*ECONOMIC AND POLICY IMPLICATIONS OF RELOCATION OF AGRICULTURAL PRODUCTION
SYSTEMS UNDER CHANGING CLIMATE: EXAMPLE OF AUSTRALIAN RICE INDUSTRY*

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ABSTRACT

The development or expansion of existing land use, agricultural industries are seen a way to manage global food security in the face climate change and reduced water availability in the traditional cropping regions. This paper examines economic and policy implications of incremental and transformational changes in production location by considering the net effects of shifting rice production from a southern area to the sugar dominated Burdekin area in northern Queensland, using a dynamic regional Computable General Equilibrium (CGE) model. Three rice transformational adaptation scenarios at two time points, 2030 and 2070, were considered. The results suggest a net reduction in real economic output and real income, although adopting a rice-sugarcane rotation in Burdekin could partly offset some of the negative impact. The displacement of sugar would result in a much larger net national loss and consequent net reduction in Gross Regional Product (GRP). The study findings suggest 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, the lower profits and the opportunity cost of turning away from sugar. Currently private investment in infrastructure can keep pace with the level of production, but a more rapid expansion would need access to government assistance.

KEY WORDS: Computable General Equilibrium Model, Rice, Sugarcane, Water, Regional Climate Change, Land Use Policy

1. INTRODUCTION

Climate change has the potential to significantly change the rainfall distribution and conditions for crop production, with important implications for food security (Kellett et al., 2015; Risbey, 2011; Potgieter et al., 2013; Sinivasan, 2011; Smith et al., 2013; Steffen et al., 2013). Under climate change 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; Robertson and Murray-Prior, 2014). 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 effectively reconfigure the geography of

intensive agriculture (IPCC 2007; Henstra, 2015; Camkin et al., 2007; Northern Australia Land and Water Taskforce, 2009b; Davidson, 1966; Mushtaq et al., 2013). In Australia there has long been an interest in, perhaps even obsession with, ‘northern development’, which has been argued for on the grounds of nation-building decentralisation and even as a defence strategy (justifications reviewed in Davidson, 1966). The latest justification for, or driver of, this renewed interest in northern agriculture is to develop a potential new food basket ‘in the face of climate change’ (Shanahan, 2007; Millar and Roots, 2012; The Sydney Morning Herald, 2007). Most importantly, northern development could fill some variable production and supply gaps associated with climate change and variability.

This land use expansion, it is argued, would not only address increasing food demand in Asia but could offset possible decreases in the irrigated area and output of the Murray Darling Basin (MDB) resulting from decreased inflows, buybacks of environmental water under the Murray Darling Basin Plan (Murray–Darling Basin Authority, 2010; Loch et al., 2014; Adamson and Lock, 2014; Wallis et al., 2013), and possible trading of water to other uses (National Water Commission, 2009). The offset would, however, be at the national level, with production moving from one location to another. The regional impacts could be significant, especially given that agricultural production has long been seen as the mainstay of regional development (Davison, 2005) and there are many communities highly dependent on irrigation schemes (Marshall et al. 2012).

For such investments to succeed, it is imperative that sustainable and profitable rotational systems are identified and adopted (Gustafson et al., 2014; Connor and Minguez, 2012). Enterprise profitability is especially critical because Australian governments are generally reluctant to commit to long-term and direct support of industry development. This is in contrast to the foundation of European-derived agriculture in Australia, whereby governments distributed land and provided subsidized finance in return for requiring particular development outcomes, such as clearing and grain production (Johnston, 1988; Connors, 1970; Lake, 1987; Roberts, 1924). Later, there were state irrigation schemes, of which the Burdekin dam was one of the last (1985) and a range of support measures including: machinery and fertilizer bounties; tariffs on competing imports; and the creation of centralized marketing systems, such as the Rice Marketing Board. State ‘intervention’ was however, criticized, notably by some agricultural economists, from the 1960s on (for overviews see Gruen, 1986) especially in the wake of some notable development failures in the north (Davidson, 1966; Graham-Taylor, 1982; Wooding, 2008). From the early 1970s, there was an incremental reduction in agricultural (and secondary industry)

support, the winding back of tariffs, a reduction in subsidies and the privatization of marketing boards (Cockfield, 2009). For irrigated agriculture, the additional consequences were increasing water prices to cover infrastructure (1990s on) and the deregulation of water pricing and trading (1990s-2000s). Most recently, the environmental costs of water have increasingly been considered, leading to the MDB Plan.

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 (Camkin et al., 2007; Northern Australia Land and Water Taskforce, 2009a) and this work is recommended to continue (Northern Australia Land and Water Taskforce, 2009b). The paper mainly focuses on the last two questions; with assumptions that there are suitable soils and crops varieties are available. The paper recognises these as heroic assumptions and all recommendations should be seen as confined only to consideration of the private and public benefit if those resources are available.

The Burdekin area was chosen for the current study to avoid considering the cost of additional irrigation infrastructure, given the existing dam, in line with an overall approach of examining just the economics at farm and regional level, assuming future studies of the agronomic factors. In addition, the Burdekin region is reasonably close to a major centre and port (Townsville), which could minimize some of the costs and logistical problems that have constrained other northern developments.

The regional impacts are important both economically and politically because agricultural production has for many years been a mainstay of regional development (Davison 2005; Thiene & Tsur 2013) and there are many communities highly dependent on irrigation systems. There is a great deal of uncertainty in the community with regard to the potential implications of major structural reforms in the irrigation sector and there is a risk of over-investment in infrastructure renewal if the likely extent of future structural adjustment is not adequately recognized (National Water Commission 2009). This paper provides information to support decisions by

examining the economic and policy implications of incremental and transformational changes in production location by considering the net effects of shifting some rice production from a southern area to the sugar dominated Burdekin area in northern Queensland using a dynamic regional Computable General Equilibrium (CGE) model. The net effects also consider impacts of shifting agricultural production by examining possible structural adjustment in the southern rice areas, given a reduction in available water. This work also contributes to discussions about the future of the Murray-Darling Basin in that the on-farm and regional impacts of reducing water allocations are examined.

2. THE RICE INDUSTRY: SIGNIFICANCE AND CLIMATE CHANGE IMPACTS

The Australian rice industry has a relatively small number of producers generating considerable export income, and value added production. Several factors combine to make rice production in Australia successful: the high grain quality owing to the climate, with plenty of sunlight and suitable temperatures, excellent water quality, good soils, expert producers who obtain an average of around 10 tonnes per hectare while increasing water use efficiency and the tight integration of the production, commercial, and research arms of the industry (Rice Growers Association, 2011; Dunn and Gaydon, 2011; Mushtaq et al., 2009). Taking into account processing and packaging operations, the rice industry directly employs more than 8,000 people and supports more than 60 towns. Indirectly, the industry further supports 33,000 people, mostly in the Riverina region in NSW (SunRice, 2010).

Australia has one of the highest yields of rice per hectare (10 t/ha) in the world. Over the past thirty years there have been substantial increases in irrigation and total water productivity. The long term Water Productivity (WP) for rice has increased by more than 60% from the 1980s to 2008 (Lacy et al., 2009; Dunn and Gaydon, 2011). Rice is a globally traded commodity and a financially attractive crop due to relatively high net returns (gross returns – total costs) which depend on the type of rice grown. For example, net returns from medium grain rice can be close to \$2,000 per ha while long grain rice can make around \$1,750 per ha. In the Burdekin, rice can be grown during winter and summer season but the yield of both summer (5t/ha) and winter (7t/ha) rice

1 is low compared to crops in the Riverina, although production is still profitable. The medium grain rice grown in
2 winter could generate up to \$1,180 per ha because of the lower volumes of water use and associated water costs.

3
4 Since, the establishment of the first commercial crop of rice in Australia in 1924, there has been a gradual
5 increase in rice area and yield (Figure 1a and b). There are, however, significant concerns about the longer term
6 impact of climate change and climate variability on water availability. Noticeable reductions in water
7 availability during the 'millennium drought period (2000-2009) has resulted in a significant decline in rice area
8 (Figure 1a). According to current modelling, it is expected that with climate change, future average water
9 availability will decline and the frequency of droughts will increase (Sanders et al., 2010)

10
11 The millennium drought provides a possible analogue of a drier future. There was significantly reduced rainfall
12 and above average temperatures from 2001-02 to 2009-10 and Basin inflows were much lower than average and
13 allocations to irrigators declined, resulting in an irrigation drought (CSIRO 2008). Total rice area in Australia
14 has a strong linear relationship with total irrigation water allocations (Figure 2a) and there was also a reduction
15 in the number of farms growing rice (Figure 2b). Although the Australian rice industry has improved its water
16 efficiency considerably, using 50% less water than the world average (Rice Growers Association, 2011), there is
17 further pressure for structural adjustment because of the continuous decline in water availability. This will affect
18 farm profitability and the regional economies where rice production is concentrated.

19
20 Insert Figure 1

21
22 Insert Figure 2

23 24 **CHALLENGES AND OPPORTUNITIES: RICE INDUSTRY PERSPECTIVES AND PERCEPTIONS**

25
26 In the future, water will probably be more expensive, less available and allocations will be less secure,
27 particularly for water intensive industries such as rice (Lee, 2014). Rice industry stakeholders and growers have
28 already adopted a risk-averse approach. At the industry level, there is a flexible and efficient global supply
29 network for procurement and processing (e.g in California and Papua New Guinea) to ensure continuous supply
30 during critical periods. At the farm level, during years of low water availability, rice growers trade water as a

tactical response and shift to low water intensive or dry land farming. This however has resulted in highly variable rice supplies and northern production could fill some production gaps.

To scope the possibilities, key experts in the rice industry were interviewed in regard to the potential for a shift in production location and they, in summary noted that:

- Based on an expected reduction in long-term water availability, because of climate change and water policy reform, the long-term outlook for the rice industry is around 800,000 tonnes a year.
- There is cautious support for considering the relocation of some rice production. However, rice grown in Burdekin is seen as ‘complementary production’, because of different types of rice, growing seasons and markets.
- Key constraints would likely include insect pests, birds such as magpie geese and transportation and production costs.
- The rice industry may be willing to invest in milling facilities provided a sufficient level of production (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.
- Concern 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.
- There is a perceived lack of agronomic knowledge about rice production within the Burdekin region
- It may be possible to make use of the fallow sugarcane fallow land to exploit the availability of fallow land during the 4-5 year planting cycle. This would mean that rice would not be seen as displacing sugar cane but as a complementary rotation crop providing additional income and supporting weed control during fallow periods

2.1 Rice relocation scenarios

Following discussion with key rice industry (Rice Growers’ Association, SunRice, Rice Marketing Board and Blue Ribbon Seed) and consideration of water policy and climate change literature, three scenarios were developed.

Baseline scenario: For the baseline scenario, the 2004 water availability was selected against which other scenarios are compared. This is the ‘no rice reduction’ scenario. From 2002 to 2012 water availability fluctuated significantly in the Riverina so this year was selected as representing historical levels of production with average water availability (50% allocation).

Scenario 1: Rice is grown on fallow sugarcane land: This scenario assumes that there is no displacement of sugar cane by rice in the Burdekin region. Sugarcane is a higher value cash crop and consultations with industry advisors suggested that farmers would be reluctant to replace the relatively certain production of sugar cane with rice. However, there is a window of opportunity to grow rice on fallow sugar cane land every 5 years.

Scenario 2: Rice displaced sugar cane land in competition with sugar cane: This scenario assumes that there is competition between rice and sugarcane with no additional land available. Any additional rice grown will displace sugar cane. This scenario provides an indication of the impacts of developing the northern rice industry at the expense of other activities. On a ‘dollars per hectare’ basis, sugar cane output is generally higher value than rice.

For the regional economic modelling, it was assumed that:

Riverina: Based on CSIRO (2008), under the best estimates and future development scenario, runoff will decrease by 11%. Assuming a further 4% reduction in water availability as a result of the MDB water buy-backs to achieve specific sub-catchment targets, it is expected that a total reduction of 15% may occur, compared with the baseline scenario (50% water availability). Using a simple regression model (see Figure 2a) involving rice areas as a function of water availability, a 15% reduction in water availability will reduce the rice area by about 18,500 ha. For simplicity, it is assumed that the same area will be converted to 10,000 ha of irrigated wheat (with 1-2 irrigations) and 8,500 ha of dryland wheat. Similarly, a 30% reduction in water availability is predicted for 2070, compared with the baseline scenario. This would reduce the rice area by about 37,200 ha, 17,500 ha of irrigated wheat and 20,000 ha of dryland wheat. The average rice yield is assumed to return from its recent high to the long term trend average of 9 t/ha. Ongoing productivity improvements of 0.4 per cent a year (equal to the rate over the past 20 years) are assumed to occur such that the average rice yield is 9.7 t/ha by 2030 and 11.3 t/ha by 2070.

Burdekin: Based on the information from the rice industry, about 17,000 ha of sugarcane fallow land is currently available each year, which is about 25% of the average total sugarcane area in the Burdekin (Australian Bureau of Statistics ABS). For this study, it was assumed that 25% of any additional rice will be grown in winter (dry season rice) and 75% in summer (wet season rice). The expected yield, based in trials, of winter rice is about 7-8 t/ha while the summer yield is about 4-5 t/ha. Further, it was assumed that 20,000 ha of fallow land would be available for rice each year up to and including 2070. As per the Riverina assumptions, an average yield increase of 0.4% per year was assumed. Finally, in the absence of other information, even though the rice varieties will differ, it was assumed that the average farm gate rice price is the same as in the Riverina.

The sugarcane fallow can be planted with legumes break crops (generally grown as green-manure crops) to alleviate the yield loss in subsequent new sugar cane crops (Skocaj et al., 2013). However, legumes are generally planted the wetter northern districts. Therefore, it was also assumed that no leguminous break crop is grown in Burdekin areas.

3. METHODOLOGY

3.1 The relocation of agriculture as industry policy: conceptualising policy development

In this section a conceptual model of policy developments is proposed based on some basic economic principles. The contention is that governments in Australia have moved through three broad stages of industry development policy for agriculture. The three policy stages are: establishment and support (of an industry); self-sufficiency, competitiveness and structural adjustment; and post-productivist adjustment (Stewart, 1994; Freedman and Stonecash, 1997; Johnston, 1988). However, 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 and support, 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). The ‘support’ 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.

Hence, the initial subsidies encouraged producers to enter the market, shifting the 'supply curve' further to the right (S to S_s in Figure 3) than would have been the case with no government intervention. In addition and assuming there are limits to the number of producers 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 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 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). 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. There could be more changes for the rice industry that result from third policy stage 'post-productivist, 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.

Insert Figure 3 about here

1 The framework suggests that all irrigation industries, especially those in the Murray-Darling Basin, are likely to
2 undergo what might be termed post-productivist adjustment as implicit environmental and social ‘subsidies’ are
3 removed. With an increased focus on externalities, the costs of agricultural production are now considered to
4 include environmental and social (post-productivist) values such as clean water and air, environmental flows,
5 habitat for non-human species and the recreational and existence value of non-agricultural vegetation. Examples
6 of post-productivist revocations in other industries include: limits on industrial and effluent discharges into
7 waterways; the restriction of logging in native forests; and the proposed carbon tax, or emissions trading. All of
8 these initiatives require producer adjustments with the adoption of waste management or emissions control
9 technology, the purchase of sequestration offsets, the switch to commercial plantation timber, or exit from the
10 industry. In the case of irrigators in the Murray-Darling Basin, governments have decided that water was ‘over-
11 allocated’ at the expense of the environment and therefore some needs to be bought back for that purpose. This
12 will further decrease supply to where environmental values are considered (S_{ev}), and net production will also
13 decrease. However, while surface water availability is influenced by climate change and variability and
14 government’s water and environmental policies, groundwater can be used optimally in conjunction with surface
15 water supplies to augment dwindling surface water supplies. Such conjunctive use systems can significantly
16 decrease the risk associated with a stochastic availability of surface water supply and can partly alleviate
17 production impacts (An-Vo et al., 2015).

18
19 The purpose of this section was to set out a conceptual framework for organizing the overall discussion but in
20 particular, to use the concept of the three stages to highlight some potential dilemmas for governments. If this
21 regional economic modelling finds were to find that rice production in the Burdekin region was relatively
22 profitable then government roles could reasonably be confined to research and extension on crop production
23 techniques, the expansion of the water distribution system and perhaps some additional roads and
24 communications infrastructure. All of these are standard government roles and the costs of the additional the
25 infrastructure could be recouped through full cost charges.

26
27 If however, there is not a clear case that rice is competitive with other land uses, then governments have to
28 decide if there is to be additional support to facilitate this expansion. This would mean that just as the southern
29 irrigation area is going through third-stage adjustment, there would be some first stage support in order to
30 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 second stage industry policy that prevails in most agricultural industries.

3.2 Regional Computable General Equilibrium Modelling

ACIL Tasman's CGE model, *Tasman Global*, was used to estimate the regional level economic impacts of the different scenarios. *Tasman Global* is an iterative dynamic CGE model that estimates the 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. The *Tasman Global* 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 which are underpinned by economic theory. 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 (such as land and labour supply). Another key advantage of CGE models is that they are able to 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.

Detail reference case assumptions and scenario assumptions are provided in supplementary material (see supplementary material section 1 & 2). For this analysis the model has been aggregated to:

- Four economic entities: the Southern Rice region; the Burdekin local government area (LGA); the Rest of Australia; and the Rest of the World.
- 34 industries/commodities to provide the maximum detail possible for the key industries.

1 The impact of rice relocation has been measured in terms of changes in Gross Domestic Product (GDP) and
2 income. At the regional level the GDP equivalent is GRP (Gross Regional Product) to reduce the potential
3 confusion the term ‘economic output’ is used for the presentation and discussion of results from all economic
4 entities in. Although changes in real GDP are useful measures for estimating how much the output of an
5 economy may change, changes in the real income of a region are more important since they provide an
6 indication of the change in economic welfare of the residents of a region. Indeed, it is possible that real GRP can
7 increase with no, or possibly negative, changes in real income. In *Tasman Global*, changes in real income at the
8 national level are synonymous with real gross national disposable incomes (RGNDI) reported by the ABS.

9
10 Importantly, to eliminate the impact of nominal price movements in the results, economic variables such as the
11 change in economic output are reported as deviations from their real rather than nominal values. Similarly, all
12 aspects not directly related to the assumed changes in the rice industry have been kept constant across all the
13 scenarios (including, for example, productivity growth, national population and all demand and supply
14 elasticities).

15 16 **4. RESULTS AND DISCUSSION**

17
18 The macroeconomic results of relocating rice production from southern (Riverina) NSW to northern (Burdekin)
19 Queensland are presented in as changes in real economic output and real income, while other variables (notably
20 employment), are not presented in this paper. When analysing the results, it is important to remember that the
21 initial impact of the scenario relates to the assumed changes in agricultural output in the Southern Rice and
22 Burdekin regions. These changes then affect each region’s total economic output with changes in the demand
23 for labour and capital. Capital is naturally mobile (albeit sluggishly) between all regions based on changes in the
24 rates of return, while, labour is assumed to be fully mobile between Australian regions. Consequently, the
25 supply of factors in the Rest of Australia is also impacted by the changes in the demand in the Southern Rice
26 and Burdekin regions. At the national level, the Rest of Australia acts to reduce the magnitude of the aggregate
27 impacts experienced in the Southern Rice and Burdekin regions.

4.1 Macroeconomic impacts: Scenario 1

Table 1 summarises the projected changes in real economic output and real income for each region under Scenario 1, whereby rice is introduced as a rotational crop with sugar, while Figure 4a and 4b show the year on year changes in real outputs, real income and employment.

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:

- –\$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 1 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 increases¹. In particular, under Scenario 1 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).

¹Essentially 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.

1 In a region with around 18,500 people, this is a substantial change, with the increase in 2069-70 representing an
2 increase in real economic output of around \$7,000 per person projected to be living in the Burdekin at this time.

3
4 Under Scenario 1, the net movement of labour is primarily between the Southern Rice and Burdekin regions,
5 with minimal net movement of labour to/from the Rest of Australia. Consequently it is projected that there will
6 be minimal impacts on the Rest of Australia under Scenario 1. At the national level however, real economic
7 output (or real GDP) is projected to change by:

- 8
- 9 • –\$11 million in 2029-30 (in 2010-11 terms)
- 10 • –\$29 million in 2069-70 (in 2010-11 terms)
- 11 • A cumulative total of –\$211 million in net present value terms over the 59 years to 2069-70 (using a
12 four per cent real discount rate).
- 13

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

19
20 Under Scenario 1, the real income (in 2010-11 terms) is projected to change by (See Table 1):

- 21 • –\$72 million in 2029-30 and by –\$161 million in 2069-70 in the Southern Rice region
- 22 • \$58 million in 2029-30 and by \$178 million in 2069-70 in the Burdekin region
- 23 • \$6 million in 2029-30 and by –\$26 million in 2069-70 in the Rest of Australia
- 24 • A national total of –\$8 million in 2029-30 and –\$9 million in 2069-70
- 25

26 Insert Table 1 about here

27
28 As with the projected changes in real economic output, these are significant regional changes. In the Burdekin,
29 the projected increase in real income in 2069-70 is equivalent to an average increase of over \$9,000 per person
30 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 assumptions, 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.

Insert Figure 4 about here

4.2 Macroeconomic impacts: Scenario 2

Table 2 summarises the projected changes in real economic output and real income for each region under Scenario 2 (rice displaces some sugar) while Figure 5a and 5b show the year on year changes in real outputs, real income and employment.

Real economic output: Since the assumptions regarding the Southern Rice region are the same for both Scenario 1 and 2, the projected impacts on the economy of the Southern Rice region are broadly the same as those discussed before. However, under Scenario 2 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 net 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 portion, 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 (namely, substituting rice for wheat and sugar for rice).

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 2):

- –\$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).

Insert Table 2 about here

Insert Figure 5 about here

5. CONCLUSIONS AND POLICY IMPLICATION

5.1 Conclusions

Climate variability and climate change will shape the nature of water availability in Australia. Climate change and on-going policy reform, especially the purchase of environmental water, will reduce the average area of rice production as water allocation reductions of 25-35 percent cannot be offset by productivity gains given current production techniques and increasing temperatures and rainfall variability.

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 rice supply chain could still be run from Australia but more of it would be located overseas, to cope with the reduction in domestic production. 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 compound the effects on some towns and regions.

There is some interest within the industry, and from potential new corporate entrants, in the relocation of some rice production to the north. However, lack of suitable varieties to sustain Australia's market niche; lack of, or risks of investing in, processing infrastructure; pest and disease problems; concern about local reactions to land use change; attracting new or existing landholders into the rice industry, sufficient to develop a regional

1 industry; and previous experience with grand schemes in the north tend to encourage caution about such
2 relocations.

3
4 Based on limited agronomic and financial data, rice production in the Burdekin area could be profitable,
5 depending on land and water values but does appear to be less profitable than in the south because of lower
6 yields. This also means that if there is roughly the same amount of additional northern production as is lost in
7 the south then there would still be a net loss of national output and income, even with the minimal impact
8 option, whereby rice production is introduced to a sugar-based rotation. The displacement of an existing
9 intensively-produced crop, such as sugar, will result in a much larger net national loss, also meaning that there
10 would be a net reduction in GRP.

11
12 In conclusion that there is unlikely to be a rapid and spontaneous increase in rice production in the north,
13 because of a lack of infrastructure, understandable wariness in relation to the agronomic issues and the
14 opportunity cost of turning away from sugar. The paper largely relied on experimental data due to limited
15 production data therefore results should be interpreted cautiously. The paper has also not yet examined the
16 social preference for traditional crops and landscapes but think that there will be a strong local attachment to
17 sugar production. This means that the rice in a rotation option is likely to be the most appealing in the short run.
18 This at least would minimize the net national and regional economic effects.

22 5.2 Policy implications

23
24 In regard to the policy implications of this study, the findings raise some questions for governments. The returns
25 from rice, per hectare, are likely to be less in the north than in the south, at least until there is further
26 developments on varieties and production techniques. The relative profitability might be moderated if it was
27 clear that land and water were cheaper in the north. There will be some further investigation on land prices but
28 the market for water in the north is much less developed. Setting aside any capital cost differences, the lower
29 profits, agronomic uncertainties and a local attachment to existing crops mean there is unlikely to be any major
30 autonomous expansion of a northern rice industry, which raises the question of whether or not governments

1 should or would provide additional support to accelerate industry development. The three main arguments for
2 support would be: cushioning the impacts on the national economy of reducing southern production; helping to
3 support the maintenance of rice processing infrastructure in Australia, which assists with local value-adding; and
4 boosting a regional economy.

5
6 Forms of government intervention, based on historical experience could include:

- 7 • Providing the additional infrastructure for an expansion of the Burdekin irrigation scheme, or develop a
8 new dam in some other area, without necessarily aiming to recoup full capital costs;
- 9 • Providing social infrastructure (roads, power etc) to support private irrigation developments;
- 10 • Providing structural adjustment funding to support the development of value-adding activities, though
11 there would need to be some clear and sustained expansion in production before such an investment;
- 12 • Research projects dedicated to increasing rice productivity in the north; and
- 13 • Extension officers to support prospective producers.

14
15 This all presumes that the environmental consequences of such an expansion were not too severe. There would
16 be no point in buying back 'environmental' water in the south, only to incur additional environmental costs in
17 the north.

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Figure Caption

Figure 1: Historical rice area and yield

Figure 2: Relationship between annual water allocation and rice area and rice farms in southern NSW, Riverina

Figure 3: A model of the Australian rice market with 2 stages of policy adjustment

Figure 4: Projected change in real economic output, real income and employment under scenario 1, relative to the reference case (2010-11 dollars)

Figure 5: Projected change in real economic output, real income and employment under scenario 2, relative to the reference case (2010-11 dollars)

Figure 1: Historical (a) rice area and (b) yield
Source: ABARE (2010)

a

b

Figure 2: Relationship between annual water allocation and (a) rice area and (b) rice farms in southern NSW, Riverina

Source: Rice Marketing Board (2013); NSW Water Information (2012)

Figure 3: 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.

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Figure 4: Projected change in real economic output and real income 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

1

Figure 5: Projected change in real economic output and real income 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

List of Tables

Table 1 Cumulative change in real economic output and real income under scenario 1, 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	-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

Table 2 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

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