key scenario assumptions

In the context of this analysis, the principal driver of the economic impacts is the future value that is added to each hectare of land under alternative crops. Underlying that value are the assumptions/projections of the future yields and prices of the key commodities. A second main driver of the economic impacts relates to the downstream value adding of the crops (notably the potential creation of a rice processing industry in North Queensland). Finally, one of the key strengths of CGE models compared to other economic impact analysis tools (such as input-output multipliers) is that they place explicit constraints on the availability and movement of factors (notably labour) within and across regions. This section discusses the various assumptions that have been made for this analysis.

Commodity assumptions[8]: The historical and projected commodity prices for wheat and rice are presented in Figure 25. The current gap of around $280 a tonne between paddy rice and wheat is projected to narrow considerably to approximately $80 a tonne by 2019-20. For comparison, recent projections by the OECD/FAO (2010) project wheat and rice prices to be 3 and 12 per cent higher in 2019 relative to 2005, respectively (in calendar US$).

[7] Where billion is defined as $1x10^9$ as per the US convention. Trillion is defined as $1x10^{12}$.

[8] Pulses, legumes and peanuts were not considered in regional economic modelling

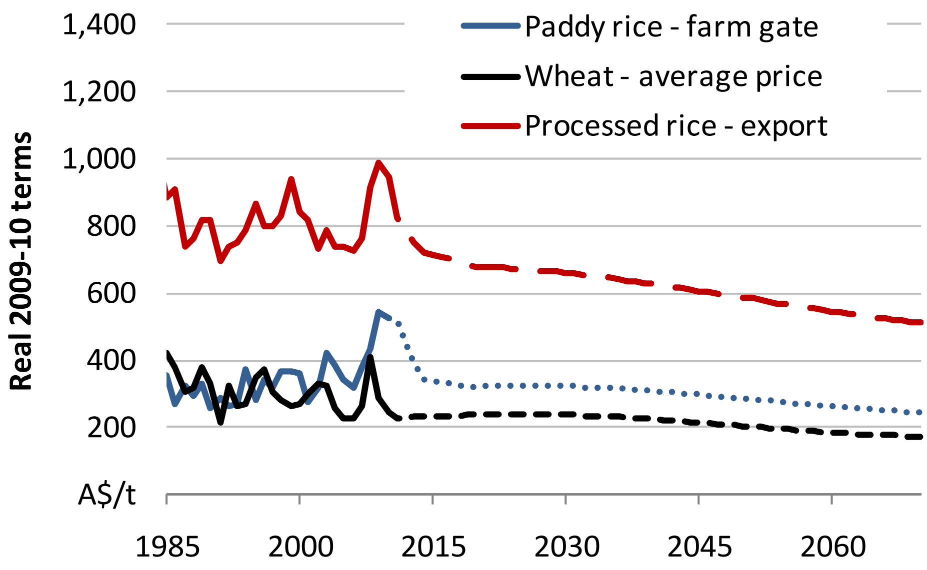

Figure 25 **Historical and projected commodity prices**

Note: All years are financial years ending June 30.

Source: ACIL Tasman projections.

Figure 26, Figure 27 and Figure 28 present the historical and assumed yields for the key crops and regions considered in this analysis.

The average yield of rice planted in the Southern Rice region is assumed to return from its current high to the long term average of around 9 tonnes per hectare and then ongoing productivity improvements of 0.4 per cent a year are assumed to occur such that the average yield by 2029-30 is 9.66 tonnes per hectare and 11.33 tonnes per hectare by 2069-70. This productivity rate is approximately equal to the rate over the past twenty years (0.38 per cent a year) but is around a third of the rate experienced over the past forty years (1.256 per cent a year).

Due to the significant climatic differences, past experience and experiments indicate that the average rice yields from irrigated land in the Burdekin will be less than those currently obtained in the Southern Rice region. For the current analysis, the average yields in the Burdekin region of summer and winter rice crops are assumed to be 50 and 75 per cent, respectively, of those achieved in the Southern Rice region (see earlier analysis). Furthermore, three quarters of the total area plantings are assumed to occur during summer months with the remainder during winter months. These assumptions imply an average yield of 6.04 tonnes per hectare by 2029-30 and 6.38 tonnes per hectare by 2069-70. Even though the rice varieties are likely to differ, the current analysis assumes that the farm gate price is the same in the Burdekin as in the Southern Rice region.

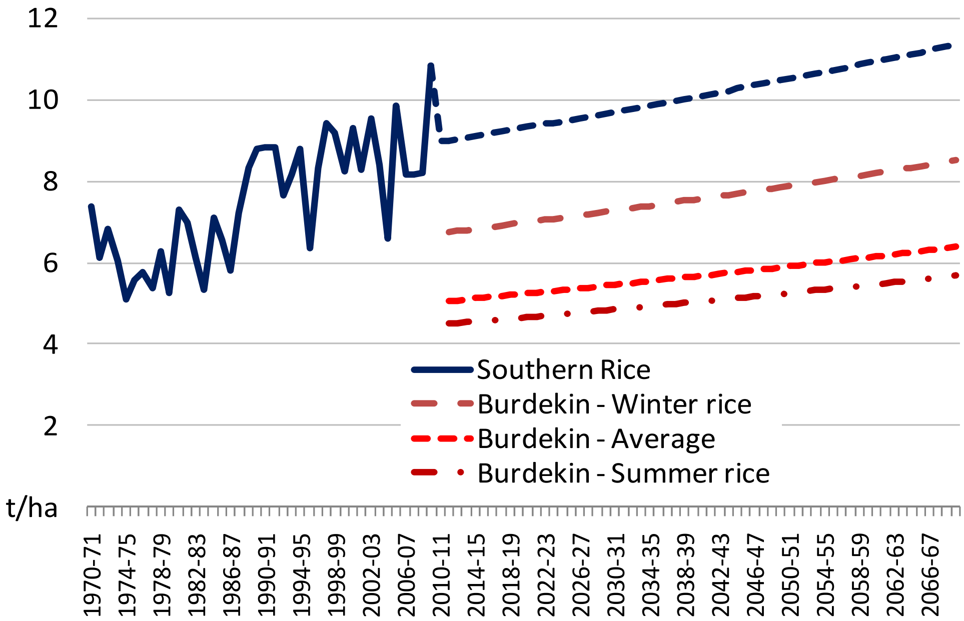

Figure 26 Historical and assumed rice yield by region

Data source: ABARE (2010) and ACIL Tasman

Wheat production is also assumed to have an ongoing productivity improvement of 0.4 per cent a year. By 2029-30, irrigated wheat in the Southern Rice region is assumed to have an average yield of 3.0 tonnes per hectare while dryland wheat is assumed to have an average yield of 1.90 tonnes per hectare. Yield improvements between 2030-31 and 2069-70 are assumed to be maintained for dryland wheat but to slow to 0.2 per cent a year for irrigated wheat. Consequently, by 2069-70, irrigated and dryland wheat grown in the Southern Rice region is assumed to have an average yield of just over 3.2 and 2.2 tonnes per hectare, respectively.

Historically, there has not been a noticeable increase in the average sugar cane yield across Australia[9]. Consequently, no productivity improvement has been allowed and the Burdekin region is assumed to maintain its 2005-06 yield of 110 tonnes[10] of sugar cane per hectare throughout the forecast period. Similarly, the ratio of sugar cane per tonne of sugar has also been assumed to remain constant after returning to the average over the past 40 years (7.3 tonnes of cane per tonne of sugar).

[9] Australian Sugarcane Annual 2009. Industry in Figures

[10] This estimate is from the ABS 2005-06 agriculture census. Hooper (2008) estimates that average yields in the Burdekin region in 2005-06 were 118 tonnes per hectare.

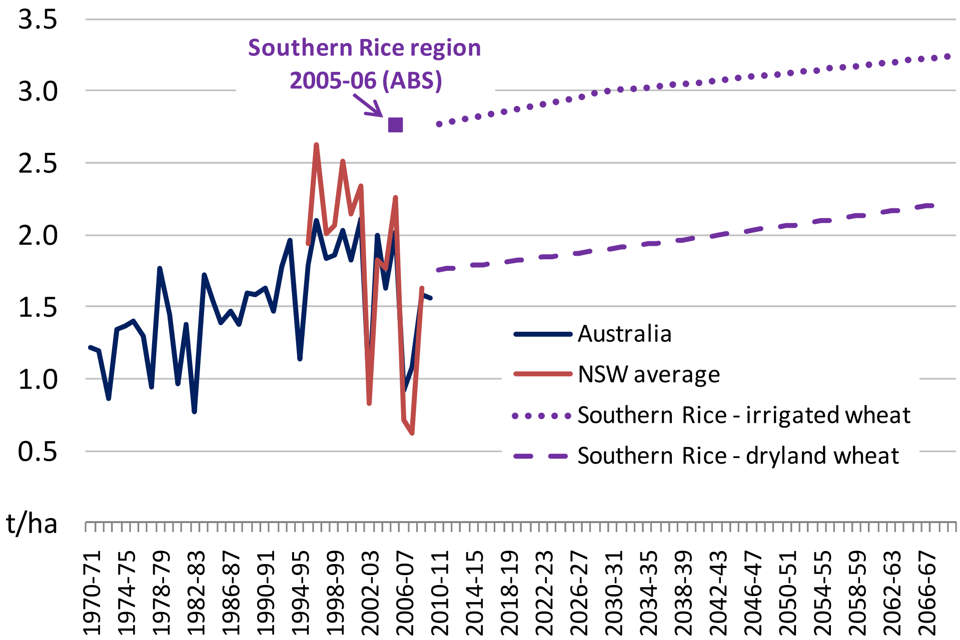

Figure 27 Historical and assumed wheat yield by region

Data source: ABARE (2010), ABS (2007) and ACIL Tasman

Rice processing assumptions: Another key component of the potential benefits of the introduction of rice growing to the Burdekin economy are the additional value adding opportunities. For this analysis rice is initially assumed to be exported for processing until annual production exceeds 75,000 tonnes a year. At this point rice milling and other processing facilities are assumed to be constructed in the Burdekin.

For a variety of reasons, but notably commercial confidentiality, the authors had difficulty in obtaining detailed estimates from the existing rice processing facilities in Australia and how applicable these may be in the context of a green fields industry in North Queensland. Consequently, ACIL Tasman's estimates of the cost structure and profitability of the existing industry in the Southern Rice region have been used to estimate the nature of such an industry in the Burdekin region

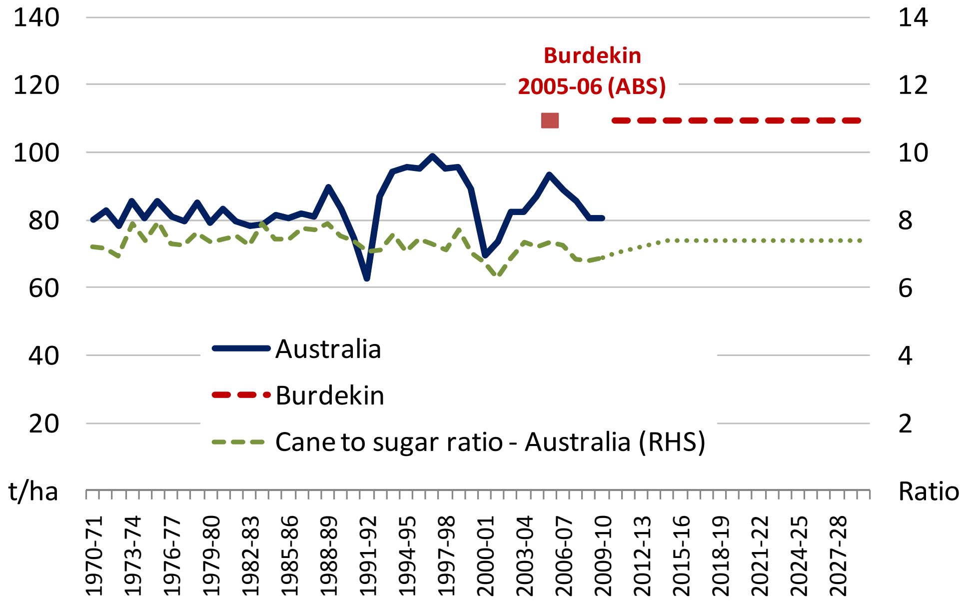

Figure 28 Historical and assumed average sugar cane yield and cane to sugar ratio
Data source: ABARE (2010), ABS (2007) and ACIL Tasman

Labour market assumptions: *Tasman Global* includes a labour market module that allows for constrained movement between Australian regions. In the simulations performed with *Tasman Global* the Australian labour market can be treated in a number of ways. Traditionally, CGE modelling utilises one of three labour market assumptions:

1. Fixed labour supply (the full employment approach) and zero labour mobility between Australian regions
2. Medium term adjustment to labour supply and zero labour mobility between Australian regions
3. Full labour mobility between regions so that changes to wages are equalised across Australian regions.

Assumption 2 simply allows local supply to vary in the medium term (five to ten years) before returning to its long run position. It provides a temporary reprieve from labour market constraints.

Assumptions 1 and 3 are more extreme. Under assumption 1, the proposed developments would have to be accomplished with only the current labour available in the Burdekin region with some allowance for natural growth, i.e. no new labour could be drawn to the Burdekin region as a result of the projects. Under assumption 3, changes to wages in the Burdekin region would be the same as changes to wages in all Australian regions, with labour shifting between Australian regions until wages equalise. Modelling under assumption 3 provides the largest movement in labour across regions.

Because of the very long time horizon of the simulations for this analysis, we have elected to use full labour mobility (assumption 3) between Australian regions. In practice, under this assumption, the changes in real wages relative to the reference case are equalised across the three Australian regions thereby allowing migration between the regions in response to changing opportunities. No changes to unemployment rates, participation rates or net international migration have been allowed.

8.3 Results of regional economic impact analysis

8.3.1 Measures of macroeconomic impacts

GDP is a measure of the aggregate output generated by an economy over a period of time (typically a year). From the expenditure side, GDP is calculated by summing total private and government consumption, investment and net trade[11]. At the state level, the GDP equivalent is called GSP (Gross State Product) while changes at the regional level are called GRP (Gross Regional Product). To reduce the potential confusion with the various acronyms, the term 'economic output' has been used in the discussion of the results presented in this report. Although changes in real GDP are useful measures for estimating the output of an economy, changes in the real income of a region are more important since they provide an indication of the change in economic welfare of the residents of a region. Indeed, it is possible that real GSP can increase with no, or possibly negative, changes in real income. In *Tasman Global*, changes in real income at the national level are synonymous with real gross national disposable incomes (RGNDI) reported by the ABS.

The change in real income is equivalent to the change in real economic output, plus the change in net foreign income transfers, plus the change in terms of trade (which measures changes in the purchasing power of a region's exports relative to its imports). As Australians have experienced in recent years, changes in terms of trade can have a substantial impact on people's welfare independently of changes in real GDP. The change in real income (as projected by *Tasman Global*) is ACIL Tasman's preferred measure of the change in economic welfare of residents.

8.3.2 Macroeconomic impacts: Scenario 1

Table 13 summarises the projected changes in real economic output and real income for each region under Scenario 1 while Figure 29, Figure 30 and Figure 31 show the year on year changes in real outputs, real income and employment. When analysing the results, it is important to remember that the initial impact of the scenario relates to the assumed changes in agricultural output in the Southern Rice and Burdekin regions. These changes then affect each region's total economic output with effects on the demand for labour and capital.

Capital is naturally mobile (albeit sluggishly) between all regions based on changes rates of return, while, labour is assumed to be fully mobile between Australian regions. Consequently, the supply of factors in the Rest of Australia is also impacted by changes in the demand in the Southern Rice and Burdekin regions. Consequently, at a national level, the Rest of Australia acts to reduce the magnitude of the aggregate impact experienced in the Southern Rice and Burdekin regions.

Table 13 Cumulative change in real economic output and real income under scenario 1, relative to the reference case (in 2010-11 terms)

[11] From the income side, GDP is equal to the returns to factors plus all tax revenues.

	Real economic output [a]			Real income [b]		
	2029-30	2069-70	NPV (2010-11 to 2069-70)	2029-30	2069-70	NPV (2010-11 to 2069-70)
	2010-11$m	2010-11$m	2010-11$m	2010-11$m	2010-11$m	2010-11$m
Southern Rice	–45	–139	–915	–72	–161	–1,298
Burdekin LGA	35	131	759	58	178	1,149
Rest of Australia	–1	–21	–54	6	–26	9
Total Australia	–11	–29	–211	–8	–9	–140

a The term 'real economic output' is used instead of gross regional product (GRP). The sum of the GRP of all three regions equals the change in Australian GDP
b Real income for Australia is synonymous with real gross national disposable income (RGNDI) as used by the ABS. In this modelling real income is a measure of the change in economic welfare
Notes: Totals may not add due to rounding. NPV = Net Present Value (calculated using a 4 per cent real discount rate). It should be noted that the NPV calculation only includes the impacts through to 2069-70 even though the impacts will be likely to continue producing beyond this artificial time horizon

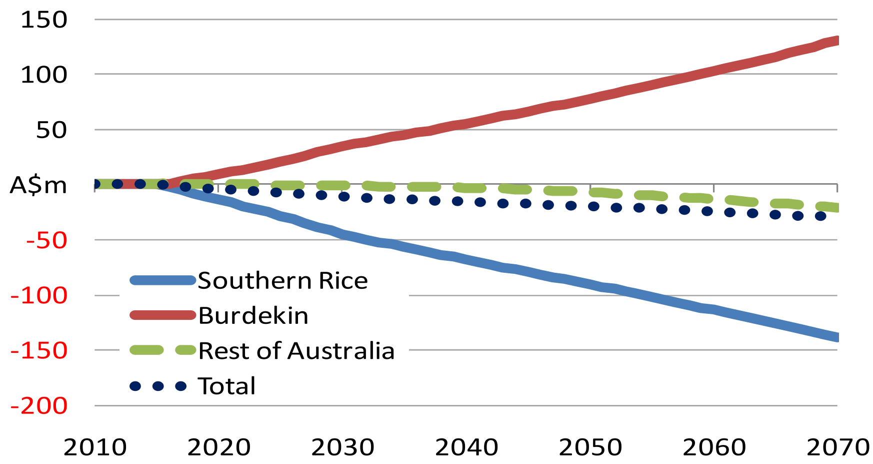

Figure 29 **Projected changes in real economic output under scenario 1, relative to the reference case (2010-11 dollars)**
Notes: The term 'real economic output' is used instead of gross regional product (GRP). The sum of all three regions GRP equals the change in Australian GDP

Real economic output: The loss of water and consequent switching away from rice to wheat, is projected to reduce the real economic output of the Southern Rice region by (

Table 13; Figure 29):

- –$45 million in 2029-30 (in 2010-11 terms)
- –$139 million in 2069-70
- A cumulative total of –$915 million over the 59 years to 2069-70 (using a four per cent real discount rate).

In a region with around 295,000 people, this is a significant change, with the increase in 2069-70 representing an average decrease in real economic output of around $550 per person projected to be living in the Southern Rice at this time.

Due to the assumption under Scenario I that there is sufficient fallow land available for introducing a rice growing (and related processing) industry into the Burdekin region, real economic output in the Burdekin increases[12]. In particular, under Scenario I it is projected that the real economic output of the Burdekin increases by:

- $35 million in 2029-30
- $131 million in 2069-70
- A cumulative total of $759 million over the 59 years to 2069-70 (using a four per cent real discount rate).

In a region with around 18,500 people, this is a substantial change, with the increase in 2069-70 equating to an increase in real economic output of around $7,000 per person.

Under Scenario 1, the movement of labour is primarily between the Southern Rice and Burdekin regions, with minimal movement of labour away from the Rest of Australia. Consequently it is projected that there will be minimal impacts on the Rest of Australia under Scenario 1.

- At the national level, real economic output (or real GDP) is projected to change by:
- –$11 million in 2029-30 (in 2010-11 terms)
- –$29 million in 2069-70 (in 2010-11 terms)

A cumulative total of –$211 million in net present value terms over the 59 years to 2069-70 (using a four per cent real discount rate).

Real income: As the Southern Rice and Burdekin regions export almost all of their agriculture production, the changes in agriculture exports has a further effect on the regions terms of trade (of the same sign). Consequently the projected change in real income is greater than the projected change in real economic output (except for the rest of Australia which has a wider range of effects and the relative magnitude of real income and economic output vary).

Under Scenario 1, the real income (in 2010-11 terms) is projected to change by (see

Table 13; Figure 30):

- –$72 million in 2029-30 and –$161 million in 2069-70 in the Southern Rice region
- $58 million in 2029-30 and $178 million in 2069-70 in the Burdekin region
- $6 million in 2029-30 and –$26 million in 2069-70 in the Rest of Australia

[12]Essentially real economic output increases because of the increased monetisation of existing factors (i.e. land) and because extra factors (labour and capital) are drawn to the region.

- A national total of –$8 million in 2029-30 and –$9 million in 2069-70

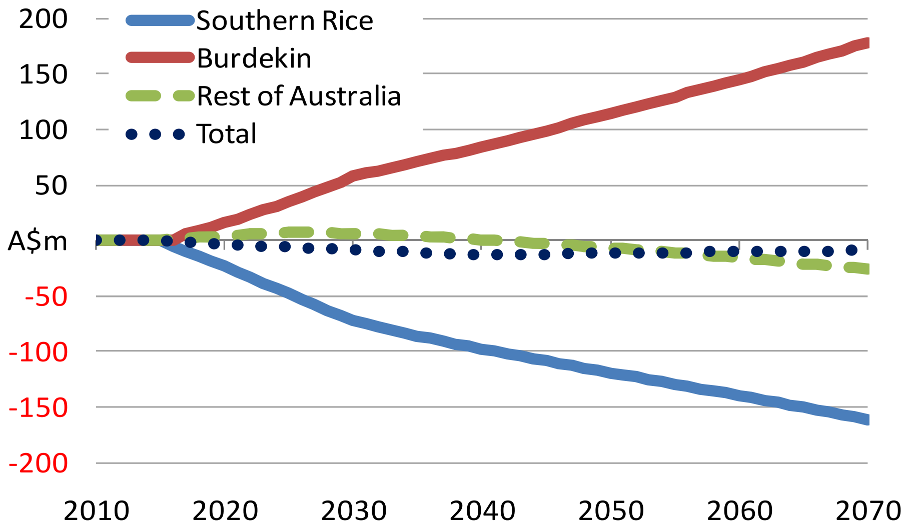

Figure 30 Projected changes in real income under scenario 1, relative to the reference case (2010-11 dollars)

As with the projected changes in real economic output, these are significant regional changes. In the Burdekin, the projected increase in real income in 2069-70 is equivalent to an average increase of more than $9,000 per person living in the region at that time, while the fall in real income of the Southern Rice region is equivalent to a decrease of over $600 per person. As with the projected change in real economic output, only minor effects are projected at the national level. Consequently, under Scenario 1, the projected changes in water availability and consequent production of agriculture commodities, essentially results in a regionally significant reallocation of resources and wealth around the nation while not significantly impacting on the total output or wealth of Australia as a whole.

Employment: This reallocation can be seen from the projected changes in employment shown in Figure 31. Under Scenario 1 the total number of FTE jobs in the Burdekin region is projected to increase by approximately 600 by 2069-70 (relative to the reference case), with almost all of the people filling these jobs coming from the Southern Rice region. In the case of the Burdekin, this represents an increase in the number of jobs of around 5.5 per cent relative to the reference case, with a similar increase in total population.

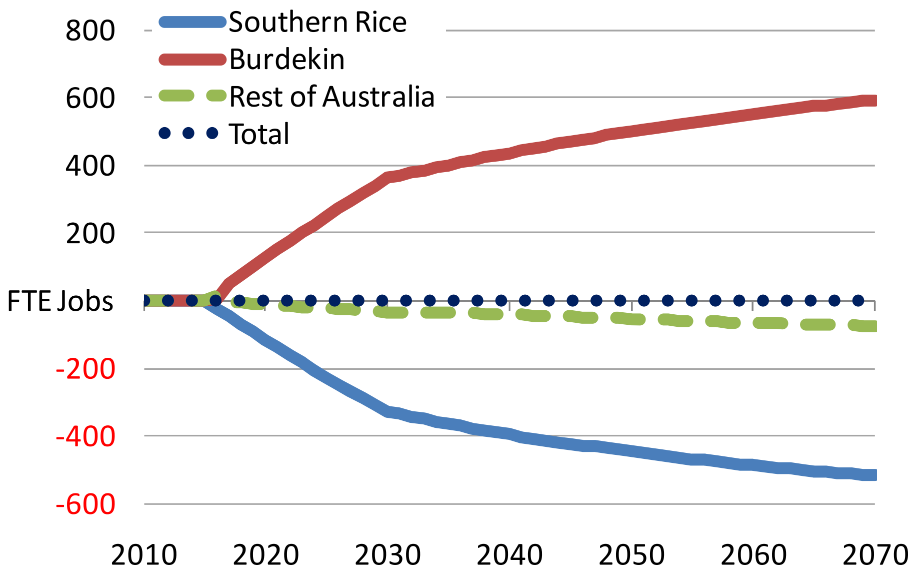

Figure 31 **Projected changes in employment level under scenario 1, relative to the reference case**

Note: FTE = Full time equivalent. 1 FTE is equivalent to one full time job held for one year or, alternatively, two full time jobs held for half a year

8.3.3 Macroeconomic impacts: Scenario 2

Table 14 summarises the projected changes in real economic output and real income for each region under Scenario 2 while Figure 32, Figure 33 and Figure 34 show the year on year changes in real outputs, real income and as well as the changes in employment.

Real economic output: As the assumptions regarding the Southern Rice region are the same under both Scenario1 and 2, the projected impacts on the economy of that region are broadly the same. In particular, it is projected that the real economic output of the Southern Rice region changes by (see Table 14; Figure 32):

- –$44 million in 2029-30 and –$129 million in 2069-70 (in 2010-11 terms)
- a cumulative total of –$876 million over the 59 years to 2069-70 (using a four per cent real discount rate).

Table 14 Cumulative change in real economic output and real income under scenario 2, relative to the reference case (in 2010-11 terms)

	Real economic output [a]			Real income [b]		
	2029-30	2069-70	NPV (2010-11 to 2069-70)	2029-30	2069-70	NPV (2010-11 to 2069-70)
	2010-11$m	2010-11$m	2010-11$m	2010-11$m	2010-11$m	2010-11$m
Southern Rice	–44	–129	–876	–71	–148	–1,251
Burdekin LGA	–50	–237	–1,244	–83	–324	–1,888
Rest of Australia	38	181	929	72	253	1,523
Total Australia	–56	–185	–1,191	–82	–219	–1,616

a The term 'real economic output' is used instead of gross regional product (GRP). The sum of the GRP of all three regions equals the change in Australian GDP

b Real income for Australia is synonymous with real gross national disposable income (RGNDI) as used by the ABS. In this modelling real income is a measure of the change in economic welfare

Notes: Totals may not add due to rounding. NPV = Net Present Value (calculated using a 4 per cent real discount rate). It should be noted that the NPV calculation only includes the impacts through to 2069-70 even though the impacts will be likely to continue producing beyond this artificial time horizon

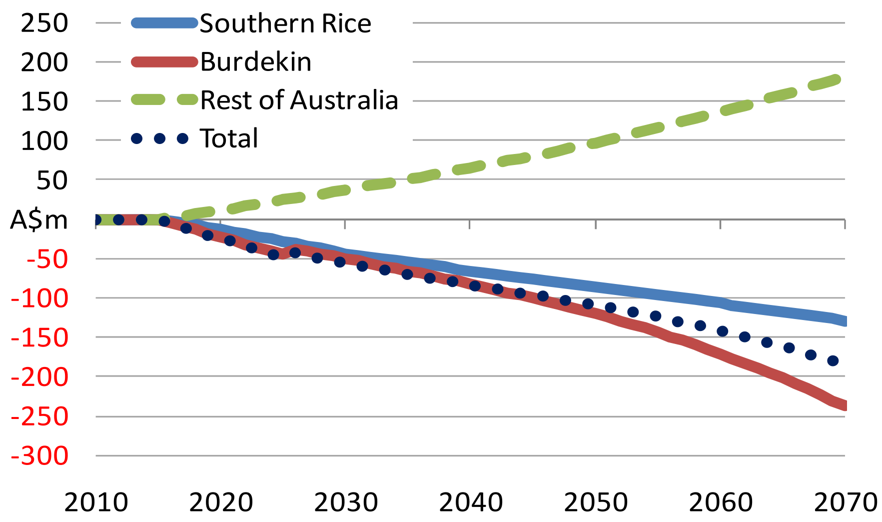

Figure 32 **Projected changes in real economic output under scenario 2, relative to the reference case (2010-11 dollars)**

Notes: The term 'real economic output' is used instead of gross regional product (GRP). The sum of all three regions GRP equals the change in Australian GDP

Due to the higher value per hectare of the sugar cane, the Burdekin region also experiences a fall in real economic output. In particular, under Scenario 2 it is projected that the real economic output of the Burdekin changes by:

- –$50 million in 2029-30 (in 2010-11 terms)
- –$237 million in 2069-70 (in 2010-11 terms)
- a cumulative total of –$1,244 million in net present value terms over the 59 years to 2069-70 (using a four per cent real discount rate).

In the context of the region, this is a substantial change, with the decrease in 2069-70 representing a loss of real economic output of nearly $14,000 per person projected to be living in the Burdekin at this time.

Under Scenario 2, the Rest of Australia is projected to benefit from a movement of labour from both the Southern Rice and Burdekin regions. Consequently it is projected that, under Scenario 2, the real economic output of the Rest of Australia will increase by:

- $38 million in 2029-30 and $181 million in 2069-70 (in 2010-11 terms)
- a cumulative total of $929 million in net present value terms over the 59 years to 2069-70 (using a four per cent real discount rate).

At the national level, the gains in the Rest of Australia negate a significant, but not all of the losses in the Southern Rice and Burdekin regions. Under Scenario 2, national real economic output (or real GDP) is projected to change by:

- –$56 million in 2029-30 (in 2010-11 terms)
- –$185 million in 2069-70 (in 2010-11 terms)
- a cumulative total of –$1,191 million in net present value terms over the 59 years to 2069-70 (using a four per cent real discount rate).

At a national level this loss (relative to the reference case) is essentially driven by the lower value of output from the fixed area of land.

Real income: As with Scenario 1, the projected changes in real income in the Southern Rice and Burdekin regions are greater than the projected changes in real economic output. Under Scenario 2, the real income (in 2010-11 terms) is projected to change by (Table 14; Figure 33):

- –$71 million in 2029-30 and by –$148 million in 2069-70 in the Southern Rice region
- –$83 million in 2029-30 and by –$324 million in 2069-70 in the Burdekin region
- +$72 million in 2029-30 and by +$253 million in 2069-70 in the Rest of Australia
- A national total of –$82 million in 2029-30 and –$219 million in 2069-70.

As with the projected changes in real economic output, in the context of the Burdekin and Southern Rice economies these are significant changes. In the Burdekin, the projected decrease in real income in 2069-70 is equivalent to an average loss in real income of approximately $19,000 per person living in the region at that time (relative to the reference case).

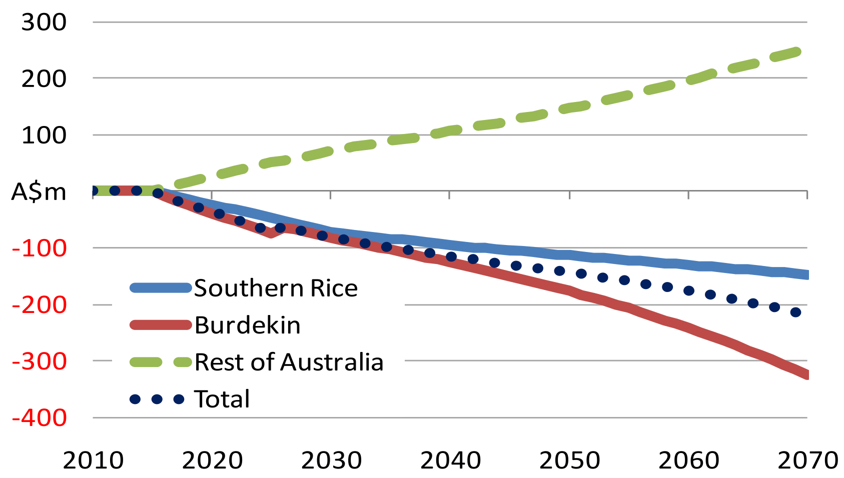

Figure 33 Projected changes in real income under scenario 2, relative to the reference case (2010-11 dollars)

Employment: The reallocation of resources from the Southern Rice and Burdekin regions to the rest of Australia is evident from the projected changes in employment shown in Figure 34. Under Scenario 2 the Burdekin region loses around 1,000 FTE jobs while the Southern Rice region loses around 500 jobs, relative to the reference case, with all of the people filling these jobs moving to the rest of Australia. In the case of the Burdekin, this represents a significant change with a decrease in the number of jobs of around 10 per cent relative to the reference case, with a similar decrease in total population. In fact, the losses are so high that total population in 2069-70 is around 10 per cent lower than at present.

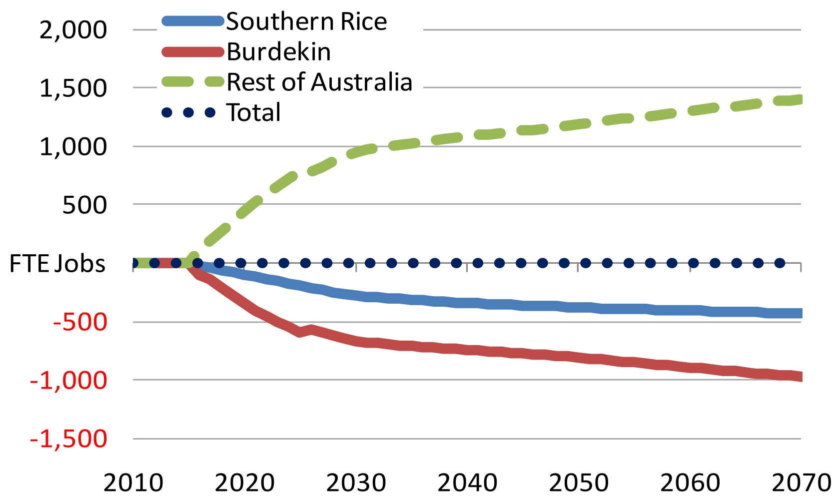

Figure 34 Projected changes in employment level under scenario 2, relative to the reference case

Note: FTE = Full time equivalent. 1 FTE is equivalent to one full time job held for one year or, alternatively, two full time jobs held for half a year

8.3.3 Macroeconomic impacts: Scenario 3

Scenario 3 results were similar to scenario 1 therefore the results are not presented here.

9. Conclusions

This case study illustrates some of the expected issues in relation to the relocation of agricultural production. The main conclusions from this are:

9. Rice farmers, as with other primary producers, face on-going adjustment pressures from the deregulation of agriculture over the last 20 years, competition from overseas producers, climate change, costs of production and, most recently, competition for water, including from governments buying on behalf of the environment.

10. Third stage industry policy reforms, allowing water trading and fourth stage buybacks will reduce the average area of rice production as water allocation reductions of 25-35 percent are unlikely to be offset by productivity gains given current production techniques and increasing temperatures and rainfall variability.

11. Southern rice farmers are comparatively diversified already and so they canchange the production systems to some extent but the loss of water will reduce the net number of farm businesses in the Riverina (and Australia), because of the additional pressures to adopt less intensive and larger-scale farming.

12. The reduction in output will also reduce net exports and have some impact on GDP, especially because of the extensive value-adding that occurs in Australia. The increase in wheat production will not compensate for the reduction in the higher value commodity. This will be a cost to the economy over and above the direct cost of the environmental water. The supply chain could still be run from Australia, but more of it would be located overseas, to cope with the reduction in domestic production.

13. There could be very large effects on some regional economies, especially if one or more mills close or operate only occasionally, as the employment effects multiply through the community. The distribution of sales to non-agricultural purposes will also be a critical variable if, for example, there is a high volume of sales in one region, substantially increasing the systemic costs for those who remain, while heavily affecting the local economy. This study has not taken account of threshold effects, such as school or service closures, which may additionally affect some towns and this will be an important area for monitoring and researching.

14. There is some interest within the industry, and from potential new corporate entrants, in the relocation of some rice production to the north. Concerns include:

    a. The lack of suitable varieties that sustain Australia's market niche;

    b. Lack of, or risks of investing in, processing infrastructure;

    c. Transport costs;

    d. Pest and disease problems;

    e. Concern about local reactions to land use change; and

f. Attracting new or existing landholders into the rice industry, sufficient to develop a regional industry.

Previous experience with grand schemes in the north generally tends to encourage caution.

15. Based on limited agronomic and financial data, rice production in the Burdekin area could be profitable, depending on land and water values. However, it does appear to be less profitable than in the south because of lower yields.

16. This also means that if there is roughly the same amount of additional northern production as is lost in the south then there would still be a net loss of national output and income, even with the minimal impact option, whereby rice production is introduced into a sugar-based rotation. The displacement of an existing intensively-produced crop, such as sugar, will result in a much larger net national loss, also meaning that there would be a net reduction in GRP.

Hence, we conclude that there is unlikely to be a rapid and spontaneous increase in rice production in the north, because of a lack of infrastructure, wariness in relation to the agronomic issues and the opportunity cost of turning away from sugar. We have not yet examined the social preference for traditional crops and landscapes but think that there will be a strong local attachment to sugar production. This means that the rice in rotation option is likely to be the most appealing in the short run. This at least would minimize the net national and regional economic effects.

In regard to the policy implications of this study, the findings raise some questions for governments. The returns from rice, per hectare, are likely to be less in the north than in the south, at least until there is further developments on varieties and production techniques. The relative profitability might be moderated if it was clear that land and water was cheaper in the north. There will be some further investigation on land prices but the market for water in the north is much less developed. Setting aside any capital cost differences, the lower profits, agronomic uncertainties and a local attachment to existing crops mean there is unlikely to be any major autonomous expansion of a northern rice industry, which raises the question of whether or not governments should provide additional support to accelerate industry development. The three main arguments for support would be: cushioning the impacts on the national economy of reducing southern production; helping to support the maintenance of rice processing infrastructure in Australia, which assists with local value-adding; and boosting a regional economy.

Forms of government intervention could include:

Providing the additional infrastructure for an expansion of the Burdekin irrigation scheme without necessarily aiming to recoup full capital costs;

Providing social infrastructure (roads, power etc) to support private irrigation developments;

Providing structural adjustment funding to support the development of a value-adding part of the value chain, though there would obviously need to be some clear expansion before such an investment;

Research projects dedicated to increasing rice productivity in the north; and

Extension officers to support prospective producers.

This all presumes that the environmental consequences of such an expansion were not too severe. There would be no point in buying back 'environmental' water in the south, only to incur additional environmental costs in the north. We note that previous investigators have been very cautious about the environmental impacts of northern expansion (Camkin et al., 2007; Petheram et al. 2008; Northern Australia Land and Water Taskforce, 2009a, 2009b). Concerns include soil erosion and degradation, especially a concern if rain events become more extreme and impacts on riparian ecosystems. The environmental impacts of any expansion are a key area for research.

Finally, there are issues about policy consistency and path dependency. Some might see inconsistency in applying stage three policies to achieve competitiveness and self-sufficiency for most industries, while applying stage one establishment policies to particular areas and industries. This is perhaps less inconsistent on closer examination. Governments still use a range of establishment incentives, such as support for renewable energy and various local government concessions to business start-ups. The path dependency issue is that governments are wary of putting in place policies that will tie them to long-term commitments, just as most large irrigation projects have tended to do. Of the forms of intervention discussed above, it is the water catchment and distribution infrastructure that is likely to incur long-term obligations, partly depending on the willingness to demand full-cost recovery. An alternative approach would be to enable the construction of private dams in the region, but this is unlikely to be as technically efficient as a large storage, again another issue for further research.

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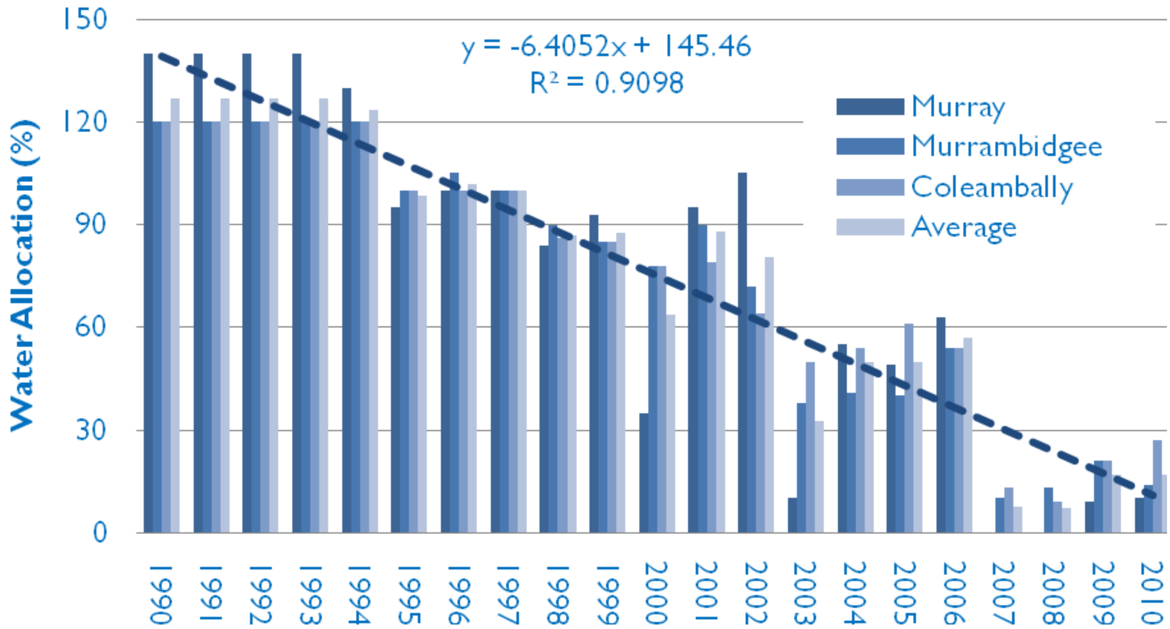
Appendices

Appendix I Historical water allocation in Murray, Murrumbidgee and Coleambally Irrigation areas, Riverina, NSW



Source: NSW Water Information.

Appendix II Rice budgets for Murrumbidgee and Burdekin areas, 2010/11

RICE - LONG GRAIN (Summer 2010/2011)					Murrumbidgee			
AREAL SOWN								
Operation	Month	Machinery			Inputs			Total Cost
		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Chisel plough	Aug	0.22	48.8	$10.74				$10.74
Broadcast phosphorus fertiliser	Sept	0.1	18.61	$1.86	125kg/ha	$430/t	$53.75	$55.61
Apply nitrogen fertiliser (urea)	Sep/Oct	0.28	46.71	$13.08	250kg/ha	$589/t	$147.25	$160.33
Reform banks (4% area)	Sep/Oct	1.18	18.06	$0.85				$0.85
Rolling	Sep/Oct	0.2	$38.55	$7.71				$7.71
Grass weed control (aerial spray Molinate)	Oct			$25.00	3.75 L/ha	$24.40/L	$91.50	$116.50
Aquatic weed control (area spray Benzofenap)	Oct			$0.00	2.00 L/ha	$69.50/L	$139.00	$139.00
Bloodworm control (area spray Chlorpyrifos)	Oct			$0.00	0.15 L/ha	$11.28/L	$1.69	$1.69
Areal Sow	Oct			$36.00	150kg/ha	$0.52/kg	$78.00	$114.00
Bloodworm control (area alpha Cypermethrin)	Oct			$0.00	0.10 L/ha	$14.09/L	$1.41	$1.41
Aquatic weed control (area spray Basagran M60)	Dec			$27.00	2.50 L/ha	$21.06/L	$52.65	$79.65
Aerial image of crop	Nov/Dec			$3.85				$3.85
Top dress nitrogen fertiliser (aerial topdress urea)	January			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Mar/Apr/May			$0.00	9.25 t/ha	$25.00/t	$231.25	$231.25
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	13.0ML	$12.38/ML	$160.94	$160.94
Cartage				$0.00	9.25 t/ha	$12.00/t	$111.00	$111.00
Research levy (farm gate value)				$0.00	9.25 t/ha	$3.00/t	$27.75	$27.75
Crop insurance (estimated crop value)				$0.00	$3,145	1.65%	$51.89	$51.89
Total costs								$1,390
Total gross margin (@ 9.25 t yield and $340/t price)								$3,145
Net return								$1,755

RICE - MEDIUM GRAIN (Summer 2010/2011)	Murrumbidgee

AREAL SOWN

Operation	Month	Machinery			Inputs			Total Cost
		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Chisel plough	Aug	0.22	48.8	$10.74				$10.74
Broadcast phosphorus fertiliser	Sept	0.1	16.61	$1.66	125kg/ha	$430/t	$53.75	$55.41
Apply nitrogen fertiliser (urea)	Sep/Oct	0.28	46.71	$13.08	250kg/ha	$589/t	$147.25	$160.33
Reform banks (4% area)	Sep/Oct	1.18	18.06	$0.85				$0.85
Rolling	Sep/Oct	0.2	$38.55	$7.71				$7.71
Grass weed control (aerial spray Molinate)	Oct			$25.00	1.5 L/ha	$5.97/L	$8.96	$33.96
Aquatic weed control (area spray Benzofenap)	Oct			$0.00	2.00 L/ha	$69.50/L	$139.00	$139.00
Bloodworm control (area spray Chlorpyrifos)	Oct			$0.00	0.15 L/ha	$11.28/L	$1.69	$1.69
Areal Sow	Oct			$36.00	150kg/ha	$0.47/kg	$70.50	$106.50
Aquatic weed control (aerial spray Thiobencarb Saturn)	Oct/Nov			$25.00	3.75kg/ha	$26.85/kg	$100.69	$125.69
Bloodworm control (area alpha Cypermethrin)	Oct/Nov			$0.00	0.10 L/ha	$14.09/L	$1.41	$1.41
Aquatic weed control (area spray Basagran M60)	Dec			$27.00	2.50 L/ha	$21.06/L	$52.65	$79.65
Aerial image of crop	Dec			$3.85				$3.85
Topdress nitrogen fertiliser (aerial topdress urea)	January			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Apr/May			$0.00	10 t/ha	$25.00/t	$231.25	$250.00
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	14.0ML	$12.38/ML	$173.32	$173.32
Cartage				$0.00	10 t/ha	$12.00/t	$120.00	$120.00
Research levy (farm gate value)				$0.00	10 t/ha	$3.00/t	$30.00	$30.00
Crop insurance (estimated crop value)				$0.00	$3,000	1.65%	$49.50	$49.50
Total costs								$1,466
Total gross margin (@ 10.0 t yield and $300/t price)								$3,000
Net return								$1,534
Net Return per ML								$110

RICE - MEDIUM GRAIN (Summer 2010/2011) **Murrumbidgee**

SOD SOWN

Operation	Month	Machinery	Inputs	Total Cost

		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Broadleaf & grass weed control (boom spray Glyphosate 450)	Sep	0.05	$41.38	$2.23	1.00 L/ha	$4.90/L	4.9	$7.13
Reform banks (4% area)	Sep/Oct	1.18	$18.06	$0.85				$0.85
Sow	Sep/Oct	0.28	$46.71	13.08	170kg/ha	$0.47/kg	$79.90	$92.98
Apply starter fertiliser (DAP)	Sep/Oct				70kg/ha	$875.00/t	$61.25	$61.25
Grass weed control (Paraquat, Barnstorm 250)	Oct/Nov			0	1.00 L/ha	$8.35/L	8.35	$8.35
Grass weed control (Barnstorm®)	Oct/Nov	0.05	$41.38	2.23	1.00 L/ha	$105.64/L	$105.64	$107.87
Grass weed control (Molinate)	Oct/Nov	Drip			3.75 L/ha	$5.97/L	$22.39	$22.39
Broadcast urea	Oct/Nov	0.1	$18.61	1.86	80kg/ha	$589.00/t	$47.12	$48.98
Aerial image of crop	Dec			$3.85				$3.85
Topdress nitrogen fertiliser (aerial topdress urea)	January			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Apr/May			$0.00	10 t/ha	$25.00/t	$231.25	$250.00
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	13.0ML	$12.38/ML	$160.94	$160.94
Cartage				$0.00	10 t/ha	$12.00/t	$120.00	$120.00
Research levy (farm gate value)				$0.00	10 t/ha	$3.00/t	$30.00	$30.00
Crop insurance (estimated crop value)				$0.00	$3,000	1.65%	$49.50	$49.50
Total costs								$1,080
Total gross margin (@ 10.0 t yield and $300/t price)								$3,000
Net return								$1,920
Net Return per ML								$148

RICE - LONG GRAIN (Winter 2010)			Burdekin					
AREAL SOWN								
Operation	Month	Machinery			Inputs			Total Cost
		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Primary and secondary tillage	Jul	1.2	35.5	$10.74				42.60

Broadcast phosphorus fertiliser	Aug	0.1	18.61	$1.86	125kg/ha	$430/t	$53.75	$55.61
Apply nitrogen fertiliser (urea)	Aug/Sep	0.28	46.71	$13.08	250kg/ha	$589/t	$147.25	$160.33
Reform banks (4% area)	Aug/Sep	1.18	18.06	$0.85				$0.85
Rolling	Aug/Sep	0.2	$38.55	$7.71				$7.71
Grass weed control (aerial spray Molinate)	Sept/Oct			$25.00	3.75 L/ha	$24.40/L	$91.50	$116.50
Aquatic weed control (area spray Benzofenap)	Sept/Oct			$0.00	2.00 L/ha	$69.50/L	$139.00	$139.00
Bloodworm control (area spray Chlorpyrifos)	Sept/Oct			$0.00	0.15 L/ha	$11.28/L	$1.69	$1.69
Areal Sow	Sept/Oct			$36.00	150kg/ha	$0.52/kg	$78.00	$114.00
Bloodworm control (area alpha Cypermethrin)	Sept/Oct			$0.00	0.10 L/ha	$14.09/L	$1.41	$1.41
Aquatic weed control (area spray Basagran M60)	Oct			$27.00	2.50 L/ha	$21.06/L	$52.65	$79.65
Aerial image of crop	Oct/Nov			$3.85				$3.85
Topdress nitrogen fertiliser (aerial topdress urea)	Oct/Nov			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Dec/Jan			$0.00	6.5 t/ha	$25.00/t	$162.50	$162.50
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	10.0ML	$5/ML	$50.00	$50.00
Cartage				$0.00	6.5 t/ha	$12.00/t	$78.00	$78.00
Research levy (farm gate value)				$0.00	6.5 t/ha	$3.00/t	$19.50	$19.50
Crop insurance (estimated crop value)				$0.00	$2,000	1.65%	$33.00	$33.00
Total costs								$1,182
Total gross margin (@ 6.5 t yield and $340/t price)								$2,210
Net return								$1,028
Net Return per ML								$103

RICE - LONG GRAIN (Summer 2010/2011)					Burdekin			
AREAL SOWN								
Operation	Month	Machinery			Inputs			Total Cost
		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Primary and secondary tillage	Nov	1.2	35.5	$10.74				42.60
Broadcast phosphorus fertiliser	Sept	0.1	18.61	$1.86	125kg/ha	$430/t	$53.75	$55.61

Apply nitrogen fertiliser (urea)	Sep/Oct	0.28	46.71	$13.08	250kg/ha	$589/t	$147.25	$160.33
Reform banks (4% area)	Sep/Oct	1.18	18.06	$0.85				$0.85
Rolling	Sep/Oct	0.2	$38.55	$7.71				$7.71
Grass weed control (aerial spray Molinate)	Oct			$25.00	3.75 L/ha	$24.40/L	$91.50	$116.50
Aquatic weed control (area spray Benzofenap)	Oct			$0.00	2.00 L/ha	$69.50/L	$139.00	$139.00
Bloodworm control (area spray Chlorpyrifos)	Oct			$0.00	0.15 L/ha	$11.28/L	$1.69	$1.69
Areal Sow	Oct			$36.00	150kg/ha	$0.52/kg	$78.00	$114.00
Bloodworm control (area alpha Cypermethrin)	Oct			$0.00	0.10 L/ha	$14.09/L	$1.41	$1.41
Aquatic weed control (area spray Basagran M60)	Dec			$27.00	2.50 L/ha	$21.06/L	$52.65	$79.65
Aerial image of crop	Nov/Dec			$3.85				$3.85
Topdress nitrogen fertiliser (aerial topdress urea)	January			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Apr/May			$0.00	4.5 t/ha	$25.00/t	$115.50	$115.50
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	8.0ML	$5/ML	$40.00	$40.00
Cartage				$0.00	4.5 t/ha	$12.00/t	$54.00	$54.00
Research levy (farm gate value)				$0.00	4.5 t/ha	$3.00/t	$13.50	$13.50
Crop insurance (estimated crop value)				$0.00	$1,500	1.65%	$24.75	$24.75
Total costs								$1,087
Total gross margin (@ 4.5 t yield and $340/t price)								$1,530
Net return								$443
Net Return per ML								$55

RICE - MEDIUM GRAIN Winter 2010					**Burdekin**			
AREAL SOWN								
Operation	Month	Machinery			Inputs			Total Cost
		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Primary and secondary tillage	Jul	1.2	35.5	$10.74				42.60
Broadcast phosphorus fertiliser	Aug	0.1	16.61	$1.66	125kg/ha	$430/t	$53.75	$55.41
Apply nitrogen fertiliser (urea)	Aug/Sept	0.28	46.71	$13.08	250kg/ha	$589/t	$147.25	$160.33

Reform banks (4% area)	Aug/Sept	1.18	18.06	$0.85				$0.85
Rolling	Sep/Oct	0.2	$38.55	$7.71				$7.71
Grass weed control (aerial spray Molinate)	Sept/Oct			$25.00	1.5 L/ha	$5.97/L	$8.96	$33.96
Aquatic weed control (area spray Benzofenap)	Sept/Oct			$0.00	2.00 L/ha	$69.50/L	$139.00	$139.00
Bloodworm control (area spray Chlorpyrifos)	Oct			$0.00	0.15 L/ha	$11.28/L	$1.69	$1.69
Areal Sow	Oct			$36.00	150kg/ha	$0.47/kg	$70.50	$106.50
Aquatic weed control (aerial spray Thiobencarb Saturn)	Oct/Nov			$25.00	3.75kg/ha	$26.85/kg	$100.69	$125.69
Bloodworm control (area alpha Cypermethrin)	Oct/Nov			$0.00	0.10 L/ha	$14.09/L	$1.41	$1.41
Aquatic weed control (area spray Basagran M60)	Oct/Nov			$27.00	2.50 L/ha	$21.06/L	$52.65	$79.65
Aerial image of crop	Oct/Nov			$3.85				$3.85
Topdress nitrogen fertiliser (aerial topdress urea)	Oct/Nov			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Dec/Jan			$0.00	7 t/ha	$25.00/t	$175.00	$175.00
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	10.0ML	$5/ML	$50.00	$50.00
Cartage				$0.00	7 t/ha	$12.00/t	$84.00	$84.00
Research levy (farm gate value)				$0.00	7 t/ha	$3.00/t	$21.00	$21.00
Crop insurance (estimated crop value)				$0.00	$2,000	1.65%	$33.00	$33.00
Total costs								$1,238
Total gross margin (@ 7 t yield and $300/t price)								$2,100
Net return								$862
Net Return per ML								$86

RICE - MEDIUM GRAIN (Summer 2010/2011) **Burdekin**

AREAL SOWN

Operation	Month	Machinery			Inputs			Total Cost
		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Primary and secondary tillage	Aug	1.2	35.5	$10.74				42.60
Broadcast phosphorus fertiliser	Sept	0.1	18.61	$1.86	125kg/ha	$430/t	$53.75	$55.61
Apply nitrogen fertiliser (urea)	Sep/Oct	0.28	46.71	$13.08	250kg/ha	$589/t	$147.25	$160.33
Reform banks (4% area)	Sep/Oct	1.18	18.06	$0.85				$0.85

Rolling	Sep/Oct	0.2	$38.55	$7.71				$7.71
Grass weed control (aerial spray Molinate	Oct			$25.00	3.75 L/ha	$24.40/L	$91.50	$116.50
Aquatic weed control (area spray Benzofenap)	Oct			$0.00	2.00 L/ha	$69.50/L	$139.00	$139.00
Bloodworm control (area spray Chlorpyrifos)	Oct			$0.00	0.15 L/ha	$11.28/L	$1.69	$1.69
Areal Sow	Oct			$36.00	150kg/ha	$0.52/kg	$78.00	$114.00
Bloodworm control (area alpha Cypermethrin)	Oct			$0.00	0.10 L/ha	$14.09/L	$1.41	$1.41
Aquatic weed control (area spray Basagran M60)	Dec			$27.00	2.50 L/ha	$21.06/L	$52.65	$79.65
Aerial image of crop	Nov/Dec			$3.85				$3.85
Topdress nitrogen fertiliser (aerial topdress urea)	January			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Apr/May			$0.00	5 t/ha	$25.00/t	$125.00	$125.00
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	8.0ML	$5/ML	$40.00	$40.00
Cartage				$0.00	5 t/ha	$12.00/t	$60.00	$60.00
Research levy (farm gate value)				$0.00	5 t/ha	$3.00/t	$15.00	$15.00
Crop insurance (estimated crop value)				$0.00	$2,000	1.65%	$24.75	$24.75
Total costs								$1,104
Total gross margin (@ 5 t yield and $300/t price)								$1,500
Net return								$396
Net Return per ML								$50

RICE - MEDIUM GRAIN (Winter 2010)					**Burdekin**			
SOD SOWN								
Operation	Month	Machinery			Inputs			Total Cost
		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Broadleaf & grass weed control (boom spray Glyphosate 450)	July	0.05	$41.38	$2.23	1.00 L/ha	$4.90/L	4.9	$7.13
Reform banks (4% area)	July/Aug	1.18	$18.06	$0.85				$0.85
Sow	July/Aug	0.28	$46.71	13.08	170kg/ha	$0.47/kg	$79.90	$92.98
Apply starter fertiliser (DAP)	Aug/Sept				70kg/ha	$875.00/t	$61.25	$61.25
Grass weed control (Paraquat, Barnstorm 250)	Aug/Sept				1.00 L/ha	$8.35/L	8.35	$8.35

Grass weed control (Barnstorm®)	Aug/Sept	0.05	$41.38	2.23	1.00 L/ha	$105.64/L	$105.64	$107.87
Grass weed control (Molinate)	Oct/Nov	Drip			3.75 L/ha	$5.97/L	$22.39	$22.39
Broadcast urea	Oct/Nov	0.1	$18.61	1.86	80kg/ha	$589.00/t	$47.12	$48.98
Aerial image of crop	Oct/Nov			$3.85				$3.85
Topdress nitrogen fertiliser (aerial topdress urea)	Oct/Nov			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Dec/Jan			$0.00	7 t/ha	$25.00/t	$175.00	$250.00
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	10.0ML	$5/ML	$50.00	$50.00
Cartage				$0.00	7 t/ha	$12.00/t	$84.00	$84.00
Research levy (farm gate value)				$0.00	7 t/ha	$3.00/t	$30.00	$30.00
Crop insurance (estimated crop value)				$0.00	$2,000	1.65%	$33.00	$33.00
Total costs								$917
Total gross margin (@ 70 t yield and $300/t price)								$2,100
Net return								$1,183
Net Return per ML								$118

Modified from NSW DPI

RICE - MEDIUM GRAIN (Summer 2010/11)					Burdekin			
SOD SOWN								
Operation	Month	Machinery			Inputs			Total Cost
		hrs/ha	Cost ($/ha)	Total ($/ha)	Rate/ha	Cost	Total ($/ha)	
Broadleaf & grass weed control (boom spray Glyphosate 450)	Sep	0.05	$41.38	$2.23	1.00 L/ha	$4.90/L	4.9	$7.13
Reform banks (4% area)	Sep/Oct	1.18	$18.06	$0.85				$0.85
Sow	Sep/Oct	0.28	$46.71	13.08	170kg/ha	$0.47/kg	$79.90	$92.98
Apply starter fertiliser (DAP)	Sep/Oct				70kg/ha	$875.00/t	$61.25	$61.25
Grass weed control (Paraquat, Barnstorm 250)	Oct/Nov			0	1.00 L/ha	$8.35/L	8.35	$8.35
Grass weed control (Barnstorm®)	Oct/Nov	0.05	$41.38	2.23	1.00 L/ha	$105.64/L	$105.64	$107.87

Grass weed control (Molinate)	Oct/Nov	Drip			3.75 L/ha	$5.97/L	$22.39	$22.39
Broadcast urea	Oct/Nov	0.1	$18.61	1.86	80kg/ha	$589.00/t	$47.12	$48.98
Aerial image of crop	Dec			$3.85				$3.85
Topdress nitrogen fertiliser (aerial topdress urea)	January			$28.00	125kg/ha	$589.00/t	$73.63	$101.63
Harvest	Apr/May			$0.00	5 t/ha	$25.00/t	$125.00	$250.00
Chaser bin		0.32	45.05	$14.42				$14.42
Irrigation				$0.00	8.0ML	$12.38/ML	$40.00	$40.00
Cartage				$0.00	5 t/ha	$12.00/t	$60.00	$60.00
Research levy (farm gate value)				$0.00	5 t/ha	$3.00/t	$15.00	$15.00
Crop insurance (estimated crop value)				$0.00	$1,500	1.65%	$24.75	$24.75
Total costs								$859
Total gross margin (@ 70 t yield and $300/t price)								$1,500
Net return								$641
Net Return per ML								$80

Modified from NSW DPI

Appendix III Overview of Tasman Global Model

ACIL Tasman's computable general equilibrium model *Tasman Global* is a powerful tool for undertaking economic impact analysis at the regional, state, national and global level.
There are various types of economic models and modelling techniques. Many of these are based on partial equilibrium analysis that usually considers a single market. However, in economic analysis, linkages between markets and how these linkages develop and change over time can be critical. *Tasman Global* has been developed to meet this need.

Tasman Global is a large-scale computable general equilibrium model which is designed to account for all sectors within an economy and all economies across the world. ACIL Tasman uses this modelling platform to undertake industry, project, scenario and policy analyses. The model is able to analyse issues at the industry, global, national, state and regional levels and to determine the impacts of various economic changes on production, consumption and trade at the macroeconomic and industry levels.

A dynamic model

Tasman Global is a model that estimates relationships between variables at different points in time. This is in contrast to comparative static models, which compare two equilibriums (one before a policy change and one following). A dynamic model such as *Tasman Global* is beneficial when analysing issues where both the timing of and the adjustment path that economies follow are relevant in the analysis.

In applications of the *Tasman Global* model, a reference case simulation forms a 'business-as-usual' basis with which to compare the results of various simulations. The reference case provides projections of growth in the absence of the changes to be examined. The impact of the change to be examined is then simulated and the results interpreted as deviations from the reference case.

The database

A key advantage of *Tasman Global* is the level of detail in the database underpinning the model. The database is derived from the latest Global Trade Analysis Project (GTAP) database. This database is a fully documented, publicly available global data base which contains complete bilateral trade information, transport and protection linkages among regions for all GTAP commodities.
The GTAP model was constructed at the Centre for Global Trade Analysis at Purdue University in the United States. It is the most up-to-date, detailed database of its type in the world.

Tasman Global builds on the GTAP model's equation structure and database by adding the following important features:

- dynamics (including detailed population and labour market dynamics)

- detailed technology representation within key industries (such as electricity generation and iron and steel production)
- disaggregation of a range of major commodities including iron ore, bauxite, alumina, primary aluminium, brown coal, black coal and LNG
- the ability to repatriate labour and capital income
- a detailed emissions accounting abatement framework
- explicit representation of the states and territories of Australia
- the capacity to explicitly represent multiple regions within states and territories of Australia.

Nominally the *Tasman Global* database divides the world economy into 120 regions (112 international regions plus the 8 states and territories of Australia) although in reality the regions are frequently disaggregated further. ACIL Tasman regularly models Australian projects or policies at the regional level.

The *Tasman Global* database also contains a wealth of sectoral detail currently identifying up to 70 industries (Appendix III Table 1). The foundation of this information is the input-output tables that underpin the database. The input-output tables account for the distribution of industry production to satisfy industry and final demands. Industry demands, so-called intermediate usage, are the demands from each industry for inputs.

For example, electricity is an input into the production of communications. In other words, the communications industry uses electricity as an intermediate input. Final demands are those made by households, governments, investors and foreigners (export demand). These final demands, as the name suggests, represent the demand for finished goods and services. To continue the example, electricity is used by households – their consumption of electricity is a final demand.
Each sector in the economy is typically assumed to produce one commodity, although in *Tasman Global*, the electricity, diesel and iron and steel sectors are modelled using a 'technology bundle' approach. With this approach, different known production methods are used to generate a homogeneous output for the 'technology bundle' industry. For example, electricity can be generated using brown coal, black coal, petroleum, base load gas, peak load gas, nuclear, hydro, geothermal, biomass, wind, solar or other renewable based technologies – each of which have their own cost structure.

Factors of production:

Capital, land, labour and natural resources are the four primary factors of production. The capital stock in each region (country or group of countries) accumulates through investment (less depreciation) in each period. Land is used only in agriculture industries and is fixed in each region. *Tasman Global* explicitly models natural resource inputs as a sector specific factor of production in resource based sectors (coal mining, oil and gas extraction, other mining, forestry and fishing).

Population growth and labour supply

Population growth is an important determinant of economic growth through the supply of labour and the demand for final goods and services. Population growth for the 112 international regions and for the 8 states and territories of Australia represented in the *Tasman Global* database is projected using ACIL Tasman's in-house demographic model. The demographic model projects how the population in each region grows and how age and gender composition changes over time and is an important tool for determining the changes in regional labour supply and total population over the projection period.

Appendix Table 1 Sectors in the *Tasman Global* database

	Sector		Sector
1	Paddy rice	36	Leather products
2	Wheat	37	Wood products
3	Cereal grains nec	38	Paper products, publishing
4	Vegetables, fruit, nuts	39	Diesel (incl. nonconventional diesel)
5	Oil seeds	40	Other petroleum, coal products
6	Sugar cane, sugar beet	41	Chemical, rubber, plastic products
7	Plant- based fibres	42	Mineral products nec
8	Crops nec	43	Ferrous metals
9	Bovine cattle, sheep, goats, horses	44	Alumina
10	Animal products nec	45	Primary aluminium
11	Raw milk	46	Metals nec
12	Wool, silk worm cocoons	47	Metal products
13	Forestry	48	Motor vehicle and parts
14	Fishing	49	Transport equipment nec
15	Brown coal	50	Electronic equipment
16	Black coal	51	Machinery and equipment nec
17	Oil	52	Manufactures nec
18	Liquefied natural gas (LNG)	53	Electricity generation
19	Other natural gas	54	Electricity transmission and distribution
20	Iron ore	55	Gas manufacture, distribution
21	Bauxite	56	Water
22	Minerals nec	57	Construction
23	Bovine meat products	58	Trade
24	Meat products nec	59	Road transport
25	Vegetables oils and fats	60	Rail and pipeline transport
26	Dairy products	61	Water transport
27	Processed rice	62	Air transport
28	Sugar	63	Transport nec
29	Food products nec	64	Communication
30	Wine	65	Financial services nec
31	Beer	66	Insurance
32	Spirits and RTDs	67	Business services nec
33	Tobacco products and beverages nec	68	Recreational and other services
34	Textiles	69	Public Administration, Defence, Education, Health
35	Wearing apparel	70	Dwellings

Note: nec = not elsewhere classified

For each of the 120 regions in *Tasman Global*, the model projects the changes in age-specific birth, mortality and net migration rates by gender for 101 age cohorts (0-99 and 100+). The demographic model also projects changes in participation rates by gender by age for each region, and, when combined with the age and gender composition of the population, endogenously projects the future supply of labour in each region. Changes in life expectancy are a function of income per person as well as assumed technical progress on lowering mortality rates for a given income (for example, reducing malaria-related mortality through better medicines, education, governance etc).

Participation rates are a function of life expectancy as well as expected changes in higher education rates, fertility rates and changes in the work force as a share of the total population.

Labour supply is derived from the combination of the projected regional population by age by gender and the projected regional participation rates by age by gender. Over the projection period labour supply in most developed economies is projected to grow slower than total population as a result of ageing population effects.

For the Australian states and territories, the projected aggregate labour supply from ACIL Tasman's demographics module is used as the base level potential workforce for the detailed Australian labour market module, which is described in the next section.

The Australian labour market

Tasman Global has a detailed representation of the Australian labour market which has been designed to capture:

- different occupations
- changes to participation rates (or average hours worked) due to changes in real wages
- changes to unemployment rates due to changes in labour demand
- limited substitution between occupations by the firms demanding labour and by the individuals supplying labour; and
- limited labour mobility between states.

Tasman Global recognises 97 different occupations within Australia – although the exact number of occupations depends on the aggregation. The firms who hire labour are provided with some limited scope to change between these 97 labour types as the relative real wage between them changes. Similarly, the individuals supplying labour have a limited ability to change occupations in response to the changing relative real wage between occupations. Finally, as the real wage for a given occupation rises in one state rise relative to other states, workers are given some ability to respond by shifting their location. The model produces results at the 97 3-digit ANZSCO (Australian New Zealand Standard Classification of Occupations) level.

The labour market structure of *Tasman Global* is thus designed to capture the reality of labour markets in Australia, where supply and demand at the occupational level do adjust, but within limits.

Labour supply in *Tasman Global* is presented as a three stage process:

1. labour makes itself available to the workforce based on movements in the real wage and the unemployment rate
2. labour chooses between occupations in a state based on relative real wages within the state; and
3. labour of a given occupation chooses in which state to locate based on movements in the relative real wage for that occupation between states.

By default, *Tasman Global*, like all general equilibrium models, assumes that markets clear. Therefore, overall, supply and demand for different occupations will equate (as is the case in other markets in the model).

Appendix IV Rice industry level questionnaire

Perception of industry on relocation to northern Queensland

- What could be sustainable future of rice industry (in terms of production/scale/export)? And what type of climate changes might hinder you getting there? What can you do to mitigate the risk or exploit opportunities? What are the relative costs and benefits?
- Perceptions of taking out the rice industry out of towns (like Leeton, Coleambally, and Deniliquin), and its perceived impact on: Town, mills, transport, storage, supply, housing etc?
- Community perceptions and additional social and environmental issues as a result of relocation
- Perception of the irrigators in Burdekin? How to bring local 'grazier on board'. Are they willing to adapt new farming system? Are they rigid in their farming practices? Farm flexibility issue?
- Key issues in terms of rice production in northern areas (eg. Pests were one of the biggest problems and Magpie geese are a big issue).
- Land use substitute: What are the land use substitutes for rice in Riverina? What sort of crops rice would be competing in Burdekin (sugarcane? Sandalwood? Chia?)
- How big are the investment needed (in term of $ cost) for set up a standard rice mill?
- The impact of structural adjustment/relocation on-farm size and productivity. The impact of scale and intensity of production, the diversity of farm output or the need to find ways to supplement their income
- The impact of structural changes/relocation on the industry performance
- Impact of various climate and economic factors (relocation) and water availability on land values.
- Equity considerations of structural change (relocation) and affects Govt support, if any structural adjustment in agriculture and regional capacity to implement sustainable adjustment
- Key infrastructure and production, economic and market issues that rice industry is expected to face if they will relocated to Burdekin
- Impact of water trading on rice industry
- Is cost of inputs (fertiliser etc) are major concern?

Industry Threshold point (key infrastructure requirements)

- Threshold points for the industry are to maintain our core infrastructure, to maintain markets. What was the threshold limit for the rice mills closed at Deniliquin?

- Issue of scale of production. What would be optimal scale of productions in Burdekin?

- Key infrastructure availability and additional requirement (eg. road, mills and irrigation water delivery system)

Climate change and water availability

- Do you think, you will continue to grow rice in southern Australia given the significance decrease in water availability?

- Impact of water buyback and environmental water requirements on rice industry?

- Climate change and rice yield?

Production, quality and economic issues

- Temperate vs. tropic rice: Market, demand, profit etc. Long rice vs. medium rice, Cold tolerance in rice

- Rice quality issues:

- Sowing time and sowing times and methods: Could be useful for international market

- Rice production:

- Crop profitability.

- Will SunRice grow crops in northern areas if experimental crops yield good results??

Value chain: Demand/Supply/Export/Import

- Domestic and international demand of long and medium rice? Major determinant of rice international demand?

- Climate and production possibilities in different regions. Length of growing season and its water runoff etc.

- Key driver: international and national market (prices and demand, and supply), national policies (income and structural support) and climate change (higher temperature) and variability (drought etc), others (Food security, bio fuels etc)

- Impact of relocation/climate change on supply, demand and pricing

- Govt support and structural change for relocation of agricultural industry:

- Supplementary (complementary) industry