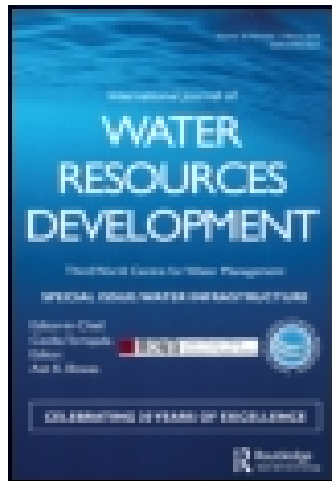


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Onil Banerjee<sup>a</sup>

<sup>a</sup> CSIRO Ecosystem Sciences and CSIRO Sustainable Agriculture Flagship, Dutton Park, Queensland, Australia

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## Investing in recovering water for the environment in Australia's Murray-Darling Basin

Onil Banerjee\*

*CSIRO Ecosystem Sciences and CSIRO Sustainable Agriculture Flagship, Dutton Park, Queensland, Australia*

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Irrigated agriculture makes an important contribution to the economy of Australia's Murray-Darling Basin. Competing water demand, recurring drought and climate change have ushered in an era of water policy reform. To recover water for the environment, surface water extraction is capped and investment in irrigation infrastructure is prioritized. This article applies a computable general equilibrium model to evaluate the economic impacts of investment in irrigation in a case study of the Murrumbidgee subcatchment. Results indicate an increase in regional output, income and employment, while at the national level there is a small negative impact resulting from the transfer of resources to the basin and the crowding out of private investment.

**Keywords:** computable general equilibrium model; water recovery; environmental water; irrigation efficiency; water policy reform; Murray-Darling Basin

### Introduction

Australia's Millennium Drought (1997–2010), the most severe drought in the country's recorded history, exposed the unsustainable nature of current levels of water allocation and sharing arrangements in the Murray-Darling Basin (MDB). In the three years leading up to October 2008, inflows were less than 25% of the long-run average (Murray-Darling Basin Commission [MDBC], 2008), and irrigation water use in 2007/08 and 2008/09 was one-third of its pre-drought level (Kirby, Connor, Bark, Qureshi, & Keyworth, 2012). Through the course of the drought, the basin's freshwater and estuarine environments suffered cascading ecosystem degradation and ecosystem service loss (Banerjee & Bark, 2013; Banerjee, Bark, Connor, & Crossman, 2013; Chiew, Young, Cai, & Teng, 2011; Crossman et al., 2011; Commonwealth Scientific and Industrial Research Organisation [CSIRO], 2012; Kingsford et al., 2011).

Consumptive users, particularly irrigators, faced drastic reductions in water allocations (Murray-Darling Basin Authority [MDBA], 2009) and mounting threats to the viability of their crops and livelihoods (Parliament of the Commonwealth of Australia, 2011). Urban water shortfalls and water quality concerns left few unaffected. Water sharing plans aimed at managing difficult trade-offs between consumptive uses were suspended (National Water Commission, 2011), and with insufficient entitlement, water left in-stream for the environment and ecosystem maintenance declined sharply, culminating in freshwater flows ceasing to reach the sea (Webster, 2010).

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\*Email: [onilb@iadb.org](mailto:onilb@iadb.org). Onil Banerjee is currently with the Inter-American Development Bank, Washington, DC, USA.

Addressing these competing demands is central to the latest round of water reform in the MDB. In November 2012 a Basin Plan was agreed to by the Australian Parliament to recover water for the environment by reducing surface water extraction by 2750 gigalitres (GL) per year on average, coming into force in 2019. This reduction can vary by up to  $\pm 5\%$  of this 'sustainable diversion limit' (SDL) as part of the 'SDL adjustment mechanism' (Commonwealth of Australia, 2012a). The actual reduction in consumptive use could therefore be between 2100 GL and 3200 GL per year (long-term average). While water buybacks have been used in the past to recover water for the environment, the Commonwealth's Water Recovery Strategy released in June of 2014 prioritized future water recovery through irrigation infrastructure investment to strengthen basin communities and deliver environmental outcomes. Over AUD 2.3 billion will be invested in infrastructure over the next 4 years, and water buybacks will be capped at 1500 GL, rephasing spending over the next 6 years to minimize negative impacts on communities (Commonwealth of Australia, 2014).

Many nations face difficult decisions around managing ailing water delivery systems. Investment in upgrading irrigation infrastructure is sorely needed as demand grows and greater climate variability increases risk (Ward, 2010). Prior to the economic liberalization of the 1990s, most governments around the globe bore the costs of large irrigation investment, including a share of operating costs (Briscoe, 1999; Burt & Styles, 1998; Fan, Gulati, & Thorat, 2008; Food and Agriculture Organization of the United Nations [FAO], 2003; Herrera, Huylensbroeck, & Espinel, 2006; Malik, 2008; Marsden Jacobs Associates [MJA], 2003; Organisation for Economic Co-operation and Development [OECD], 2009; World Bank, 2007). Supporting rural community development is frequently a key objective of these investments.

In the post-liberalization period, the cost-recovery dictum took root. The public sector would continue to play a significant role in major irrigation investment, while the private sector assumed responsibility for investments in secondary and tertiary water conveyance systems and farm-level irrigation efficiency (Briscoe, 1999). What is unique to Australia's reform efforts (and those of a handful of other countries) is that a large share of the recovered water will be allocated to the environment instead of consumptive uses (Productivity Commission, 2010).

In Australia, investment in irrigation infrastructure upgrades has not been the most cost-effective mechanism for recovering water for the environment, however. The Productivity Commission (2010) reports that water recovered through the Living Murray Initiative recovered water at a price 50% higher than that offered on the market, while the Sustainable Rural Water Use and Infrastructure programme is recovering water at a premium of AUD 7500 per megalitre (Productivity Commission, 2010). In the southern MDB, infrastructure projects to reduce conveyance losses cost between AUD 650 and AUD 30,000 per megalitre (MJA, 2003). Even in drought years when the price of water is elevated, investment in irrigation infrastructure is insufficient to generate a positive return on the investment. Furthermore, with supporting rural communities a key objective of the investment, buying equivalent volumes of water on the market and investing in other sectors such as the services sector could yield up to four times the number of jobs, though the water removed from productive use would still slow GDP growth (Wittwer & Dixon, 2013).

In this article, a computable general equilibrium (CGE) model is applied to evaluate the plan, announced by the previous minister, for the Department of Sustainability, Environment, Water, Population and Communities to invest AUD 50 million in upgrading the Murrumbidgee region's irrigation system to recover 6 GL of water per year

(Department of Sustainability, Environment, Water, Population and Communities, 2011). Using a case-study approach, this article: (1) isolates the investment from the broader irrigation infrastructure investment and buyback programme to analyze the national and regional economic impacts; and (2) examines the mechanisms driving the results, in search of insights to improve programme design. A CGE modelling approach is particularly powerful where intersectoral linkages and economic feedback effects of agent behaviour are important (Dixon, Parmenter, Powell, & Wilcoxon, 1992; Lofgren, Harris, Robinson, Thomas, & El-Said, 2002; Robinson, Yunez-Naude, Hinojosa-Ojeda, Lewis, & Devarajan, 1999; Shoven & Whalley, 1992).

The section that follows provides a snapshot of the MDB's economy, environment and context of water policy reform. The next reviews previous economy-wide analyses of investments in irrigation infrastructure. The fourth section presents the analytical approach and the scenario design and is followed by a section of results and analysis. The concluding section emphasizes the key findings and insights to improve programme design.

### **The Murray-Darling Basin**

Australia's MDB spans over 1 million km<sup>2</sup> encompassing the Australian Capital Territory (ACT) and portions of the states of South Australia (SA), Victoria (VIC), New South Wales (NSW) and Queensland (QLD). The basin occupies 14% of Australia's territory and is home to 2 million people, 10% of the Australian population. The gross value of irrigated agricultural production (GVIAP) in the MDB was over AUD 4.4 billion in 2009/10. Sixty-five per cent of Australia's irrigated agricultural land is located in the basin (Australian Bureau of Statistics [ABS], 2008), and dry-land and irrigated agriculture account for 84% of the MDB's land use (Murray-Darling Basin Authority [MDBA], 2011). Fifty-four per cent of Australia's irrigation-water consumption occurs in the MDB (Australian Bureau of Statistics [ABS], 2011).

Average annual rainfall in the MDB is 480<sup>mm</sup>, and annual stream flow is highly variable (Kirby et al., 2006). A median climate change scenario for the MDB estimates a reduction in rainfall of up to 3.5% and an increase in temperature of 0.8 °C by 2030 (Commonwealth Scientific and Industrial Research Organisation & Australian Bureau of Meteorology, 2007). Reduced runoff and higher temperatures will increase agricultural crop evapotranspiration and irrigation-water requirements (Potter & Chiew, 2011) and could hasten conversion of irrigated agriculture to dry-land farming.

Water diversions in the MDB increased from 3000 GL in the 1930s to over 11,000 GL by the 1990s (MDBA, 2009). The unsustainable nature of current levels of water extraction and water sharing arrangements in the MDB were exposed during the Millennium Drought. The drought resulted in widespread ecosystem degradation, including the die-off of the iconic river red gums, riverbank collapse, acid sulphate soils, high levels of salinity, and other serious water quality issues (Banerjee et al., 2013; Crossman et al., 2011). The drought crystallized the need for reform and for improved strategies to manage drought and increase system resiliency (Bark, 2011; Chiew et al., 2011; Kingsford et al., 2011). The situation became untenable from the irrigation industry's perspective, where reliable water supply is the industry lifeblood. Under the stress of severe drought, the over-allocated system could no longer provide irrigators with their full allocation; in some areas, irrigators did not receive any allocation at all.

In response to these new pressures, the Water Act (2007) was passed. The central goal of the act is to return water extraction to sustainable levels (Commonwealth of Australia,

2007). To achieve this end, two institutions were established: the Murray-Darling Basin Authority (MDBA), responsible for developing a plan for the basin; and the Commonwealth Environmental Water Holder, to manage environmental water allocations. Following a lengthy analysis of the trade-offs in reducing surface water extraction, the MDBA issued a Basin Plan in 2012 which called for a 2750 GL recovery of water for the environment, coming into force in 2019 (Commonwealth of Australia, 2012a).

To recover this water over the next 10 years, under the AUD 12.9 billion Water for the Future initiative, the Commonwealth government is pursuing a two-prong strategy for water reform (Commonwealth of Australia, 2012b). The AUD 3.1 billion Restoring the Balance in the Murray-Darling Basin programme will purchase water entitlements for the environment, and the AUD 5.8 billion Sustainable Rural Water Use and Infrastructure programme will invest in irrigation infrastructure efficiency upgrades, with the recovered water shared between the environment and irrigators. The mandate of the Sustainable Rural Water Use and Infrastructure programme is to deliver value for money in the context of (1) delivering substantial and lasting returns of water for the environment and (2) securing a long-term future for irrigation communities. Indeed, it is often argued that consideration of community and community resilience requires planners to move beyond purely economic rationales in water allocation decisions (Sullivan, 2014).

As of 30 April 2014, 1900 GL of the 2750 GL were secured through Commonwealth and state environmental water recovery programmes: 543 GL through infrastructure investment, 1142 GL through buybacks, and 215 GL through other programmes. It is also anticipated that the SDL could be adjusted by 650 GL as a result of investment in environmental works and changes to river operating rules which achieve the same environmental outcomes with less water. If all of these measures are realized, the amount still to be recovered would be 200 GL (Commonwealth of Australia, 2014).

Investment in irrigation infrastructure efficiency in the Murrumbidgee subcatchment is underway and is the focus of this case study (Figure 1). The Murrumbidgee subcatchment corresponds to 8.2% of the MDB's surface area and is home to 27% of the MDB's population. Twenty-two per cent of the MDB's surface water diversions occur in this region, with an annual average of 2257 GL diverted, representing 53% of the available surface water in the Murrumbidgee.

Irrigated agriculture in the region accounts for 79–92% of total agricultural output (MDBA, 2011). Fruits, nuts, grapes, cereals and grains are the most important crops, with a GVIAP in 2008/09 equal to AUD 423 million and accounting for over 10% of the MDB's irrigated output. Rice is the predominant crop in the Murrumbidgee, and rice farmers hold the greatest number of general security water entitlements. Because rice is a relatively low-value crop, rice farmers in the Murrumbidgee tend to be price elastic with regard to water; as the price of water increases, rice farmers tend to sell their water allocations to higher-value uses both within and outside the subcatchment (MDBA, 2011).

### **Economy-wide modelling of investment in irrigation efficiency**

The emphasis of the literature on irrigated agricultural water use is on irrigation management, productivity and efficiency. Only a few recent studies have evaluated the economy-wide impacts of irrigation efficiency upgrades (Australian Bureau of Agricultural and Resource Economics and Sciences- Bureau of Rural Sciences [ABARE-BRS], 2010; Calzadilla, Rehdanz, & Tol, 2011; Wittwer, 2011). Calzadilla et al. use the global GTAP-W model<sup>1</sup> to evaluate the impacts of enhancing irrigation

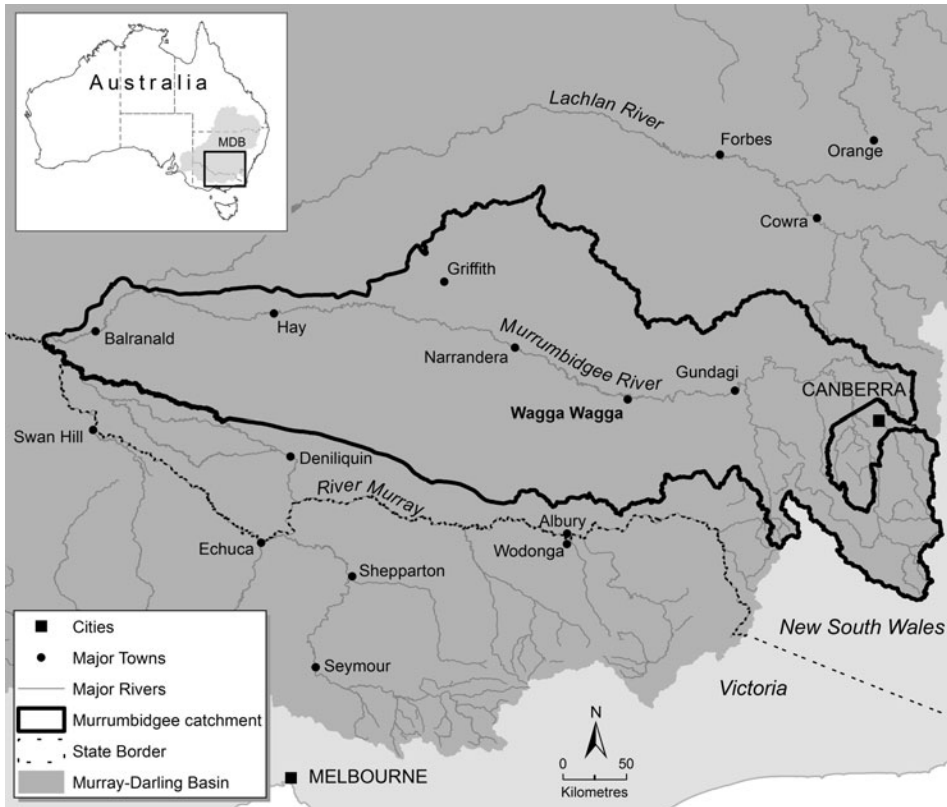


Figure 1. Murrumbidgee Natural Resources Management Region.  
Source: Contributed by Martin Nolan, CSIRO Adelaide.

efficiency on the global economy. A key finding is that increased irrigation efficiency has implications for competitiveness, negatively impacting rain-fed agriculture in some regions and reducing welfare. Overall, these losses are offset with increased irrigated agricultural output and lower food prices. A limitation of this study is that efficiency gains are modelled as being achieved without cost, which probably results in an overestimation of the net gains.

The Australian Bureau of Agricultural and Resource Economics and Sciences – Bureau of Rural Sciences (2010) models a 2800 GL SDL scenario at the MDB scale, similar to the Basin Plan's 2750 GL target SDL (Commonwealth of Australia, 2012a). Results indicate that imposing this SDL reduces GVIAP by 12.7%. Taking into account the offsetting effect of irrigation infrastructure investment, this negative impact falls to 9.3%. The 2800 GL scenario results in a 1.1% decline in gross regional product (GRP) without investment in irrigation infrastructure and a 0.8% decline with such investment. For the Murrumbidgee alone, GVIAP is reduced by 18.7% in the long run, representing the greatest impact on any one region. This result is largely explained by the high proportion of low-value irrigated crops in the Murrumbidgee. Recent experience in the region during the Millennium Drought has shown that water is traded out of the subcatchment as it becomes more scarce, with a concomitant decline in cereal and rice output (Kirby et al., 2012).

Wittwer (2011) modelled a fully compensated water buyback and investment in irrigation infrastructure for 2008 to 2029. At the basin scale, results for a 2800 GL SDL

scenario indicate that farm output declines by 1.1% and 0.7% without and with investment in irrigation infrastructure, respectively. Real gross domestic product (GDP) falls by 0.01% and GRP by 0.18% without infrastructure investment; the GVIAP contribution to the decline in GRP is 0.33%, while expansion of dry-land farming has a positive 0.22% offsetting effect.<sup>2</sup>

With the regional terms-of-trade gain as a result of the buyback, household consumption increases by 0.34%. With the infrastructure investment, the decline in basin GRP is 0.05% (0.016% in GDP); household consumption increases by 0.42%. The author argues that it would cost AUD 4 billion to purchase 2800 GL of water entitlements, while a AUD 4 billion basin-wide investment in irrigation infrastructure would generate only 810 GL in water savings.

Previous analyses evaluated the basin-wide impacts of the water recovery programme, the relative cost-effectiveness of water buybacks and investment in irrigation infrastructure, and the impacts of alternative uses of public funds. With the recent prioritization of infrastructure investments in the Commonwealth's Water Recovery Strategy, this article adopts a case-study approach to isolate and evaluate a single investment of AUD 50 million within the AUD 2.3 billion programme of infrastructure investments. The case-study approach is conducive to analysis of the mechanisms driving the results and the interactions between the target subcatchment of investment, other subcatchments in the basin and the rest of the Australian economy. Changes in output driven by the movement of relative prices are decomposed through the disaggregation of factor and intermediate input costs, allowing their relative contributions to changes in output to be determined. The section that follows describes the case-study approach in detail.

## Methods

This article applies TERM-Water, a multiregional, static CGE model developed by the Centre of Policy Studies at Victoria University, Australia. TERM-Water's customization for application to water issues in the MDB is documented in detail by Wittwer (2003, 2012). Introducing large-scale CGE modelling in 1977 (Horridge, Madden, & Wittwer, 2005), the centre based the TERM-Water CGE model on their ORANI modelling tradition (Dixon, Parmenter, Sutton, & Vincent, 1982). TERM was an advance over the ORANI class of models, with a bottom-up regional specification and greater computational efficiency. In a country as expansive as Australia, large distances can result in significant price differentials between regions due to trade and transport margins. TERM represents each region as a separate economy, linking regions with trade flows and factor movements (Wittwer, 2012). TERM's bottom-up model design allows policies with region-specific price effects and imperfect factor mobility to be analyzed (Horridge et al., 2005).

TERM-Water is a static, one-period model and represents the Australian economy with 48 economic sectors. The model has considerable agricultural-sector detail, with 20 agricultural sectors, 16 of which use irrigation water as a production input. The model is disaggregated into 3 main regions and 20 subregions (Table 1). One reason for this regional disaggregation is to enable the simulation of water trade between and within regions. In this specification, water trade may occur between and within Regions 1 and 2. Region 3 is not able to trade with other regions, but trade may take place within Region 3's boundaries.

Two scenarios were implemented in TERM-Water. Reducing water loss through irrigation infrastructure investment would increase or maintain current levels of agricultural output depending on the proportion of savings retained by irrigators. The first

Table 1. TERM-Water model regions.

Main region 1	Main region 2	Main region 3	Other main regions	States
Murray NSW	Ovens Murray VIC	Northern NSW	Rest of NSW	SA
Murrumbidgee NSW	Goulburn VIC	North West NSW	Rest of VIC	WA
Mallee VIC	Loddon Campaspe VIC	Far West NSW	Rest of QLD	TAS
Murray Lands SA		Darling Downs QLD		NT
		South West QLD		ACT

Source: Following Wittwer (2003).

scenario simulated the AUD 50 million investment in irrigation infrastructure with 100% of the 6 GL water savings returned to the environment. In the second scenario, 3 GL of water savings were retained by irrigators to use in production and/or trade and 3 GL were returned to the environment.

Works under the infrastructure investment include replacing concrete-lined and earthed water distribution channel supply systems with 48 km of gravity, low- and high-pressure pipelines and refurbishing portions of a 51.5 km stretch of open channels (Department of Sustainability, Environment, Water, Population and Communities, 2011). The investment impact in both scenarios is modelled as an increase in government expenditure on the construction services sector, which includes irrigation infrastructure. A long-run closure is applied where capital supply is endogenous, national labour supply is exogenous and household savings are a fixed share of income. The choice of a long-run closure enables factor mobility in response to changes in relative prices. The scenarios were programmed in TERM-Water and solved using a three-step Euler solution method. Results reported here were obtained and analyzed using GEMPACK economic modelling software, also developed by the Centre of Policy Studies (Harrison & Pearson, 1996).

## Results and analysis

### Scenario 1 results

Considering the results for the Murrumbidgee, real GRP, household consumption, employment, wages, imports and aggregate capital stock increase, while export volumes and real investment decline (Table 2). The consumer price index (CPI) also increases, indicating slight inflationary pressure. Construction sector output and price increase by 1.81% and 0.87%, respectively. For most other sectors, output tends to fall slightly or remain unchanged.

Table 2. Scenario 1: 100% of water savings returned to environment. Results in percentage change.

Indicator	Murrumbidgee	National
Real GRP	0.070	-0.002
Consumption	0.035	-0.001
Employment	0.105	0.000
Wages	0.133	0.002
Capital stock	0.013	-0.007
Export volume	-0.165	-0.025
Import volume	0.084	0.004
Real investment	-0.013	-0.006
Consumer price index	0.076	0.011

The positive impact on GRP is attributed to the increase in government expenditure in the region and the increase in output from a few sectors, including construction, communications and business services. Equation (1) demonstrates how the investment in irrigation infrastructure is transmitted through the regional economy.

$$\text{GRP} \uparrow = C \uparrow + I \downarrow + G \uparrow + X \downarrow - M \uparrow \quad (1)$$

In this equation,  $C$  is consumption,  $I$  is investment,  $G$  is government expenditure,  $X$  is exports and  $M$  is imports. In this simulation, the negative impact of increased imports and reduced investment and export volumes was more than offset by increases in consumption, investment and government expenditure (on irrigation infrastructure), resulting in an increase in GRP.

What is driving these regional results? Investment in irrigation infrastructure pushes prices and costs of production for most sectors upwards. Costs of production may be decomposed into intermediate and factor inputs, with factor inputs further disaggregated into labour, capital and land (Table 3). Intermediate input costs increase for all sectors, and factor costs increase for most sectors. Increased factor costs are responsible for 84% of the overall rise in production costs. Seventy-six per cent of the primary factor cost increase is due to an increase in the wage bill, and 26% to rising capital costs, while reduced land rental rates have a 2% offsetting effect. The reason factor costs increase only for some sectors is this decline in land rental rates. For those sectors that use a significant amount of land as a factor input (e.g. wheat, other broadacre crop and livestock sectors), the reduction in the land rental rate in some cases offsets the increase in the wage bill and price of capital.

Examining the construction sector alone, increased factor costs are responsible for over 98% of the increase in this sector's output price, over 99% of which is attributable to the increased wage bill. Material costs increase the price of construction sector output primarily through the increase in the price of other manufactured goods and business services, which are key intermediate inputs into the construction sector's production process. The price increase of construction sector output is passed on to all industries that use construction sector goods and services as an intermediate input. Exacerbating these effects, the increase in construction sector output raises demand for all inputs, further pushing up prices.

Impacts at the national level are small, which is expected given the small size of the investment relative to the Australian economy (Table 2). Nonetheless, aggregate capital

Table 3. Cost shares of total and construction output for regional and national results.

Regional output		National output	
Intermediate input	16.0%		36.0%
Factors	84.0%		64.0%
Labour	76.0%	Labour	63.0%
Capital	26.0%	Capital	38.0%
Land	-2.0%	Land	-1.0%
Regional construction		National construction	
Intermediate input	1.6%		15.8%
Factors	98.4%		84.2%
Labour	99.7%	Labour	98.0%
Capital	0.3%	Capital	2.0%
Land	0.0%	Land	0.0%

stock, exports, real investment, household consumption and real GDP are all negatively affected, while imports and the average real wage increase. The balance of trade deteriorates slightly, with increased imports and reduced export volumes. The increase in the CPI is indicative of inflationary pressure.

Capital stocks decline slightly in all states (from 0.005% in SA to 0.007% in VIC). Labour supply falls in all states, with the exception of NSW and ACT. Some volumes of irrigation water are traded from the Murrumbidgee, Goulburn and Ovens Murray, into the Murray, Mallee, Loddon Campaspe and Murray Lands. Domestic production of all goods and services declines slightly (from 0.015% for the mining sector to 0.002% for the trade margins sector). Construction sector output increases by 0.36%. Household consumption impacts are negative for all regions, with the exception of the Murrumbidgee, Ovens Murray and ACT.

What is driving the national results? Over 64% of the increase in production costs is attributable to the increase in factor input prices (Table 3). Sixty-three per cent of the increase in factor input prices is attributable to labour cost increases, 38% to capital cost increases. A small decline in the rental price of land has a 1% offsetting effect. Considering the construction sector alone, increased factor costs explains 84% of this increase, 98% of which is due to higher wages. Manufactured goods and business services are key inputs to the construction sector, both becoming more expensive as a result of the investment in irrigation infrastructure.

### Scenario 2 results

Table 4 presents the decomposed impacts of the investment on the regional economy. In this scenario, in addition to the stimulus provided by the investment in the construction sector, the 3 GL of water recovered and allocated to irrigators enhances the growth effect on all indicators, with the exception of exports and real investment.

What is driving these regional results? The construction sector in the Murrumbidgee increases output by 1.8%, and output prices increase by 0.87%. Most other sectors experience a small negative impact. In this region, 85% of increased production costs are attributable to factor cost increases, with the remaining 15% due to increased intermediate input costs (Table 5). Seventy-four per cent of the increase in factor costs is attributable to the wage bill, and 25% to capital rental rate increases. These increases in factor costs are only slightly offset by a 1% reduction in land rental rates.

For the construction sector, 98% of the increased production costs are due to factor cost increases. Ninety-nine per cent of the increase in factor costs is due to an increase in the wage bill. As in the previous scenario, material costs increase the price of construction sector output largely because of an increase in the price of other manufactured goods and business services.

With the additional 3 GL of water recovered and available for use in production, agricultural sector output falls by less than it would otherwise. The prices of water-intensive crops tend to increase, while those of less water-intensive crops fall. The influences of private consumption, investment, government expenditure, and exports and imports on GRP follow the same trends as those presented in Equation (1). One distinction is that while the investment in irrigation infrastructure tends to push investment downwards, the water recovered and used in production has a positive impact on regional investment, which is a central aim of the Water for the Future programme.

The national results for this scenario follow a pattern similar to the national results for the first scenario and are dominated by the investment impact rather than by the additional

Table 4. Scenario 2: 50% of water savings returned to environment, 50% to irrigators. Results in percentage change.

Indicator	Murrumbidgee			National		
	Overall	Water savings	Infrastructure	Overall	Water savings	Infrastructure
Real GRP	0.075	0.005	0.070	-0.002	0.000	-0.002
Consumption	0.038	0.003	0.035	-0.001	0.000	-0.001
Employment	0.109	0.005	0.105	0.000	0.000	0.000
Wages	0.140	0.006	0.133	0.003	0.000	0.002
Capital stock	0.021	0.008	0.013	-0.007	0.000	-0.007
Export volume	-0.169	-0.004	-0.165	-0.025	0.000	-0.025
Import volume	0.091	0.007	0.084	0.004	0.000	0.004
Real investment	-0.003	0.010	-0.013	-0.006	0.000	-0.006
Consumer price index	0.077	0.001	0.076	0.011	0.000	0.011

water available through improved irrigation efficiency (Table 4). The investment alone has a small though negative impact on real GDP, real investment, exports, aggregate capital formation, and household consumption. The CPI, imports and average real wages increase slightly. The recovered water has a very small positive impact on real GDP, real investment, imports, aggregate capital formation, average real wages and the CPI. The recovered water partially offsets the negative impacts at the national level, though not enough to change the direction of effect.

Household consumption increases marginally (by up to 0.035%) in the Murrumbidgee, Murray, Mallee, Ovens Murray and ACT. The increased consumption is probably a function of recovered water being used in production or trade. Household consumption remains unchanged in the Murray Lands and declines slightly in all other regions, by between 0.006% and 0.002%. Capital stocks fall in all states, while wage-weighted labour supply increases marginally in ACT and NSW. The Murray Lands, Loddon, the Mallee and the Murray are net water purchasers, while the Murrumbidgee, Goulburn and the Ovens Murray are net sellers.

For the nation as a whole, production costs tend to increase. Primary factor price increases are responsible for 65% of this increase, and material costs for 35% (Table 5). Both labour and capital costs increase for most sectors, while reduced land rental rates offset some of the higher labour and capital costs to varying degrees, particularly for those sectors that use land extensively. Overall, a higher wage bill accounts for 63% of increased primary factor costs, capital accounts for 38%, and reduced land rental rates have a small offsetting effect (less than 1%). Construction sector output increases by 0.036%, while most other sectors experience a slight contraction. Eighty-four per cent of increased construction sector costs are attributable to primary factor cost increases, 98% of which is due to a higher wage bill.

## Discussion and conclusions

This analysis shows that the investment in the Murrumbidgee has a positive impact on regional production, capital stock, average real wages, employment and income. The portion of water recovered and used for production generates further gains for the region, though of a lesser magnitude than the economic activity stimulated by the infrastructure

Table 5. Cost shares of total and construction output for regional and national results.

Regional output		National output	
Intermediate input	14.8%	Intermediate input	35.3%
Factors	85.2%	Factors	64.7%
Labour	74.0%	Labour	62.8%
Capital	24.9%	Capital	37.5%
Land	1.1%	Land	-0.4%
Regional construction		National construction	
Regional output	1.7%	National output	16.1%
Intermediate input	98.3%	Intermediate input	83.9%
Factors Labour	99.7%	Factors Labour	98.0%
Capital	0.3%	Capital	2.0%
Land	0.0%	Land	0.0%

investment. National-level results are less encouraging, as resources are transferred from other regions of Australia to farmers and irrigation infrastructure operators in the Murrumbidgee; GDP, real investment, household consumption and capital stocks are negatively impacted. Inflationary pressure renders exports less competitive, and Australia’s trade balance worsens. Considering only market benefits, the water recovered through the investment is very costly, at AUD 8300 per megalitre. The additional economic activity resulting from the investment and the additional water used in production are insufficient to recover this cost.

The theory of crowding out, or ‘diversion’ as it was called by economist John Maynard Keynes, provides insight into the interpretation of these results (Buiter, 1977). Crowding out is the displacement of private investment by public investment, where public investment increases the demand for factor inputs, resulting in increased prices and reduced profitability of private enterprise. In a climate of high unemployment and surplus capacity, Keynesian economics postulates that government investment in public goods may improve economic performance. Investment under these circumstances can raise demand for industrial output, increase cash flow and stimulate economic optimism. However, the Australian economy, with neither high unemployment nor excess capacity, does not exhibit the conditions in which most Keynesian economists would advocate economic stimulus through increased public spending.

In the results of this case study, public investment in irrigation infrastructure crowded out private investment by pushing up factor prices and intermediate input costs, leaving most industries worse off. Australia’s trade balance worsened, consistent with the investment savings/liquidity preference money supply model (Hicks, 1937). Public investment is likely to crowd out private investment, at least in the short run (Serven, 1996), and when public investment is made in areas where private investment is active, crowding out is often both a short-run and a long-run phenomenon (Afonso & Aubyn, 2008; Argimon, Gonzalez-Paramo, & Roldan, 1997).

To explore whether the crowding out that occurred in the Murrumbidgee case study is a short-run phenomenon, a dynamic model would be required. Dynamic CGE models such as TERM-H2O (Dixon, Rimmer, & Wittwer, 2011; Wittwer, 2012; Wittwer & Banerjee, 2014) can shed light on the economic adjustment and transition path resulting from a policy shock and can be used to quantify both short- and long-run benefits and costs (Banerjee & Alavalapati, 2014; Cattaneo, 1999). A dynamic model permits a phased implementation of shocks. For example, in the short run, government expenditure on

irrigation infrastructure could be shocked, resulting in increased regional demand and returns to labour. In the long run, greater factor productivity and returns to the recovered water would arise with the upgraded irrigation infrastructure and additional water available to irrigators for productive use.

The Commonwealth's investments in irrigation infrastructure are variations of public-private partnership agreements and have been increasingly used to fund Australia's urban water infrastructure. Public-private partnerships are characterized by shared responsibility, managed risk and predictable cash flow, which create incentives for private-sector engagement (Briscoe, 1999; Johnson, Svendsen, & Gonzalez, 2004; MJA, 2003; OECD, 2009; Trier, 2014; World Bank, 2007). Value for money in partnership arrangements is created through the optimal sharing of risk between the public and private sectors, including risks associated with construction, off-take, markets, stranded assets, regulatory risk and contract risk (MJA, 2003). Allocation of these risks has been shown to be key to successful public-private partnerships (Heiler, 2002; Préfol et al., 2006), and shared responsibility can create an enabling environment for higher levels of private co-finance. Furthermore, optimal allocation of irrigation infrastructure investment over a longer time-frame would reduce the factor supply constraints that resulted in higher prices and crowding out in the Murrumbidgee case study.

While beyond the scope of this case study, it is important to note that the volume of actual return flow resulting from irrigation infrastructure upgrades may be different from the volume of water recovered. The water saved through improved irrigation efficiency reduces the volume of water returning to the basin system which may otherwise have been used downstream. When water-balance modelling for a catchment does not account for return flows, the water savings may be overstated. In addition, where investment in irrigation efficiency reduces the nonconsumptive portion of water use, return flows are reduced and investment in infrastructure efficiency may have no real net effect on water savings (Adamson & Loch, 2013; Huffaker & Whittlesey, 2000; Qureshi, Schwabe, Connor, & Kirby, 2010; Scheierling, Young, & Cardon, 2006).

It is important to note that the net negative effect of the investment at the national level, though small in this case study, could be significant when scaled up to the overall water recovery programme: the AUD 50 million investment in the Murrumbidgee represents only 2% of the AUD 2.3 billion investment in irrigation infrastructure upgrades planned for the basin over the next 4 years. While the MDB will benefit from this transfer of resources, the rest of the Australian economy will absorb the cost. To maximize welfare, it is critical that the most effective investment alternatives are selected and that the benefits and costs of using public funds are measured against the Commonwealth's Water Recovery Strategy criteria of value for money and the long-run stability of basin communities (Singh, 1994). While this study considered the market benefits of the investment, ensuring long-run community stability obliges the consideration of environmental and social benefits in evaluating investment alternatives. These environmental and social benefits could be substantial (CSIRO, 2012; Hatton MacDonald, Morrison, Rose, & Boyle, 2011; Morrison & Macdonald, 2010).

A recent study by the Commonwealth Scientific and Industrial Research Organisation (2012), using benefits transfer and avoided cost methods, estimates that with a 2800 GL SDL, the water recovered for the environment could generate between AUD 3 billion and AUD 8 billion in the supply of habitat ecosystem services alone. Improvements in freshwater supply could save up to AUD 30 million in treatment costs. Banerjee et al. (2013) corroborate these findings for South Australia, where maintenance of adequate in-channel water levels during the Millennium Drought could have saved over AUD 810

million in ecosystem service loss. More water for the environment would also reduce future mitigation or damage costs, for example those related to groundwater salinity and accession (Kemp & Hafi, 2001). Social benefits include increasing community stability and resilience and improving the health of residents. It is estimated that an SDL of 2800 GL could provide social value, including that generated through aesthetic beauty and tourism opportunities, worth up to AUD 160 million annually (CSIRO, 2012). In the case of South Australia alone, over AUD 174 million in social value was lost during the course of the Millennium Drought (Banerjee et al., 2013).

While two investments of identical dollar amounts may recover the same volume of water, they could be very different with regard to social and environmental benefits. A social cost-benefit analysis provides a transparent framework for prioritizing investment options based on economic, social and environmental criteria and the consideration of the longer-term trade-offs and risks (Connor et al., 2011; Hatton MacDonald et al., 2012). Cost-benefit analysis that incorporates social and environmental values is becoming increasingly common, for example in the selection of investment alternatives in projects funded by international development banks and donors. A robust assessment of market and non-market social and environmental benefits and costs may catalyze renewed investment interest (Khan & Mushtaq, 2009). After all, recovering water for the environment in a way that maximizes both regional and national welfare is the central goal of the MDB Plan.

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### Notes

1. The GTAP-W model is an extension to the Global Trade Analysis Project's (GTAP) model and version 6 of the GTAP Database representing the global economy in 2001. Salient features of the GTAP-W model are a new production structure where the land endowment is disaggregated into pasture land, rain-fed land and irrigated land. In addition, water in GTAP-W is treated as an explicit factor of production (Calzadilla et al., 2011).
2. It is important to note that while GVIAP may be reduced with SDLs, increased dry-land production may offset some of this decline. Dixon, Rimmer, and Wittwer (2010) developed TERM-H2O, a dynamic multiregional CGE with considerable detail in the agricultural sector, to explore water buybacks in a context of temporary drought. The framework they develop is able to capture this offsetting impact through how land is modelled. In TERM-H2O, agricultural sectors use 'effective land', which is a constant elasticity of substitution combination of irrigated land, unwatered irrigable land and dry land. This enables irrigable land to move between irrigated agriculture and dry-land agriculture depending on the price of irrigation water. An increase in the price of irrigation water reduces the rental value of unwatered irrigable land, resulting in increased demand from dry-land industries for unwatered irrigable land (Dixon et al., 2010; Wittwer & Griffith, 2011). Mobility of land between irrigated and dry-land agriculture represents an improvement on TERM-Water.

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