REPORT

CENTRE FOR INTERNATIONAL ECONOMICS

NATIONAL PROGRAM FOR Sustainable Irrigation

Implications of water reforms for the national economy

Prepared for the

National Program for Sustainable Irrigation

FINAL REPORT

Centre for International Economics
Canberra & Sydney

July 2004

The **Centre for International Economics** is a private economic research agency that provides professional, independent and timely analysis of international and domestic events and policies.

The CIE's professional staff arrange, undertake and publish commissioned economic research and analysis for industry, corporations, governments, international agencies and individuals. Its focus is on international events and policies that affect us all.

The CIE is fully self-supporting and is funded by its commissioned studies, economic consultations provided and sales of publications.

The CIE is based in Canberra and has an office in Sydney.

The **National Program for Sustainable Irrigation** is a partnership between irrigators, water authorities, research agencies, state and national government departments and commodity groups to invest in research and development to achieve substantial improvement in the environmental and productive performance of irrigated agriculture and horticulture in Australia. The Program is managed by Land & Water Australia on behalf of the partners.

ISBN (Print): 1 920 860 38X ISBN (Electronic): 1 920 860 398 Product code: PR040745

Centre For International Economics
Ian Potter House, Cnr Marcus Clarke Street & Edinburgh Avenue Canberra ACT

GPO Box 2203
Canberra ACT Australia 2601

Telephone +61 2 6248 6699 Facsimile +61 2 6247 7484
Email cie@TheCIE.com.au Website www.TheCIE.com.au

Land & Water Australia
Level 1, 86 Northbourne Avenue Braddon ACT

GPO Box 2181
Canberra ACT Australia 2601

Telephone +61 2 6263 6000 Facsimile +61 2 6263 6099
Email Land&WaterAustralia@lwa.gov.au Website www.lwa.gov.au

Acknowledgments

THIS REPORT HAS been prepared by the CIE as part of the National Program for Sustainable Irrigation. The financial assistance provided by the Program through Land and Water Australia is gratefully acknowledged.

Many people have contributed to this study. Murray Chapman, Program Coordinator for the National Program for Sustainable Irrigation deserves praise for his enthusiastic support and assistance throughout the study. Colin Creighton, formerly Rivers Manager, Land and Water Australia, first suggested the project.

Special acknowledgment is deserving of the Steering Committee (see appendix C) for their professional advice, encouragement and helpful comments on drafts. The Program Management Committee under the chairmanship of Mike Logan also provided valuable advice and encouragement which is gratefully acknowledged.

The CIE team was led by George Reeves with Derek Quirke and Kevin Hanslow doing the modelling work and Martin van Bueren being one of the principal authors. Kirsten Oliver provided valuable word processing and editorial support.

Contents

Boxes, charts and tables

Executive summary

THE TWO KEY OBJECTIVES of this study were, first, to estimate the real contribution of the irrigation sector to the Australian economy and, second, to estimate the economic impacts of recent and future water reforms at the national level. This is the first part of a wider project, which also assesses the regional impacts of water reforms using the Goulburn Broken region as a case study. The study is being funded by Land and Water's Sustainable Irrigation Program and is being guided by a steering committee consisting of prominent people from the irrigation sector and government.

The approach

This study uses a modified version of the Centre for International Economics' (CIE) economywide general equilibrium model of the Australian economy. This modelling framework allows the net economic value of the irrigation sector to be quantified both in terms of its *direct* contribution to gross domestic product (GDP) and employment, and the *indirect* contributions, which capture the economic linkages between the irrigation sector and other sectors of the economy.

Value added is the measure most frequently used throughout this report to assess the economic contribution of irrigation to the economy. This is the gross value of production (GVP) less the cost of goods and services used in production excluding the cost of capital, land and labour. Thus, value added represents the returns to these inputs. The sum of value added for all industries is about equal to GDP (before adjusting for taxes and subsidies). Estimates are also presented for impacts on employment.

The base year selected was 1996-97. This marked the beginning of serious reforms to the water industry and the first year the Murray Darling Basin (MDB) Cap was formalised. It was also a relatively 'normal' irrigation year and the latest available year for the Australian Bureau of Statistics (ABS) input output tables as well as the year on which the National Land and Water Resources Audit (NLWRA) based its estimates of water use and availability.

Regions identified in the model are largely based on three broad categories. These are the MDB northern/central connected valleys, the MDB southern connected valleys and all other irrigation regions. The MDB accounts for about 70 per cent of irrigation diversions in Australia.

The model includes all major agricultural industries as well as 90 other major sectors of the economy. The irrigation sector has been greatly expanded from the original CIE economywide model and permanent water trading between irrigation regions that are physically connected has been incorporated. This means that there is no water trading between the northern/central regions of the MDB and the southern connected system (SCS) but trading is allowed in the model between regions in the SCS.

In assessing the contribution of irrigation to the economy, an 'economic' approach has been adopted. This takes into account the opportunity cost of resources used in irrigation, mainly land. Thus, the opportunity value added from dryland alternatives to irrigation is deducted from the value-added estimates for each irrigation enterprise. The 'economic' approach therefore gives an estimate of the additional value that irrigation has given to the economy. For comparative purposes, an accounting measure of irrigation's contribution is also estimated. This is simply a measure of irrigation contributions as a proportion of the total GDP pie — without taking into account the opportunity cost of land and other resources used in the irrigation sector. In other words, the accounting approach does not recognise that without irrigation, land would have been used for dryland production.

In analysing the effects of water reforms, the approach taken was, first, to assess the impacts of reforms which have taken place to date and then to analyse the impact of likely future water reforms, especially reductions in irrigation diversions and what this may mean for irrigators and the economy. The objective was to develop a better understanding of the magnitude of direct and indirect economic impacts imposed on the irrigation sector (both positive and negative) from changes in water use efficiency (WUE), enhanced trading, increased environmental flows, and increased water charges. It is stressed that the study does not set out to undertake a full benefit-cost analysis of reallocating water to the environment or other user groups. Instead, it aims to identify the *opportunity costs* of reduced diversions, which provides a useful benchmark against which to compare the size of potential environmental benefits.

Contribution of irrigation to the economy

Irrigation makes a substantial contribution to incomes and standards of living of Australians. Without irrigation:

- GDP could be $12.4 billion or 2.3 per cent lower;
- total household expenditure on goods and services could be $2.8 billion lower — representing over $530 for each Australian household per year; and
- total exports would fall by $7.4 billion and imports would be $4 billion higher.

Table 1 summarises the contribution of irrigation to all agriculture, food and fibre processing, and to all sectors of the economy in terms of value added under 'accounting' and 'economic approaches'. The key points are as follows.

- Using the 'accounting' approach, irrigated agriculture contributed over $5 billion to Australian GDP for 1996-97, representing 33 per cent of all agriculture and 0.9 per cent of GDP.
- The 'economic' approach estimates the contribution of irrigation to the economy over and above the dryland agricultural activities that could have developed in the absence of irrigation.
- Using the 'economic approach' irrigated agriculture directly contributed $3.4 billion or 23 per cent in 1996-97 to the value added for all agriculture. This equates to a 0.65 per cent contribution to Australia's GDP.
- The flow-on effects to the rest of the economy are significant. Value added in the food and fibre processing sector were estimated at $2.5 billion. Value added from first stage processing of irrigation products contributes 0.47 per cent to GDP.
- The flow-on effects from farm and processing industries through to other industries in the economy and through to household incomes are most significant. These flow-on effects beyond early stage processing are estimated at $6.4 billion or 1.2 per cent of GDP.
- In total, the direct and indirect contribution of irrigation to the economy is estimated at $12.4 billion or 2.3 per cent of Australia's GDP.
- In addition, irrigation directly and indirectly contributes around 171 000 employee jobs to the Australian economy, representing 2.6 per cent of total employment in Australia (table 2). An additional 17300 persons are estimated to be employers.

1 Summary of contributions of irrigation to the economy: 1996-97

		Value added	
	Unit	***Accounting***	***Economic***
Direct contribution to GDP			
Irrigated agriculture	$m	5 036	3 446
▪ All agriculture	$m	15 069	15 069
▪ Irrigation as a per cent of all agriculture	%	33.4	23.0
▪ Irrigation as a per cent of GDP	%	0.9	0.6
Indirect contribution to GDP			
Irrigated food & fibre processing	$m	–	2 521
Flow-on effects	$m	–	6420
▪ All food & fibre processing	$m	–	12 528
▪ Irrigation processing as a per cent of all food and fibre processing	%	–	20.0
Total contribution to GDP	$m		12 387
▪ GDP	$m	–	529 858
▪ All irrigation as a per cent of GDP	%	–	2.33

Source: CIE irrigation model.

2 Summary of contributions of irrigation to employment[a]: 1996-97

		Employment	
	Unit	***Accounting***	***Economic***
Direct employment			
Irrigated agriculture	‘000 persons	44.6	28.9
▪ All agriculture	‘000 persons	120.5	120.5
▪ Direct irrigation employment as a per cent of all agriculture	%	37.0	24.0
Indirect employment			
Irrigated food & fibre processing	‘000 persons	–	19.7
Other indirect irrigation employment	‘000 persons	–	122.4
▪ All food & fibre processing	‘000 persons	–	162.5
Total irrigation-related employment	‘000 persons	–	171.1
▪ Total economy	‘000 persons		6 590
Total Irrigation employment as a per cent of total economy	%	–	2.6

a Employees only — full-time equivalents.

Source: CIE economywide irrigation model.

Impact of water reforms

Reforms to date

Key reforms from 1996-97 to date have included a doubling of water charges on average in real terms, a facilitation of water trading of temporary water allocations and permanent entitlement between regions, and implementation of the MDB Cap. These reforms and other factors have stimulated increases in WUE but the extent of these increases is largely unknown, although an increase of 1 per cent a year is a reasonable assumption. Trade in permanent entitlement between connected regions has been quite small to date and for this reason, our analysis of reforms to date has not examined the impact of inter-region trading. The model allows for substitution between enterprises within regions and to this extent water trading within regions is taken into account, although the effects are not able to be analysed separately. That is, this feature of the model cannot be switched on or off.

The impacts of increases in water charges in isolation and in combination with increases in WUE are summarised in table 3. The key points are as follows.

- The increase in *water charges* in isolation has had little impact on the economy as a whole but the net result has been a transfer of wealth from irrigators to irrigation water providers (IWPs). The cost to irrigators has been in the order of $114 million each year since 1996-97. However, the increase in water charges is likely to have had two additional impacts not accounted for here. First, there has been less subsidy from public revenue to water providers and second the increased revenue has no doubt enabled water providers to upgrade infrastructure thus contributing to off-farm WUE. Increased water charges may have improved on-farm WUE although there is little information on the nature of this relationship.
- *Increases in WUE* have provided positive benefits to irrigators but the main increase in value adding has come through flow on effects in other sectors of the economy.
- Assuming WUE has increased at 1 per cent each year, this would have partially offset the cost to irrigators from higher water charges. The combined impact of higher charges and a 1 per cent improvement in WUE annually is a **net welfare loss** to irrigators of $24 million. However, if WUE has been higher, at say 2 per cent per year, then irrigators would have received a **net gain** of $78 million.

3 Annual impact of charging reforms and improved WUE since 1996-97

				100% increase in water charges together with	
	100% increase in water charges[a]	*1% pa increase in WUE*[b]	*2% pa increase in WUE*[b]	*1% pa increase in WUE*	*2% pa increase in WUE*
	$ million	$ million	$ million	$ million	$million
Irrigated agriculture	-114	90	192	-24	78
Dryland agriculture	1	-52	-113	-51	-112
Food and fibre processing	1	43	96	44	97
Other industries[c]	138	124	272	262	410
Total GDP	**26**	**227**	**495**	**253**	**521**

a With no increase in WUE. The model 'shock' is a one off doubling of water charges. **b** With no increase in water charges. A 1 per cent increase in WUE a year is equivalent to a 5 per cent increase over the five year period. **c** Includes IWP.

Source: CIE irrigation model.

- The *MDB Cap* has undoubtedly had positive benefits in terms of increasing the reliability of water delivery to irrigators, improving water quality and enhancing environmental outcomes. The problem has been that entitlements have been over allocated and had diversions been allowed to continue unrestrained, in total they would have exceeded capped average diversions by around 1600 gigalitres (GL). Thus, in addition to having many positive benefits, the CAP has also meant that some irrigators have been denied the opportunity to fully utilise their entitlement. Of interest is the lost 'option value' to irrigators and the economy of denying irrigators the opportunity to take full advantage of the additional 1600 GL.
- This option value is difficult to determine because it may not have been economic to fully develop the entire 1600 GL. Thus, the approach taken was to estimate an 'upper bound' estimate of this 'option value' which assumes all 1600 GL is utilised.
- This upper bound lost 'option value' to the economy is estimated to be $428 million per annum including lost opportunity value to irrigators of an estimated $174 million a year Australia-wide. This can be interpreted as maximum benefits that must accrue to better reliability of the system, water quality and improved environmental outcomes for the CAP to have had a positive outcome for the economy.
- It is stressed that the opportunity losses are maximum gross measures of 'option value' and are not realised losses.

Future reforms

The most significant future reform affecting the irrigation sector is likely to be a reallocation of irrigation water to environmental and/or urban purposes. The impact of reallocating water using two different mechanisms is assessed. Water is assumed to be recovered either through an **administered scheme** — whereby pro-rata reductions are imposed across all users — or through a **market-based buy-back** of existing active entitlements. The purpose of this analysis is not to advocate a particular policy option but to demonstrate the potential divergence in costs between the different approaches. Key model results are as follows.

- The cost of reducing irrigation diversions by 540 GL (10 per cent) in the **southern MDB** are relatively small in terms of reductions in total GDP. In the case where trading between regions is allowed to occur — **the market based approach** — it is estimated that GDP would fall by $88 million per annum, equivalent to a lump sum net present value of nearly $1.0 billion over a 20 year period
- The indirect impact of diversions makes up a significant proportion of the total impact. For example, **direct losses** to irrigators in the southern MDB are $32 million a year — equivalent to a 2 per cent cut in annual net income. This compares to **indirect losses** from processing of $12 million and flow-on losses of $47 million per annum.
- The costs imposed on the irrigation sector are partially compensated by increases in value added generated by dryland agriculture. This is due to higher domestic commodity prices — in particular the higher prices received for dairy, sheep and grains — and lower wages following a reduction in irrigation activity.
- Reducing diversions by 540 GL is estimated to result in the loss of 400 to 900 jobs in irrigation and related activities, depending on the approach used for recovering water. However, there may be some off setting job gains in managing environmental flows in some areas.
- If diversions in the southern system were cut by 1080 GL (20 per cent) the economywide GDP loss would rise to $230 million or $2.6 billion in net present value terms.
- The reductions in GDP provide a benchmark against which to compare the environmental benefits of increased flows in the Murray. In other words, the recovery of 540 GL would have to result in environmental benefits with a present value of at least $1.0 billion for society to be better off in net terms. Environmental benefits under the 20 per cent level of recovery would need to be $2.6 billion over twenty years.

- Recovering water through **administered reductions** in water use, where every user is forced to take a proportional cut and trading is not possible, is almost twice the cost of using a market based method. For example, a 540 GL cut in diversions in the southern MDB connected system is estimated to reduce GDP by $161 million per annum under an administered approach but only $88 million under a market based approach.
- The market-based approach has a lower overall impact on the irrigation sector because water is sourced from users who have the lowest marginal value for water. However, under a process of unfettered market buy-back, consideration would need to be given to the possible costs of externalities — including redundant assets, a change in supply reliability for some users and water quality problems. These costs are not estimated in this analysis.
- A 10 per cent reduction in irrigation diversions across the **whole MDB** (equivalent to 1020 GL) using a market based approach would result in annual GDP losses of $195 million or $2.2 billion in net present value terms over 20 years. Job losses would be 1000. Costs would rise to $462 million if diversions were reduced by 20 per cent.
- **For Australia** as a whole, a 10 per cent reduction in diversions (equivalent to 1440 GL) using a market based approach would reduce GDP by $324 million annually or $3.7 billion in present value terms over 20 years.
- The market price of water is determined by supply and demand. Where demand is increased for environmental purposes, the market price of water is likely to rise irrespective of how the government acquires the water. It is expected that governments would take a flexible approach to any buy back scheme — possibly buying up permanent water entitlements in times of plenty and selling temporary water in times of scarcity. Such an approach could have a more stabilising influence on the water market compared with a strict administered approach.
- Ongoing **WUE improvements** will assist to off set the cost of potential reductions in diversions. The model indicates that an additional annual efficiency improvement of 1.3 per cent across all irrigators in Australia is sufficient to completely off set the direct value added losses from a 10 per cent (1440 GL) reduction in diversions.
- To the extent that environmental water can be sourced from off farm water savings rather than reduced allocations, there may be some scope for reducing the costs to irrigators and the rest of the economy. However, the cost-effectiveness of saving water would need to be evaluated and this is beyond the scope of the study.

1 Introduction

FROM HUMBLE BEGINNINGS in the 1880s by individual farmers along inland rivers and, in particular, the efforts of the Chaffey brothers at Renmark and Mildura in 1887, the irrigation industries in Australia have expanded to where they now use three quarters of all water used, have a combined area of about 2.6 million hectares under irrigation and produce agricultural outputs worth over $9 billion. Irrigation industries are an integral part of many regional economies and the national economy, and, on one estimate, make up nearly half of the profits earned from agriculture, but from only about 0.5 per cent of agricultural land (NLWRA 2002).

Increasingly, however, use of Australia's water resources have been on a less than ecologically sustainable basis, and over the past decade governments have been pursuing reforms of the way water is managed. Water management is primarily a state responsibility under the constitution, but the Australian Government has taken an active part in the reform process through the Murray Darling Basin Ministerial Council, the Council of Australian Governments (COAG) and other processes and programs. In particular, a large impetus to reform has come through the National Competition Policy (NCP), which has linked the progress of water reforms in the states to fiscal payments to the states.

In relation to irrigation in Australia, water reforms are pursuing four key objectives — all four being interconnected:

- increased environmental outcomes;
- maintenance or enhancement of the economic and social well being of irrigation industries and associated regions;
- increased water use efficiencies — technical efficiencies on and off-farm — and allocation efficiencies where water is put to best use; and
- improved security of water access entitlements, improved water trading and full cost recovery charging for water.

Trade-offs between the first two are perhaps at the centre of the debate but the other objectives are heavily intertwined with these.

There is mounting evidence that many of our river systems need attention and can be brought back to a reasonably healthy state by increasing environmental flows and modifying the pattern of flows to better mimic natural conditions. There is a great deal of uncertainty about the amount of water which should be returned to rivers as well as the effects this might have on improving the environmental condition of rivers. There is growing recognition that merely increasing river flow across the board is unlikely to be cost effective and a different approach is needed, targeted at special riparian sites where increased water flows at the right time will have the greatest environmental value.

A key area of debate is how strategic increased environmental flows can be achieved. One option would be to administratively reduce water allocations to irrigators. A Cap on increases in water extractions was set for the Murray Darling Basin (MDB) in 1995 and made permanent in July 1997. The cost of any further reductions in the Cap would be primarily borne by irrigators if they were not compensated. Alternatively, water for the environment could be purchased on the open market by government authorities or through a tender process — which would effectively compensate irrigators for their water losses at market value. Increased water savings through increases in water use efficiency (WUE) may also be a potential source of water for the environment. Increases in efficiency can come about through increases in technical efficiency and/or through changing to higher value crops which use relatively less water. But increasing efficiencies will inevitably require additional private and/or public investment. Several mechanisms are available for improving WUE.

- Water charges have a bearing on how much water is extracted and the rate of adoption of practices which enhance WUE. Reforms on water charges have so far concentrated on increasing water charges to a 'lower bound' recovery of the costs of providing the water to irrigators.
- Water trading has the potential to provide water savings and increased economic benefits by making the true scarcity value of water transparent to users. It allows water to be directed to its most valuable use through market transactions. At present work is progressing on how water markets can be improved by reducing the impediments to water trading.
- Third, governments can directly fund projects aimed at enhancing WUE — either on- or off-farm. Inevitably, public investment will be required to fund water saving projects for the purposes of increased environmental flows, because irrigators own any water they save through increased efficiencies.

Thus, governments can, in effect, secure water for the environment by reclaiming water either through regulation or purchasing water, or through investing in improved water efficiency and savings. In August 2003, COAG recognising the need to refresh its 1994 water reform agenda, agreed to develop a National Water Initiative to:

- improve security of water entitlements;
- ensure ecosystem health;
- ensure water is put to best use by encouraging the expansion of water markets and trading; and
- encourage water conservation in cities.

At the same time member jurisdictions of the MDB agreed to provide new funding of $500 million over five years to address water over-allocation and support improved environmental outcomes in the MDB. A priority for investment will focus on delivery of agreed environmental outcomes for six significant ecological assets identified in the Living Murray Initiative. The $500 million expenditure will give practical effect to the objectives of the National Water Initiative and progress the Living Murray Initiative. Details of these measures are being worked out. These agreements follow the December 2000 agreement by the New South Wales, Victorian and Australian Governments to invest $375 million over 10 years to restore 21 per cent of average natural flows to the Snowy River.

A key aspect of these water reforms is the implications they have for irrigators, regional economies and the national economy. This paper reports the results of a study focusing on the last of these. It uses a modified version of the CIE's economywide model to assess the implications of water reforms for the national economy. This is part of a wider project, which also assesses the regional impacts of water reforms, using the Goulburn Broken region as a case study. The project is funded by Land and Water Australia's Sustainable Irrigation Program.

This paper is a report on stage one of the project. Its focus is on:

- the economic and employment contribution of the irrigation sector to the national economy, including the direct contribution and 'second round' contributions through upstream and downstream industries associated with irrigation; and
- the economic and employment impacts of water reforms on the national economy.

2 *Water and water reforms in Australia*

THIS CHAPTER PROVIDES contextual background to irrigated agriculture in Australia in terms of the industry's water use, trends in irrigation supply and demand, and the array of reforms that are currently confronting the industry.

Water resources and use

Australia is the driest inhabited continent on earth. It has the least runoff per unit area, the lowest percentage of rainfall as runoff and the least amount of water in rivers of any continent. Yet parts of Australia — northern coastal Queensland and western Tasmania — are among the wettest on earth. Around 65 per cent of surface runoff in Australia occurs in the northern parts of Australia but only a small fraction of this has been developed for human use. In contrast, the Murray Darling system accounts for most of Australia's irrigation industries but is under stress from over exploitation and accounts for only six per cent of surface runoff in Australia. Water scarcity in the southern Murray Darling system is exacerbated by the highly seasonal pattern of rainfall and the large variation in water availability between years.

The following is a brief summary of Australia's water resources and use — as documented by the National Land & Water Resources Audit (2001).

- Over 3.2 million gigalitres (GL) of rain falls on the Australian land mass in an average year but only 12 per cent of this or 387 000 GL runs off into rivers while a further 1 per cent or 32 000 GL accesses ground water aquifers (table 2.1).
- In 1996-97 around 19 000 GL of fresh water were extracted from rivers and dams with around 75 per cent, or 15 500 GL used for irrigation. Total groundwater use in 1996-97 is estimated at 4 960 GL.

2.1 **Water availability and use in Australia: 1996-97**

	Water volume
	GL
Water availability	
Mean annual runoff	387 184
Mean annual outflow	348 752
Sustainable surface water yield	45 191
Storage capacity in large dams	78 919
Storage capacity of farm dams	2 000
Sustainable groundwater yield per annum	25 780
Mean annual surface water use	19 109
Irrigation	15 354
Urban/industrial	3 303
Rural/other	451
Mean annual groundwater use	4 962
Irrigation	2 582
Urban/industrial	1 451
Rural/other	953
Total water use	24 071
Irrigation	17 936

Source: National Land and Water Resource Audit (2001).

- Thus, total water use in Australia is estimated at about 24 000 GL with irrigation using 17 940 GL.
- Between 1983-84 and 1996-97 water used for irrigation increased by 76 per cent compared with an increase in total water use in Australia of 65 per cent.
- Since 1996-97, surface water use has been constrained by droughts limiting water supplies and the Cap placed on water extractions from the MDB. The Cap was agreed to by the Murray Darling Basin Ministerial Council in 1995, and confirmed as a permanent Cap from July 1997.
- The MDB stands out as the drainage division where the volume of water diverted is significantly greater than the mean annual outflow (table 2.2). This is indicative of the high concentration of irrigation in the Basin, which is under stress. In contrast, the river systems of northern Australia, in particular, are generally under-utilised. Some 26 per cent of surface water management areas are either close to or over-used when compared with sustainable flow regime requirements. A high proportion are in the Murray Darling Basin Drainage Division.

2.2 **Water availability and volume diverted by drainage division: 1996-97**

Drainage division	*Mean annual run-off*	*Volume diverted*[a]	*Mean annual outflow to sea*[b]
	GL	GL	GL
North East Coast	73 411	3 182	na
South East Coast	42 390	1 825	40 591
Tasmania	45 582	451	45 336
Murray Darling	23 850	12 051	5 750
South Australian Gulf	952	144	787
South West Coast	6 785	373	5 925
Indian Ocean	4 609	12	3 481
Timor Sea	83 302	48	81 461
Gulf of Carpentaria	95 615	52	24 748
Lake Eyre	8 638	7	na
Balloo–Barcannia	546	<1	-
Western Plateau	1 486	1	na
Australia	**387 184**	**18 147**	**348 752**

[a] Volume diverted is the amount of fresh water extracted from rivers; for the South West Coast and MDB, the figures shown do not include volume extracted from unregulated surface water management areas.[b] Mean annual outflow to sea is the average annual volume of water flowing out of a surface water management area after allowing for diversions, losses and 'consumption' by wetlands. Total for Australia excludes the last three inland diversions.

Source: NLWRA (2001, p. 25).

2.3 **Water use and gross value of production for irrigated agriculture: 1996-97 and 2000-01**

	Net water use		*Irrigated area*		*Gross value per ML*	
	1996-97	*2000-01*	*1996-97*	*2000-01*	*1996-97*	*2000-01*
	GL	GL	'000 ha	'000 ha	$/ML	$/ML
Livestock, pasture, grains and other agriculture	8 795	8 403	1 175	1 403	289	373
— dairy	–	2 834	–	–	–	529
Vegetables	635	556	89	116	1 762	3 270
Sugar	1 236	1 311	173	211	418	217
Fruit	704	803	82	116	1 459	1 213
Grapes	649	729	70	133	945	1 859
Cotton	1 841	2 908	315	437	613	420
Rice	1 643	1 951	152	179	189	179
Total	**15 503**	**16 660**	**2 057**	**2 506**	**–**	**–**

Source: ABS (2004).

Water use by irrigated agriculture

Table 2.3 summarises net water use by different irrigation industries. Note that this water use data is net of delivery losses and is thus a measure of water actually delivered to the farm gate. The source is ABS Water Account Australia 2000-01, and 1993-94 to 1996-97. Total net water use across all agricultural industries is estimated at 15 503 GL for 1996-97, and 16 660 GL in 2000-01. These estimates are somewhat less than total gross diversions indicated in table 2.2.

On an area basis, irrigated pastures account for over half of the area under irrigation in Australia. The irrigation industries using most water are live-stock (particularly dairy on irrigated pasture which uses about a third of water used for livestock, pasture, grain and other agriculture), cotton, rice and sugar (table 2.3). These industries generate relatively low gross values of production per megalitre (ML) of water used. Rice in particular has a high water use per hectare and a low gross value of output per ML. In contrast, vegetables and fruit have the highest gross returns per ML of water used.

It is tempting to conclude on the basis of these estimates that water trading will eventually result in water moving away from relatively low value activities — such as irrigated pasture and rice — to crops that use less water per dollar value of output. However, water is just one input and when these industries are assessed in terms of net returns to all inputs (total factor productivity (TFP)), the apparent divergence between horticulture and broadacre irrigation or rice is lessened considerably. In brief, there are many factors influencing the relative profitability of using water in different irrigation enterprises, and consideration must be given to the high fixed costs associated with intensive horticulture operations, the amount of investment needed for conversion to high-technology water applications and the nature of commodity markets. Some small vegetable or fruit industries, for example, are domestically oriented and prices are sensitive to increased production.

The distribution of irrigation areas across the states is summarised in table 2.4. Most irrigation takes place in New South Wales and, to a lesser extent, Victoria and Queensland.

2.4 **State breakdown of irrigated agriculture: 1996-97 and 2000-01**

State	*Area under irrigation*		*Water use in irrigation*		*Irrigation as a proportion of total water consumption*	
	1996-97	*2000-01*	*1996-97*	*2000-01*	*1996-97*	*2000-01*
	'000 ha	'000 ha	GL	GL	%	%
New South Wales	907	1 073	7 181	7 322	82.4	77.6
Victoria	546	640	4 047	3 725	60.5	52.2
Queensland	404	511	2 541	3 454	69.0	73.3
Western Australia	30	46	618	565	43.4	40.1
South Australia	116	163	992	1 302	78.7	79.1
Tasmania	52	68	113	222	36.0	53.0
Northern Territory	2	4	9	70	8.6	43.8
Total	**2 057**	**2 506**	**15 501**	**16 660**	**70.0**	**66.9**

Source: ABS Water Account for Australia (2000 and 2004).

Overview of irrigation industry and reforms

The various institutional and policy reforms being introduced in the rural water industry represent a complex set of incentives and disincentives to the irrigation sector. The reforms will affect both the supply and demand side of the water industry. As the reforms are implemented, irrigators and water suppliers will face a changed operating environment. The purpose of this study is to diagnose the economic impact of these changes — but the task is not straightforward because many of the policies are interlinked and have interaction effects. For example, increased water charges may provide users with an incentive to increase WUE but the financial incentive will be considerably greater under a regime of enhanced trading.

Identifying the various impacts requires a good understanding of the current structure of the water supply and irrigation industries, a clear definition of the reforms and how they affect different stages of water delivery and use. Chart 2.5 is a stylised representation of the water industry and the reforms taking place.

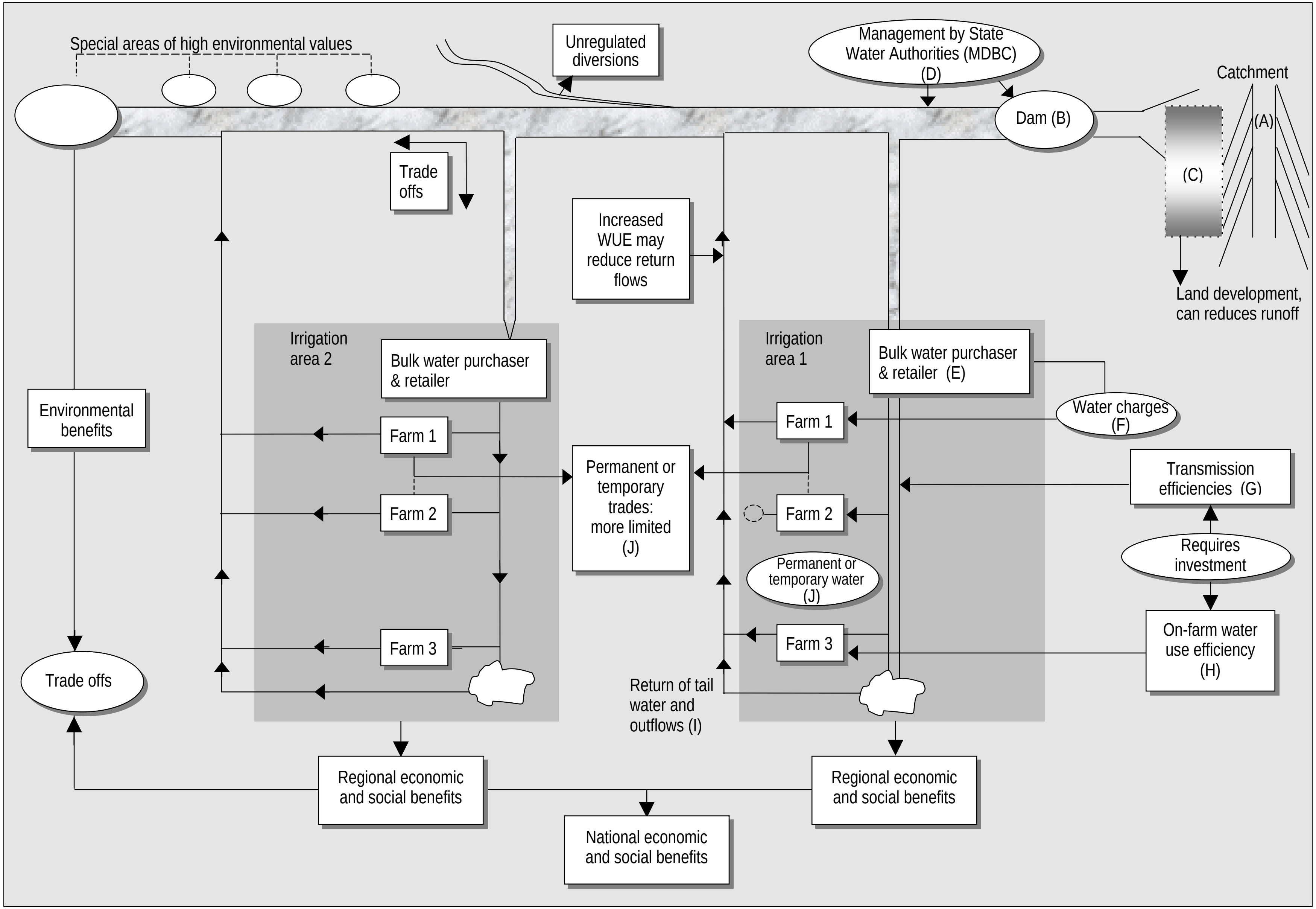
Water harvesting stage

The first stage of water supply is the harvesting of surface flows and the extraction of ground water. With reference to the chart, surface runoff in catchment (A) collects in streams and rivers, which flows into storage dams (B). Some forms of land development, such as large scale forestry enterprises or large private dams (C) have the capacity to reduce run-off and/or lower groundwater yields, thus impinging on the availability of water for use further downstream. Some states are contemplating legislation to regulate such developments, requiring landowners to have water entitlements for the estimated amount of water diverted.

Another risk to the security of users' entitlements is uncontrolled pumping of water by irrigators with unrestricted assess to the resource. In the past it has been common for irrigators located along unsupplemented (or unregulated) rivers to have area-based licences, permitting them to divert an unspecified volume of water to irrigate a particular area of land. In the main these licences are progressively being converted to volumetric entitlements and meters are being installed to monitor diversions. However, it will be some time before all such diversions can be metered.

Also, water diversions for stock and domestic use are often uncontrolled. In some cases, water is diverted for stock purposes through open drains where up to 90 per cent of the water is wasted through evaporation and seepage.

2.5 **Stylised water reform issues**



State water authorities and bulk water retailers

State water authorities (D) generally manage the release of water from headworks and deliver bulk water to rural customers or water retailers (E). Under the COAG's water reform framework, there have been significant institutional reforms that have separated the roles of water resource management and service provision from policy and regulatory enforcement. Most states now maintain policy functions within state bureaucracies. In New South Wales for example, water policy and regulatory functions are now undertaken by the Department of Infrastructure, Planning and Natural Resources (DIPNR). State Water is a government authority whose core function is the storage and delivery of bulk water to rural 'retailers' such as Murray Irrigation Limited (MIL). The latter holds a bulk licence from DIPNR of nearly 1500 GL and supplies water to over 1800 individual irrigation businesses whose owners are the shareholders of MIL. In the case of MIL, irrigators hold shares in the private company instead of having individual water entitlements. These water rights are equivalent to general rather than high security entitlements. MIL's bulk licence is subject to several conditions particularly those imposed by the relevant water management plan. Because of the share ownership structure, responsibility for meeting the restrictive conditions is sheeted home to the individual irrigator shareholders.

In Victoria all water is vested in the Crown and the relevant minister allocates bulk water to state owned water authorities for delivery to private entitlement holders. Goulburn Murray Water (GMW), for example, has a bulk entitlement and delivers about 2100 GL a year to water users. Included in its bulk entitlement is an estimate of transmission losses which it 'owns'. Thus, if it makes transmission efficiency gains, it can benefit by on-selling the water savings made. In general the water entitlements in Victoria are high security and carry the right to additional 'sales' water when it is available. The water authorities generally ensure that enough water is stored in dams to meet entitlement holders' allocations for the following season before making 'sales' water available in the current season. Landholders outside irrigation districts can hold diversion licences issued for 15 years and subject to certain conditions. These are also high security with rights to 'sales' water.

In South Australia most irrigation districts come under local trusts which are statutory bodies under the Irrigation Act 1994. These trusts own the conveyancing infrastructure and are allocated separate licences to take water. The trusts then allocate volumetric entitlements to individual irrigators. The Central Irrigation Trust (CIT) overlays the local trusts and provides services to the trusts including the operation of a water market.

Control of water in the River Murray and lower Darling comes under the Murray Darling Basin Agreement and is managed by River Murray Water within the Murray Darling Basin Commission (MDBC). River Murray Water determines the shares of water available and, once these are set, state water authorities operate within these boundaries in allocating water to irrigators or bulk water retailers and charging for the water.

Water charging

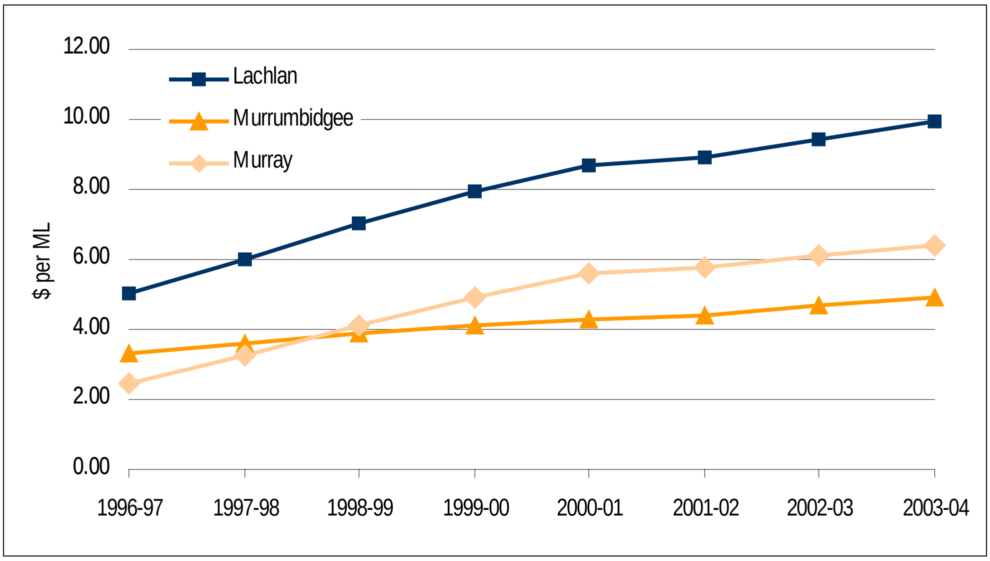
One of the main principles of the COAG water reform agreement of 1994 was to achieve consumption-based and efficient pricing of water based on full cost recovery (F). Most state water authorities have now achieved so-called 'lower bound' cost recovery charging, which includes full recovery of operating, maintenance, renewables and depreciation costs. Few authorities have gone the step further to achieve 'upper bound' charging, which, in addition, includes an appropriate rate of return on infrastructure assets.

In no cases are charges made for the intrinsic value of the water itself. Water entitlements have historically been allocated by governments to irrigators for a minimal fee or, in some cases, at no charge. However, new entrants to the industry must buy entitlement or purchase irrigation land which has the value of entitlement capitalised into the purchase price. With the exception of Queensland, no new entitlements are being issued. In some parts of Queensland (outside the Murray Darling system) water is still available for development and permanent water entitlement is sold by auction to willing buyers.

Pricing reforms have resulted in a significant increase in charges for rural water over the past decade. For example, chart 2.6 shows the increase in bulk water charges (in real terms) for three New South Wales irrigation districts since 1996-97. Depending on district, charges have risen by 50 to 160 per cent in real terms. The composition of charges has also changed, with a move towards a two-part tariff structure which includes a fixed charge on entitlement held and a volumetric charge on the amount of water used. Formerly, most states operated on the basis of a fixed entitlement charge, which did not vary with consumption. Two-part pricing is aimed at signalling the true costs of delivering water to users on a consumption basis while maintaining revenue stability for water supply authorities.

Water charges are substantially less than market prices for water entitlement, either on a temporary or permanent basis, depending on seasonal conditions. Thus, the economic rents generated from the use of water reside with irrigators.

2.6 **Real increases in the charges for bulk water in New South Wales[a]**



[a] General security entitlements.

Data source: IPART (2001).

Water trading and entitlements

A fundamental requirement for efficient water markets is to have a sound system of water entitlements, unbundled from land. While considerable progress has been made on this issue, state reforms have generally fallen short of introducing water entitlements with secure — in perpetuity — tenure. Instead, governments have opted for licences with fixed periods of tenure (10 to 15 years) and under the National Water Initiative, irrigators are to bear the risk of 'adaptive' changes made by government to the pool of water available for consumption for the purposes of maintaining resource 'sustainability'. From the irrigator's perspective, this represents considerable uncertainty and could hamper trade.

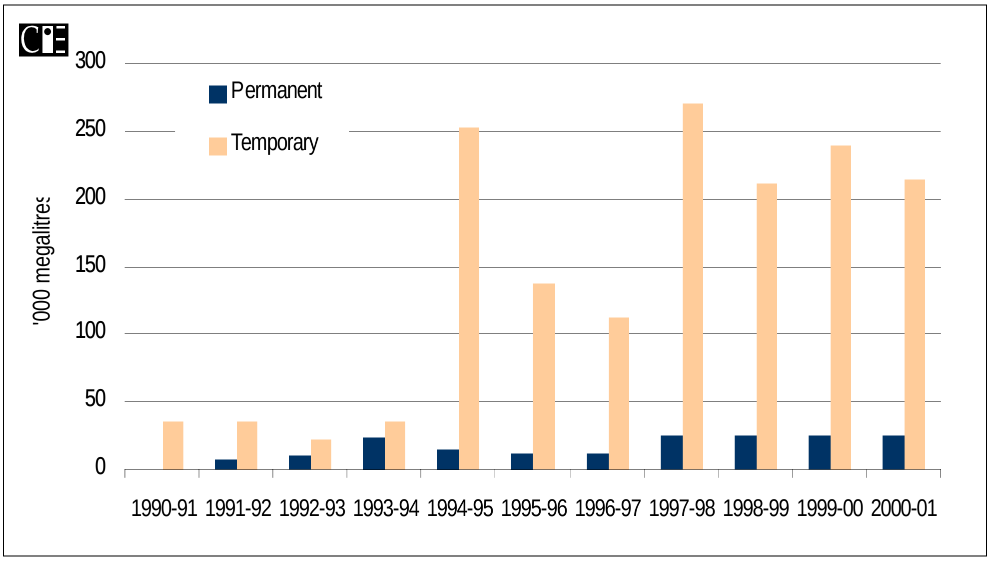
Water trading is now permissible in all states and there has been considerable growth in trading activity over the last five years. Table 2.7 summarises the volume of water traded on a permanent and temporary basis in the MDB during 2001-02. Permanent trades represent only a small fraction of the total volume of irrigation water used, while temporary trades constitute a larger proportion — in the order of 3 to 18 per cent depending on the State. Most of the trades occur within irrigation districts. Volumes traded between districts are small and interstate trades are negligible.

2.7 Water trading in the MDB: 2001-02

		Volumes traded as a percentage of diversions	
	Irrigation diversion[a]	*Permanent trades*	*Temporary trades*
	GL	%	%
New South Wales	6 565	0.4	9.7
Victoria	3 571	0.8	3.3
South Australia	494	1.9	17.8
Queensland	325	0.0	8.1
ACT	5	0.0	0.0
Total Basin	**10 960**	**0.6**	**7.9**

[a] New South Wales, Victoria and Queensland diversions include an estimate of unregulated stream diversions.
Source: MDBC (2003).

2.8 Growth in temporary water trade in Victoria



Data source: DNRE (2001).

Since 1994-95 the volume of temporary trade in Victoria has increased to between 100 000 and 250 000 ML each year (chart 2.8), which represents 3 to 8 per cent of the State's total water use (DNRE 2001). Permanent transfers have built up gradually but only represent about 25 000 ML per year — equivalent to about one per cent of water entitlement.

The increased levels of temporary trades in Victoria since the early 1990s has been due to a number of factors, including:

- a widening of trading rules in 1994 to allow trade for the first time out of irrigation districts;
- a series of relatively dry years since 1994-95;
- the decision in 1995 to cap diversions in the MDB; and

- farmers becoming more accustomed to the ‘culture’ of trading and gaining confidence in the market.

Increased water trading can be expected to lead to improved national welfare as it can facilitate water moving to where it can be put to most valuable use. This is not to say that efficiency gains cannot be made in the absence of a water market. Property sales (with water rights attached) provide irrigators with some flexibility to acquire/sell water rights and restructure their enterprises. However, these transactions generally do not allow water to be transferred to a new region.

While water markets offer greater flexibility to irrigators, there are significant barriers to water trading. One, in particular, is the redundant asset problem whereby permanent trades in water entitlement out of a district can leave infrastructure under-utilised and result in higher charges to those irrigators remaining. In some states, trades are restricted by rules that limit the amount of water that can be permanently traded out of a region. For instance, in New South Wales many of the bulk water purchasers (E) are owned cooperatively by irrigators in the district and exit fees are imposed on water trades out of the district. Only a small percentage of permanent entitlements are permitted to be traded out of the region. In Victoria, also, a maximum of 2 per cent of entitlements are permitted to be traded out of irrigation areas in any one year.

Another major impediment to trading is the ongoing uncertainty about entitlement security. Irrigators and their financiers need to know ‘what they are buying’ before committing to a major investment in new entitlement. Part of the problem is that rights for the use of water, as a physical product, have not been adequately separated from the rights to use infrastructure to deliver the water.

Management of return flows (I)

There are several strategies and plans aimed at reducing the amount of salt carried into the Murray River by drainage and run off water. For example, in 1988, the MDB Ministerial Council adopted the *Salinity and Drainage Strategy* to improve water quality in the river, ensure sustainable use of land resources and conserve the national environment (MDBC 1999). The relevant states undertake joint works to reduce river salinity levels including interception works. These earn salinity credits which can be used to offset against actions or developments significantly affecting river salinity. While this strategy and other similar ones may affect irrigators, they are not taken into account in this study.

Enhanced water use efficiencies

WUE refers to achieving the same outcome or value of production with less water. At the outset, it is important to distinguish between TFP and WUE. The former refers to total value of output relative to the total value of inputs. In most cases, WUE will be a subset of TFP, but it is possible that excessive focus on WUE can mean reduced TFP. That is, it may not be economically efficient or profitable to pursue the goal of increasing WUE if it means reducing overall returns to the farm business.

With concerns about declining river health and calls for increased environmental flows, governments have moved to consider a variety of options to retrieve water for environmental flows. Increased WUE can potentially have a big role in reducing the social and economic costs of delivering more water for the environment and also improving the well being of irrigators and communities.

Water savings made through increased WUE are not necessarily available for increased environmental flows. This is because the savings made are mostly owned by irrigators or service providers making the savings. Thus, governments would need to purchase the savings or make other arrangements to capture the savings from increase WUE.

From a technical perspective, WUE can be achieved by better off-farm water delivery or transmission systems (G), more efficient use of water on farms (H) — through improved water application technology or better plant varieties — and better management of return flows (I). It is important to note that not all water 'losses' are real losses to the system because a proportion of water returns to rivers for consumptive or non-consumptive purposes, implying that a 'loss' in one part of the system is a gain elsewhere. The only real losses in an irrigation system are evaporation and seepage to saline groundwater. The MDBC estimates that half to two thirds of apparent 'losses' are in fact return flows and cannot be counted as water lost from the system or reductions to environmental flows.

Drivers of improved efficiency

An important driver of increased WUE has been increased *market prices* for traded water. Because irrigator entitlements are defined in gross terms (use plus on-farm losses), any on-farm water savings are owned by the irrigator. This means that higher market prices for water provide a financial incentive to users to increase their water use efficiencies and sell the saved water. Efficient water trading (J) can enhance *allocative efficiency*, resulting in water being diverted to crops with the highest value of output or value added per unit of water used. Higher market prices, and greater flexibility to trade, should also provide an incentive for water suppliers to deliver *off-farm savings*. However, in practice, not in all cases do water suppliers own the water savings and this removes the incentive to improve delivery efficiencies.

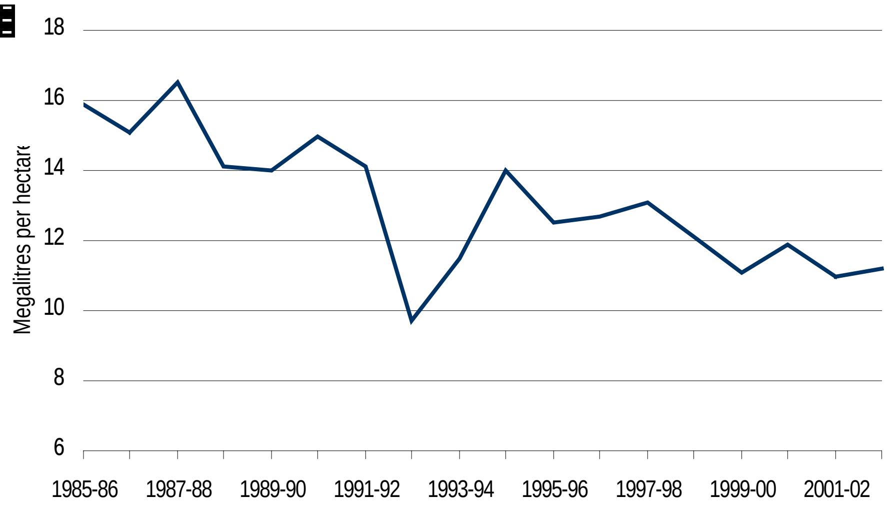
Institutional arrangements and the *modus operandi* of irrigation water providers (IWP) can potentially have a big influence on improvements in WUE on and off-farm. Marsden Jacobs Associates (2003) highlight the differences between states in the role of IWPs in enhancing WUE. In New South Wales for example, the bulk licences of IWP corporations have conditions attached which requires them to enforce compliance with these conditions by individual irrigator members. In contrast, Queensland's SunWater — the state's principal IWP — has no role or responsibility for farmer behaviour.

Higher *water charges* can also, potentially, be a driver for improved WUE as lower water use reduces production costs. However, water is a minor cost factor in the production of most irrigated crops (typically less than 10 per cent) and therefore tariff increases would need to be substantial before they had a significant impact on irrigator behaviour. The tariff structure is also influential in determining the response to higher charges. Tariffs with a high fixed component limit the incentive for irrigators to conserve water. Several studies indicate that the demand for irrigation water is relatively inelastic — or unresponsive to price increases — at least up to about $50 per ML (Productivity Commission 2003). Agriculture NSW undertook detailed studies into the potential economic impact of price increases prior to embarking on a path of higher water charges — that were to be phased in over the period 2000-01 to 2003-04. It was estimated that irrigators in the Lachlan Valley would absorb the cost of higher charges rather than reduce their water consumption. Across the representative farms evaluated, it was estimated that net farm income would fall by 8.3 per cent (Jayasuriya, Crean and Hannah 2001).

Other incentives for increasing on-farm WUE are *reduced labour costs* and improved *product quality* (for example, wine grape quality improves with controlled water applications). However, these incentives — and the other incentives discussed above — must be balanced against the cost of conversion to more water efficient technology.

What achievements have been made?

Modest *on-farm* improvements in WUE have been achieved over the last five to ten years in most irrigation industries. Some industries, such as rice, 2.9 **Increasing WUE in the rice industry: Coleambally, New South Wales**



Data source: Coleambally Irrigation Annual Environmental Report 2002-03.

cotton and wine grapes, have made significant gains. The rice industry, for example, has reduced its application rates from about 16 ML per hectare in the eighties to 12 ML per hectare, while achieving an increase in average yield from 6 to 9 tonnes per hectare (Rendall McGuckian 2002). Chart 2.9 shows the decline in water application rates for rice growers in the Colleambally district. Both the cotton and rice industries have introduced intensive extension campaigns and research and development (R&D) programs to assist growers to improve on-farm WUE.

In the case of wine grapes, the push to achieve higher WUE has mainly been driven by corporate investment in large vineyards. For example, there has been a high rate of conversion to pressurised drip irrigation among horticultural businesses in the Murrumbidgee Irrigation Area. According to the Murrumbidgee Horticultural Council (personal communication, 29 January 2004), approximately 40 per cent of horticultural land area has been converted — mostly in the last five years — and businesses are routinely selling their high security water savings on the market.

The potential for further increases in WUE

A scoping study by CapitalAg Pty Ltd (2002) indicates considerable potential for water savings through more efficient water use on farms, as well as through improved infrastructure to reduce losses through seepage, leakage and evaporation. Even with a scenario of 50 per cent adoption rate of good management practices, which require low levels of investment, these authors estimate a potential saving of 1500 GL across the basin by greater WUE on and off-farm.

While there may be considerable scope in a technical sense for improving WUE, and improvements are being achieved, there remain considerable barriers to enhancing the rate of improvements or adoption of WUE technologies or practices on and off-farm. CapitalAg Pty Ltd (2002) suggest that irrigation practices are still largely a legacy of the past when water was plentiful, and the mood in many irrigation communities continues to be one of uncertainty and caution about future water policies. This impedes the more rapid uptake of technologies and practices to enhance WUE. In some regions water is not sufficiently scarce to justify the cost of making water savings.

A general conclusion from several other studies that have examined WUE on- and off-farm is that, increasingly, water savings will require increasing levels of investment. For example, ACIL (2003) examined a range of investments in water savings within the MDB and concluded that:

- off-farm infrastructure upgrades could yield up to 365 GL of potential savings at a marginal cost of around $1000 to $1500 per ML. Costs then rise, reaching $4500 per ML at around 420 GL. Above 488 GL marginal costs rise sharply; and
- on-farm water savings could yield an additional 200 GL at a cost of between $500 and $3000 per ML, however it is questionable whether these are net savings.

The Murray Darling Basin Cap

Perhaps the most fundamental and important water reform initiative was the introduction of the MDB Cap in 1997. The Cap was introduced to halt the increase in diversions from the Basin. Further diversions were forecast to significantly undermine the reliability of existing entitlements and to exacerbate environmental problems. The Cap does not attempt to reduce Basin diversions — rather, it aims to prevent them from increasing. The Cap is defined as the volume of water that would have been diverted under 1993-94 levels of development. This does not mean the volume of water that was used in 1993-94. Given any type of season, it equates to the volume of water that would have been used with the infrastructure (pumps, dams, channels, etc.) and management rules that existed in 1993-94. Thus, the Cap provides scope for greater water use in certain years and lower use in other years. New developments are possible under the Cap provided that the water for them is obtained by improving WUE or by purchasing water from existing developments.

In order to examine the long-term economic impacts of the Cap on irrigators, it is necessary to understand:

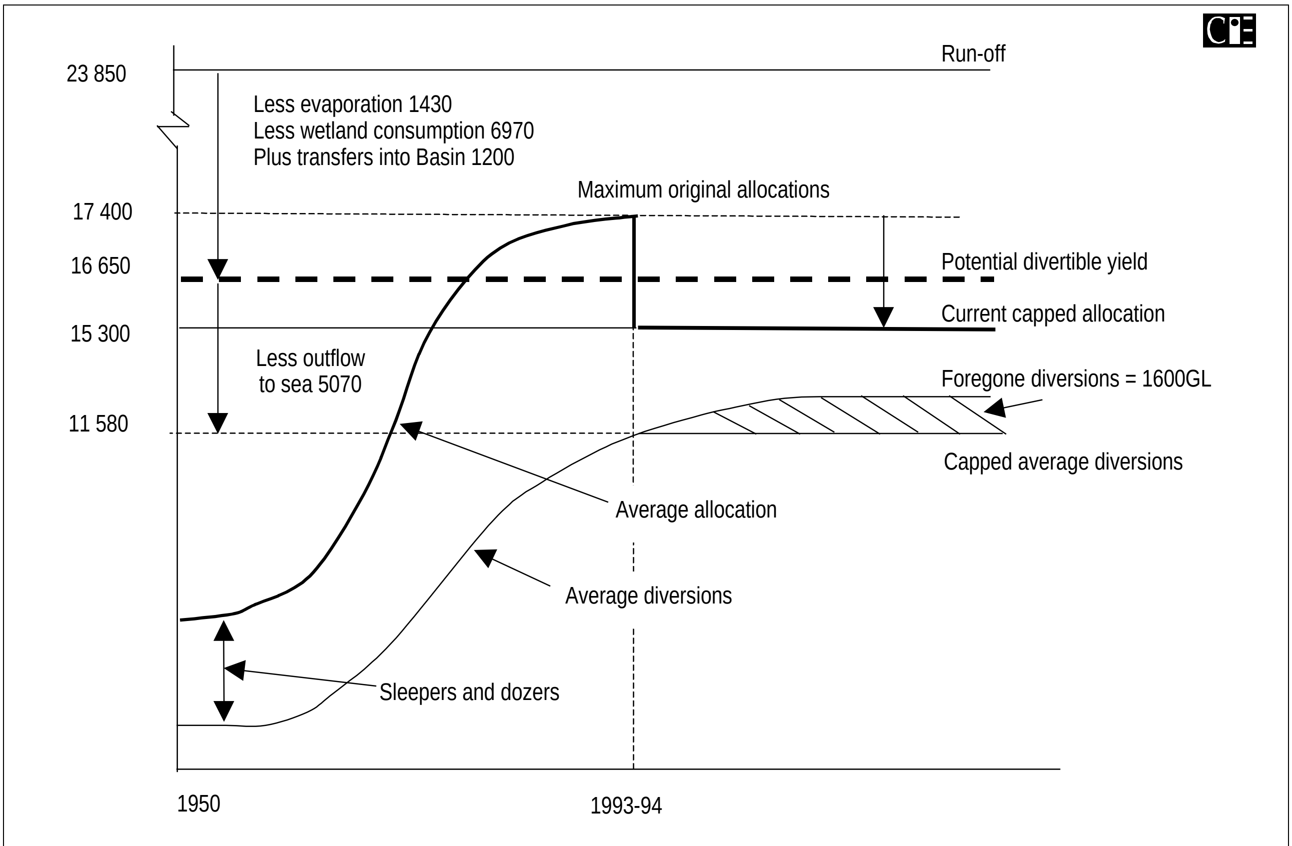
- the historical rate of increase in diversions and the potential for future development had the Cap not been imposed (referred to as a full development scenario under existing entitlements);
- the physical limits of the system that would have constrained future development had the Cap not been introduced (that is, to what extent was the system over-allocated);
- the extent to which sleeper and dozer entitlements could become activated under the Cap and thus reduce the reliability (security) of allocations to existing users; and
- the reduced levels of reliability that would have resulted under the No Cap scenario due to further development.

Chart 2.10 puts some dimensions around these factors. The trend lines are stylised to represent moving averages. From 1950 to 1970 diversions from the Basin increased rapidly. There was another period of rapid growth in the late eighties. By 1994, diversions had reached almost 12 000 GL and average annual allocations (volumes authorised for use) totalled 17 400 GL. A water balance for the MDB indicates that the maximum divertible yield of the system is approximately 16 650 GL, which indicates that the system was in fact over-allocated (divertible yield is defined as the average annual volume that could be diverted using both existing and potential infrastructure, making no allowance for environmental water requirements).

In the five years leading up to 1995, average diversions were only 63 per cent of allocation, suggesting that there was a substantial number of sleeper and dozer licences and considerable scope for increased diversions — at least up to the maximum divertible yield. The effect of the Cap was to fix annual average diversions at about 12 000 GL. To meet this target, allocations have been reduced to 15 300 GL to bring authorised volumes into line with natural system constraints and to counter the activation of sleeper and dozer licences which effectively reduce the reliability of the system to deliver allocation. Marsden Jacob Associates (2003) outline the reductions that have occurred in each state.

- New South Wales Murray — Nominal allocations reduced by 323 GL. Off-allocation limits reduced by 173 GL.
- New South Wales Murrumbidgee — Nominal allocations reduced by 179 GL. Off-allocation limits reduced by 260 GL.
- In Victoria a suite of measures were implemented, including a moratorium on diversions, limiting high security entitlement access to sales water, cut back in availability of sales water to general security entitlement holders and limited access to off quota.

2.10 **Impact of the Cap on diversions and future development**



Data source: Data based on MDBC Water Resources Fact Sheet, November 2003 (www.mdbc.gov.au)

- In South Australia, announcement of the Cap had little impact on existing water management procedures as South Australia already had an effective cap on diversions in place since 1968.

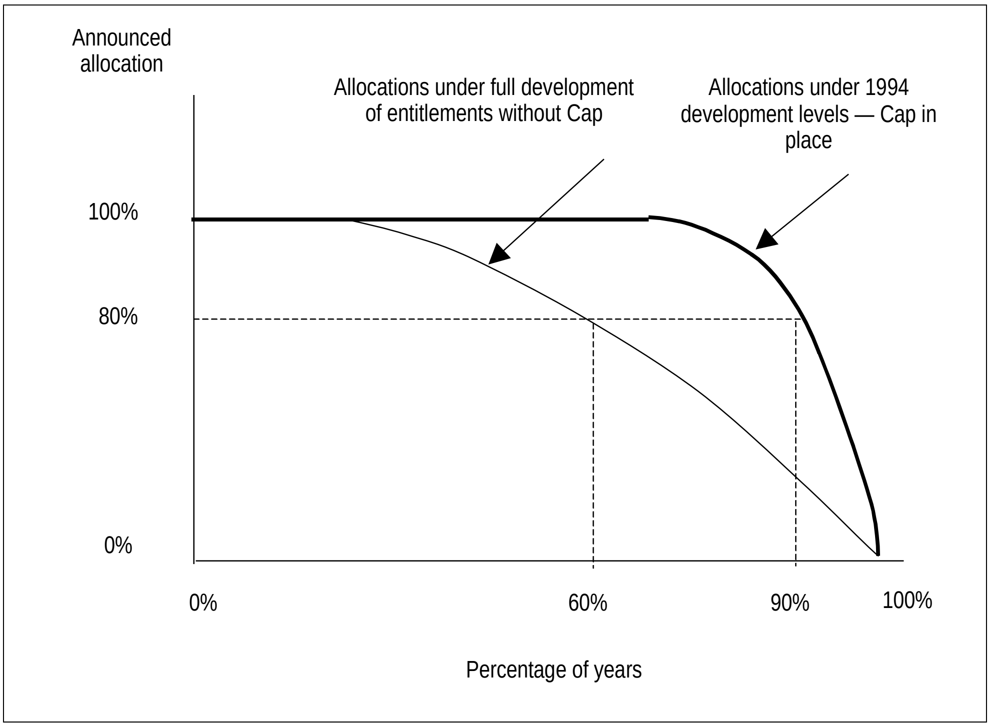
Foregone development opportunity

Under the 'No Cap' scenario the 1995 MDBC Audit estimated that diversions could increase by a further 15 per cent on 1994 levels if all existing entitlements were fully developed (MDBC 2000). This represents an additional 1600 GL of water. It represents the amount of foregone development potential due to the Cap. However, it should be viewed as an *upper limit* because some of this potential may not have been economic to utilise owing to physical limitations in the system.

Improved supply reliability

At aggregate level, the Cap is expected to greatly enhance the reliability of supply of users — relative to the 'No Cap' scenario. Chart 2.11 illustrates the expected impact of full development on the reliability of allocations. The chart is a stylised example — the exact relationships vary from one

2.11 **Impact of the development on the reliability of announced allocation**



Data source: Based on modelling documented in MDBC (2000).

valley to the next. Under existing diversions (capped at 1994 levels), announced allocations of 80 per cent could be achieved in 90 per cent or more of years. But under full development of entitlements in the absence of the Cap, allocations of 80 per cent of entitlements could only be achieved in 60 per cent of years (MDBC 2000).

However, one of the effects of the Cap, combined with the introduction of trading, has been to accelerate the activation of unused licences. This may have the effect of reducing the reliability of supply to some individuals, but there is little doubt that the cap has had a positive impact on enhancing reliability of supply to most irrigators.

In the 2000 Review of the Operation of the Cap (MDBC 2000), Marsden Jacob Associates assessed the economic and social impacts of the Cap. Their report made the following conclusions.

- Overall, the Cap has provided — and will continue to provide — positive economic and social benefits to the irrigation community.
- This is founded on hydrological modelling work which shows that, in the absence of the Cap, the full development of existing entitlements would significantly reduce the supply reliability currently enjoyed by irrigators — particularly those in the major southern systems. The guaranteeing of supply security provides a more certain climate for

investment and jobs growth. Long term investment in high value agriculture and value-adding processing is dependent on underlying security of the water resource.

- The improved security offered by the Cap is potentially offset by the reduction in development opportunities, particularly in less developed valleys. However, it is concluded that while individual high water users will be adversely affected — particularly those who have in the past relied on the unused allocations of other entitlement holders — most industries and regions appear likely to continue to prosper.
- The Cap has put in place a framework that is conducive to trading and the establishment of secure water rights. This will help to prevent the costly conflicts and legal disputes between irrigator groups and between regions that could be expected under a full development scenario.
- Within the agricultural economy, the Cap is likely to have differential impacts between valleys and between irrigators. Northern regions could be adversely impacted more than irrigators in the southern systems, the latter who stand to benefit the most from improved reliability. Because northern regions are more reliant on unregulated sources of water and are less developed, the Cap is expected to be more limiting for these regions.

These findings were based on qualitative work rather than a rigorous analytical assessment of the costs and benefits.

Other policies impacting on diversions and environmental flows

At the time of its introduction, the Cap was viewed by the MDB Ministerial Council as an essential first step in establishing management systems to achieve healthy rivers and sustainable consumptive uses. As such the Cap was never envisaged as an end in itself but rather a first step towards achieving the longer term goal of 'sustainability'.

The COAG package of water reforms requires the states to define formally the entitlements of users and to recognise the environment as a legitimate user of water. Most states have now legislated to give formal recognition to environmental flows and, in most cases, such flows are given first claim on the available resources. For instance, New South Wales in its Water Sharing Plans has made allowances for additional environmental flows — up to a maximum of 10 per cent above Cap reductions. Environmental flow regimes have been determined for each valley to achieve specific environmental outcomes. Decisions on these objectives are taken by locally based management committees.

Questions remain, however, on how much water should be allocated to environmental flows and how this water can best be sourced. For the River Murray, substantial volumes of water for environmental flows are being debated. The Living Murray Scientific Reference Panel, has suggested in an interim report that a minimum of 1500 GL (approximately three times the volume of Sydney Harbour) will be required to make an even moderate 'whole of river' difference to the ecological health of the River Murray (CRCFE 2002). Such a volume may not be able to be met purely by water savings from increased WUE within a reasonable timeframe and at a reasonable cost. Hence, it may involve substantial tradeoffs between water for irrigation and for the environment.

At about the same time as the Living Murray process was initiated by the MDBC, the New South Wales, Victorian and Australian Governments agreed in December 2000 to invest $375 million over ten years to restore 21 per cent of average natural flows to the Snowy River — referred to as the Snowy Water Agreement. This is equivalent to 212 GL of additional water that is to be dedicated to environmental flows. A further 70 GL is ear-marked for the River Murray. The water is to be sourced primarily through water efficiency projects in the irrigation areas, thus resulting in no impact on existing irrigator entitlements.

In August 2003 COAG agreed to develop a National Water Initiative which would involve implementing regimes to protect environmental assets at a catchment scale, improving security of water entitlements, making them nationally compatible and improving water markets. With regard to the Murray–Darling Basin, new public funding of $500 million over five years will target specific environmental assets of high ecological value. This sum equates to approximately 500 GL which represents approximately 6.5 per cent of current water use in the Murray, Murrumbidgee and Goulburn systems. Governments are still in discussion on a range of options for recovering the 500 GL. Options could include water being purchased for the environment either directly on the market or by tender, or through investments in water savings projects (on and off-farm). Specific environ-mental 'icon' areas will be targeted with the benefits of increased flows being assessed carefully before diverting further flows to the environment. Governments have publicly stated that the 500 GL is a first step and further diversions may follow in future.

Beyond the MDB

Surface water

While being the focus of much public debate on water reform, it is important to recognize that MDB surface water is not the only resource that will be subject to major reforms and reductions of entitlements. Developments in other surface water systems are briefly outlined below while groundwater resources are considered in the next sub-section. vanessa

Queensland is currently completing a planning process of water resources in all catchments. Under the *Water Resources Act 2000*, a Resources Operations Plan for each catchment will be developed which identifies objectives for environmental flows and resource security to certain users. However, detailed plans for some catchments, especially those with groundwater areas, have not been developed due to the lack of detailed modelling data. Therefore it is very difficult to quantify by how much reductions in access to water will impact on irrigators. In terms of surface water in Queensland catchments outside of the MDB, it would be reasonable to say that water is not scarce at this stage. This is particularly the case in Water Supply Schemes (WSS) such as Burdekin-Haughton. But while not under direct stress by consumption, catchments such as the Nogoa-McKenzie and Dawson Valley have been experiencing reductions in the reliability of existing entitlements. In these catchments moratoriums have been put on developments of water harvesting infrastructure.

In Western Australia, most rivers are intermittent, with winter flows in the south, summer flows in the north and ephemeral flows in the north-west and interior. Permanent stream flows are relatively rare (Water and Rivers Commission 2000). Overall, state-wide commitment of surface water to development is only 16 per cent of sustainable yield.

A feature of surface water resources in the south-west in the prolonged period of below average rainfall and absence of high rainfall events. This is illustrated by data for annual inflows into major metropolitan reservoirs. This shows that between 1911 and 1975 there were some 27 years with inflows well above average. But since 1975 in no years have inflows exceeded the long-term average and for most years inflows have been well below the average (Water and Rivers Commission 2000). This has put pressure on surface water resources, with Perth having had permanent water restrictions for the past 10 years. Research is continuing to clarify whether the phenomenon of below average rainfall will continue in the future.

In 1996-97, Western Australia had only 30 000 hectares under irrigation or just over 1 per cent of the total area under irrigation in Australia. This increased to 46 000 hectares in 2000-01. However, projections using the Monash economic model indicate a statewide water demand of the order of 3600 GL a year by 2020, compared with water consumption of around 1800 GL a year in 2000 (Water and Rivers Commission 2000).

Surface water irrigation in South Australia outside the MDB is relatively insignificant.

In Victoria, several south flowing rivers are under stress with less than 70 per cent of natural flows. Victoria is considering major changes to water management in the state with the aim of returning all stressed rivers to sustainability and preventing overallocation on other rivers. For over-allocated rivers an environmental reserve will be established recognising the rights of existing entitlement holders. The proposal is to cap seven southern river basins at current extraction levels. These are the basins of Werribee, Moorabool, Barwon, Snowy, Thomson/Macalister, Latrobe and Yarra Rivers. Catchment Management Authorities will take on the role of 'environmental manager' and an 'adaptive management' approach will be adopted to bring extraction rates back into line with sustainability. This may include the government purchasing water for the environment (Victorian Department of Sustainability and Environment 2003).

Similarly some river systems flowing east in New South Wales are under stress but water management plans are being developed for all river basins in the state. In some cases government buy back of entitlement in over-stressed rivers may be necessary.

Groundwater

In aggregate Australia's groundwater resources are relatively under-utilized. Sustainable yields from groundwater resources are estimated at 25 780 GL a year of water suitable for potable, stock and domestic use and irrigated agriculture. But only 10 per cent of this (2489 GL) is used (NLWRA 2001).

These aggregate estimates, however, hide the fact that many groundwater aquifers are under stress. Even the Great Artesian Basin, which covers 1.7 billion hectares, stores 8 700 000 GL and supplies 570 GL a year for grazing and mining is under stress through declining artesian bore pressures. This resource is not suitable for large scale irrigation and is not considered further in this report.

Table 2.12 summarises the groundwater systems under stress across Australia. Overall, extraction rates have increased by 58 per cent since 1983-84 to around 4200GL per year in 1996-97, with increases being 200 per cent in New South Wales, Victoria and Western Australia (NLWRA 2001).

Western Australia is in the fortunate position of, currently, having utilisation of all groundwater units well under sustainable yields (Water and Rivers Commission 2000). Average utilisation for sedimentary and fractured rock aquifers are 25 per cent and 11 per cent respectively of sustainable yields. Much attention is being given to environmental water allocations, these being sourced not only directly from water resources — surface and groundwater — but also through land planning reservations.

Groundwater in Queensland is generally under stress with use being some 600 GL greater than allocations for 1996-97. Since then the situation in many catchments has deteriorated. In total, groundwater accounts for around one third of consumptive use in Queensland. The systems under stress include:

- Burdekin Delta
- Condamine Valley

2.12 **Groundwater systems under stress**

System	*Annual use*	*Natural*	*Annual recharge*
	GL		GL
New South Wales			
Namoi Valley	160	110	0
Queensland			
Burdekin Delta	263	200	53
Bundaberg	100	na	0
Condamine Valley	87	13	0
Lockyer Valley	47	25	1
Callide Valley	36	39	8
Pioneer Valley	21	35	3
South Australia			
Angus-Bremer	25	na	0
Padthaway	24	na	0
North Adelaide Plains	20	7	0
Victoria			
Western Port	10	na	0
Western Australia			
Millstream	9	13	0
Mt Newman	10	3	7

Source: Adapted from Australians and the Environment (Cat. No. 4601.0, p.175).

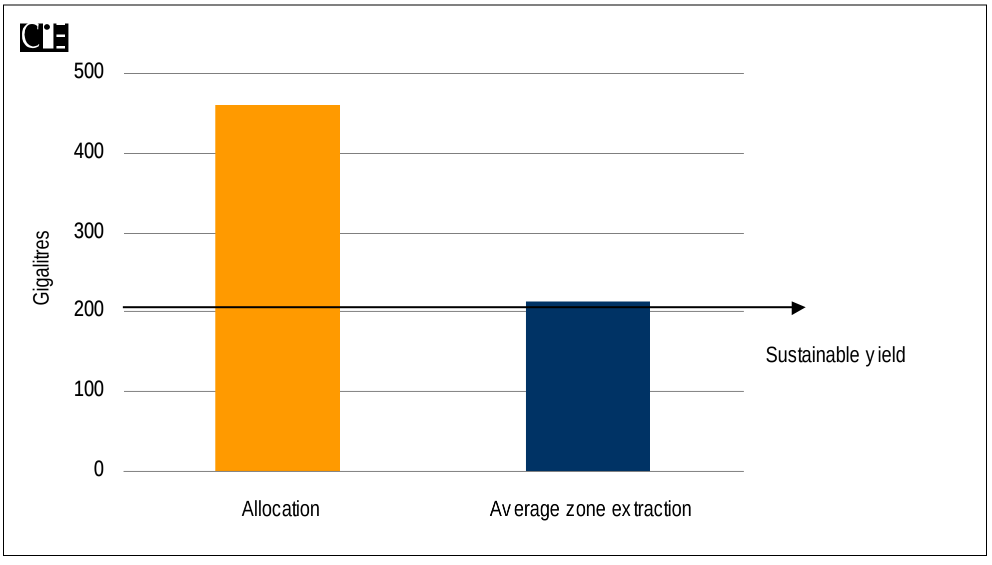
- Lockyer Valley
- Callide Vally
- Bundaburg.

A good example is the Callide Valley in the Fitzroy Basin. Announced allocations exceed availability of groundwater in the Benefited Area (an irrigator area utilising groundwater which benefits from actively recharging the acquifer). Actual use is only 60 per cent of announced allocations because the reliability of the resource to most users is very low.

Because of overallocation of water licenses in some groundwater systems, there is significant potential for use to significantly exceed recharge rates in the future unless corrective actions are taken. A particular example is the Namoi groundwater system in central-northern New South Wales. In this region, the vast majority of irrigation for agricultural purposes is used in cotton production (78 per cent), with the remainder used in cereal crop production. There is significant pressure on existing groundwater resources in the Namoi valley. The Upper Namoi Valley is one of the most stressed aquifers in New South Wales (Nancarrow, McCreddin and Syme 1998). Namoi groundwater is allocated above the sustainable yield level by 252 GL (chart 2.13).

As at 1998, a large proportion of licenses were unused (sleepers) or only partially used (dozers) (Department of Land and Water Conservation (DLWC) 2002). Average use of these groundwater resources also slightly exceeds sustainable yield (chart 2.13). If some of the unused or partially

2.13 **Allocation and use in the Namoi groundwater system**



Data source: Department of Land and Water Conservation (2002) and Wolfenden and Van der lee (2002).

unused licenses were used, there would be even greater pressure on existing resources.

To address the current stress on water resources in the Namoi region, Water Sharing Plans have been developed for each of its water sources.

Under these proposed Plans water management of Namoi groundwater resources will include the following three components.

- Future groundwater extractions in each zone will be managed within the sustainable yield of the zone.
- Shares in each zone's sustainable yield will be distributed in proportion to existing licence entitlements.
- A range of measures will be introduced for high water users whose allowable history of use exceeds their share of sustainable yield, including groundwater trading, more flexible water accounting, and a Groundwater Structural Adjustment Program (DLWC 2002).

Under the proposed plan, the new entitlements are to be implemented immediately with some exceptions. Zones one and five of the Upper Namoi will have entitlements equal to 125 per cent of their sustainable yields. Historically high water users will be issued with a supplementary water licence which will be phased out over 10 years. This will be different for each irrigator and initially will be equal to the difference between existing use and the new entitlements. By the end of the 10 year plan, it is intended that groundwater sources will be managed to ensure they are used within their natural recharge limits.

The Water Sharing Plan was due to be implemented in July 2003 but has been deferred until July 2004. As part of this deferral there are likely to be some changes to the phasing in of the re-allocation of entitlements.

The net impact of these changes will be some reduction in irrigation activity even though in aggregate current extraction is only marginally above sustainable yield. For example, one review found that the proposed re-allocation could lead to a contraction in production of all irrigated crops, apart from some specialty crops (CARE 2003b). Cereal production is anticipated to contract by significantly more than irrigated cotton, and irrigated maize and lucerne production are also expected to fall.

In South Australia, the most important groundwater resources for irrigation are in the South East. Irrigators required a licence but metering of extraction rates have not yet been introduced although this is likely to occur in 2006.

A particular issue in this region is the rapid growth at private forestry in areas where normally recharge rates average around 200mm a year. Under forestry, recharge rates are very low. Such forestry developments based largely on Tasmania blue gum have the potential to significantly impact on groundwater resources, which up to now have been largely in equilibrium. If nothing is done to curb the rate of growth of forestry, water managers will have an obligation, under the *Water Resources Act 1997*, to adjust downwards permissible water extraction rates to ensure the sustainability of the declining resource (Department of Sustainability and Water Resources 2001). Several options are currently being considered.

3 Modelling approach

THIS CHAPTER OUTLINES our approach to analysing the contribution of irrigation to the national economy and the national impacts of rural water reforms. An economywide 'general equilibrium' model is used. This modelling framework allows the net economic value of irrigated agriculture to be quantified — in terms of this sector's *direct contribution* to Australian gross domestic product (GDP) and employment. The framework also captures the economic linkages between the irrigation sector and other sectors of the economy. This enables estimates to be made of irrigation's *indirect contributions* to the economy. This is a major strength of the model because the so-called indirect effects are often left out of traditional analyses. For example, the direct economic impact of increased environmental flows are often expressed in terms of lost income and employment in the irrigation sector. But this fails to account for impacts to related industries servicing the irrigation sector and the social decline of regional areas that are largely dependent on irrigated agriculture.

The economywide model developed in this study is used to build a 'snapshot' picture of the economic and employment contributions made by the irrigation sector. This snapshot is based on 1996-97 diversions, production levels and commodity prices. The reasons for choosing this year are outlined below. The model is then used to assess the economic impact of various water reform scenarios such as the emergence of water trading, higher water charges, reductions in water availability and improvements in WUE. Our approach is to examine the impact of changes that have been made to date since 1996 and also conduct a forward-looking analysis that estimates the potential impacts of future reforms.

We start out in this chapter by defining the economic measures used in this study and then focus on the model structure and the methodology used for assessing the impact of water reforms.

What is meant by value added?

Several measures are used by the Australian Bureau of Statistics (ABS) and other organisations to indicate the relative size of industry in value terms. Measures include gross value of production (GVP), net value of farm production, farm income, profit at full equity and value added.

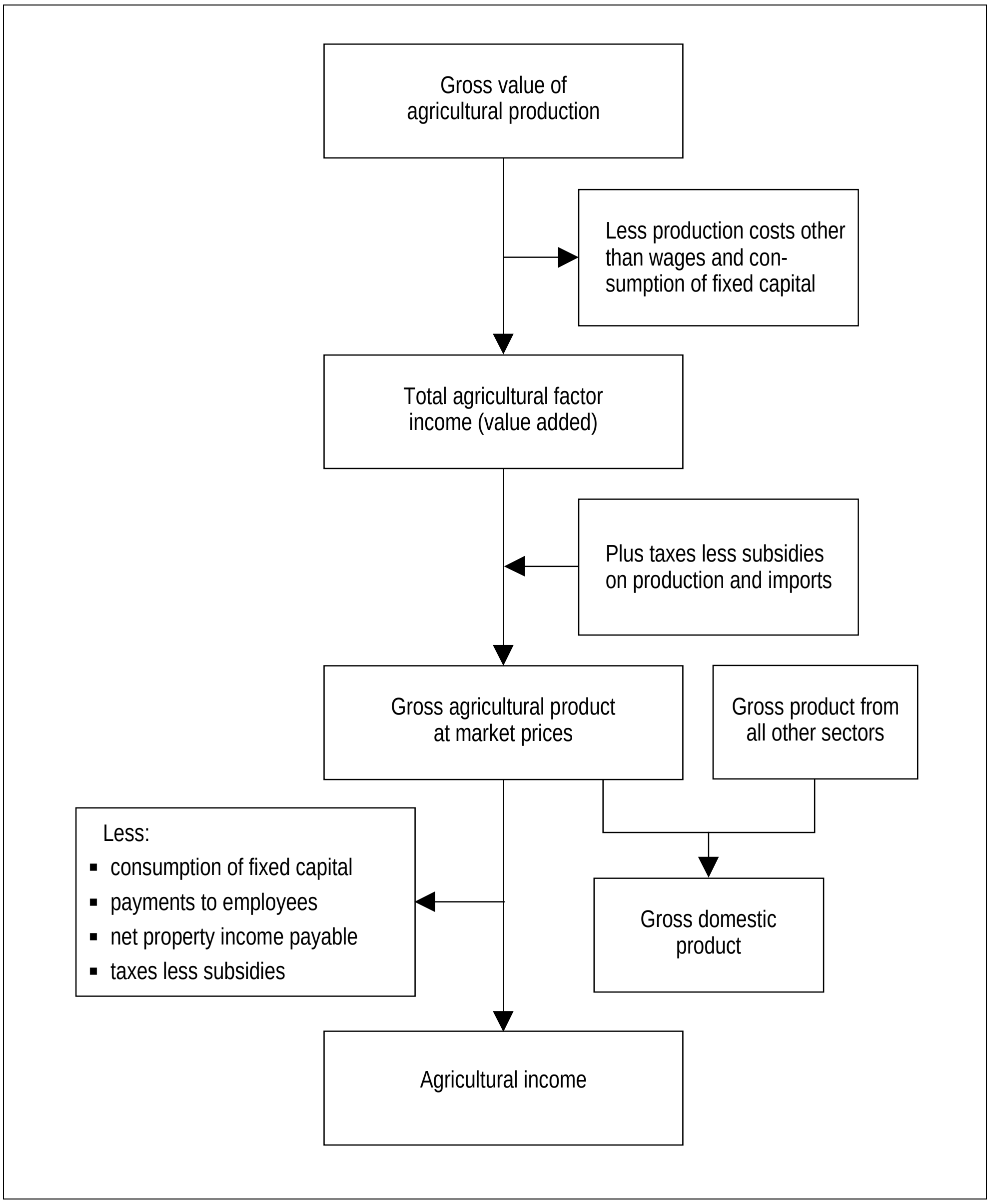
For the purpose of measuring the contribution of an industry or sector to the economy, the most appropriate measure is *value added*. This is measured by taking the value of goods and services produced by an industry — that is, GVP — and deducting the cost of goods and services used up by the industry in the production process, excluding the cost of land, labour and capital. Thus, value added represents the net economic returns to these inputs. The sum of value added for all industries in the economy after adding taxes and taking off subsidies is then equal to Australia's GDP, which is the most common measure of the country's economic output and performance. Chart 3.1 shows the linkages between gross value of production, value added and GDP.

The ABS does not publish value added information for the irrigation sector. All that is available are estimates of areas of crops and pastures irrigated, GVP, and water use by broad agricultural irrigation industries. To estimate value added for irrigation, it was necessary to revert back to basic industry information and build up estimates of dryland and irrigated agriculture for each agricultural industry using a variety of industry sources. Estimates were tied into the ABS data available (including GVP data and value added for agriculture as a whole) but in some cases estimates were built up from regional industry data.

Direct and indirect effects

Simply put, the direct contribution of irrigated agriculture is the value added directly generated by irrigated production. The indirect contribution of irrigated agriculture is observed by the flow-on effects of this economic activity to the rest of economy. By use of a comprehensive model of the Australian economy, all the direct and indirect effects can be taken into account. This is because the model is based on a comprehensive input–output table incorporating all the main sectors of the economy. In this case, the detail of the irrigation/water sector has been substantially expanded. Like all other industries, irrigated agriculture has both forward and backward linkages to the rest of the Australian economy and overseas.

3.1 **Relationship between gross value of production, value added and GDP**



Primary irrigation activity connects with the rest of the economy in three basic ways. The irrigation sector:

- purchases goods and services from other industries, which expand to cater for the demand for input goods and services by irrigators;
- the income earned by irrigators is spent on consumption goods, which stimulates activity in a wide range of other sectors; and
- the primary products from irrigation are transported, processed, marketed or exported, thus stimulating economic activity in all these areas.

The forward linkages include sales to other industries, including those directly above in the value chain such as food processing, and to households and exports. In the case of backward linkages, irrigated agriculture purchases inputs from a range of Australian industries and from overseas. These industries and activities in turn contribute value added to the Australian economy. In each case, there are further flow-on or multiplier effects that permeate even more widely throughout the economy.

The model

The model used in this study is a modified version of CIE's economywide model, which is a static general equilibrium model of the Australian economy. The model includes production from both surface and ground water diversions. The model uses production, area and water use data collated by CapitalAg (2002) which was originally sourced from ABS land use statistics. Details of the model and in particular the 'water' modifications are presented in appendix A. Below is a brief summary of the main model components.

The base year

The base year for 'calibrating' the model and evaluating the impacts of various change scenarios was selected as 1996-97. There are a number of reasons why this year was selected as the baseline.

- 1996-97 can be considered to be a 'normal' irrigation year in terms of climatic conditions and world prices — especially for the sugar industry. Therefore, for this year the contribution of irrigated agriculture to the Australian economy could be considered to be reasonably representative of its contribution over the medium term.
- 1996-97 marks the beginning of the reform process and the first year in which the MDB Cap was formalised.
- At the time of analysis, 1996-97 was the latest available year for the ABS Water Account publication, which provides a comprehensive and consistent picture of water use throughout Australia. The 2000-01 Water Account was published in May 2004.
- In 2001 the National Land & Water Resources Audit collated and published extensive information on irrigated areas, diversions and production for 1996-97. Our model uses these statistics.

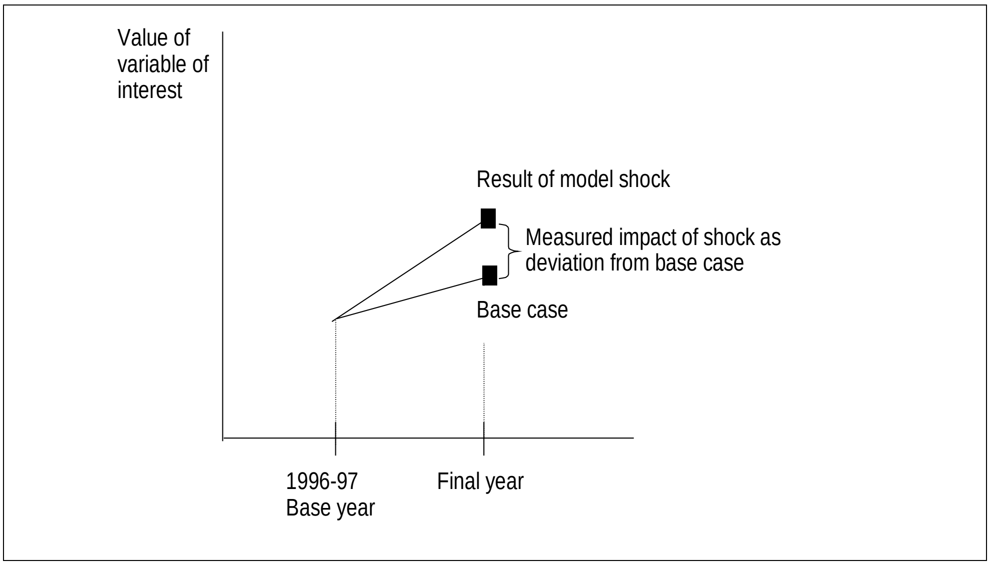
- 1996-97 is also the latest available year for the ABS input–output tables — the CIE economywide model uses these tables as a base for describing the economic linkages in the Australian economy.

Comparative–statics approach

The model is a one period comparative–static model. This means that the impact of a 'shock' to the model, such as increased water charges, is measured by comparing model solutions with and without the shock at a single point in time. Thus, the impact of the policy change is measured by the difference between the two model solutions. The model does not examine the dynamics of moving from one point to the next. However, from our experience the additional insights from building a fully dynamic model are marginal because results become highly dependent on the assumptions regarding key dynamic variables such as seasonal influence — about which little is known.

It should be noted that in the vase case, average trend rates of increase in key variables such as TFP. Shocks to the model are then measured as deviations from the base case as illustrated in chart 3.2.

3.2 **The model estimates impacts of policy changes as deviations from a base case**



Regional coverage

The regions that form the spatial dimension of the model have largely been identified by observed patterns of trades. For the purposes of the model, irrigation districts are grouped into three broad 'regions':

- MDB northern/central connected valleys
- MDB southern connected valleys
- rest of Australia.

Table 3.3 summarises the individual valleys within each of the MDB groupings and the irrigation areas and diversions associated with each. Trading is assumed to be possible *between* valleys *within* the southern connected system (SCS) but not between valleys in the northern and central system. Irrigation districts outside the MDB are included in the model in aggregate form and are grouped into a 'Rest of Australia' category. The model does not attempt to capture inter-valley trading within this 'mega-region'. The model has an MDB focus because this system accounts for about 72 per cent of irrigation diversions and 70 per cent of Australia's irrigated area.

3.3 **Regional structure, irrigated area and diversions: 1996-97**

Regions	*States*	*Area under irrigation*	*Diversions*
		'000 ha	GL
MDB Northern and Central connected valleys			
▪ For example, Barwon-Darling, Lachlan, Gwydir, Namoi, Peel, Macquarie, Border Rivers	NSW, Qld	711	4 784
MDB southern connected valleys			
▪ Murrumbidgee Valley	NSW	418	2 253
▪ Murray River NSW (including lower Darling)	NSW	259	1 631
▪ Goulburn–Broken–Loddon	VIC	321	1 143
▪ Murray River Victoria (including Synraysia)	VIC	61	267
▪ Murray River SA (Riverland and Lower Swamps)	SA	44	284
Total MDB		**1 814**	**10 362**
Rest of Australia		**775**	**3 930**
Total Australia		**2 589**	**14 293**

Source: Data derived from National Land & Water Resources Audit (2001).

Commodity types

The commodities included in the model are listed in table 3.4. Some commodities are grown under both irrigation and dryland production systems, as indicated. The model differentiates between irrigated and dryland production and explicitly takes account of the interaction effects between these activities.

3.4 **Agricultural activities identified in the national model**

Commodities	*Irrigated*	*Dryland*
Wool		✓
Sheep and lambs	✓	✓
Wheat	✓	✓
Barley	✓	✓
Rice	✓	
Other grains	✓	✓
Beef cattle	✓	✓
Dairy cattle	✓	✓
Pigs		✓
Poultry		✓
Vegetables	✓	
Wine grapes	✓	
Multipurpose grapes	✓	
Pome and stone fruit	✓	
Citrus	✓	
Other tropical and orchard fruit	✓	
Sugar	✓	✓
Cotton	✓	✓
Crops for fodder	✓	✓
Other agriculture		✓

Source: CIE.

The analysis focuses on rural irrigation and does not include the nursery or garden market sector which, at retail, is valued at over $5 billion dollars (Nursery and Garden Industry Australia 2003). Nearly 60 per cent of the garden market sector is accounted for by retail sales and overall this sector mostly depends on town water supplies. Furthermore, water costs constitute a small proportion of total costs or gross sales.

Incorporation of trading into the model

Water trading can occur at two levels in the model:

- within-region trading, which occurs by default in the model and cannot be switched off. In effect, it corresponds to changes in enterprises; and
- inter-region trading, which is an optional feature of the model and can be switched on or off.

Within-region trading allows water to move between different enterprises according to the marginal value of water in each activity. Observed market prices for permanent water are used as an indicator of these marginal values. In a perfectly functioning market the marginal value of water should be equal across all activities. But in the real world, even in the presence of trading, this tends not to be the case. For instance, the value of an additional megalitre to rice growers tends to be different to an additional megalitre to horticulturalists. This is because different enterprises have different levels of risk, fixed costs, management requirements and different market sizes for commodities produced. It explains why horticulture cannot effectively compete for all the water used by so-called 'lower value' crops and pastures. Thus, the model, through its trading function, does not attempt to equalise marginal benefits across enterprises.

Instead, we have assigned observed market prices to those enterprises with high gross margins for water, such as horticulture, and scaled down the marginal values (prices) for lower value crops in proportion to their gross margins.

Water trading *between regions* can be switched on or off. When trading is permitted, trade is assumed to equalise the marginal value of water across all regions involved in trading. That is, water is allowed to move from regions with low marginal values — as determined by the average of the marginal values generated by each enterprise in a given region — to regions with high marginal values until equivalence is achieved. This is known as the market-clearing price for water. The model only permits trade to occur between regions (or valleys) in the SCS.

When trading is switched on, water is allowed to move freely from one region to the next within the southern connected MDB system. This implicitly changes the 'opportunity cost' of holding water entitlement. The term 'opportunity cost' is used to refer to the foregone benefits from using water in one activity, which precludes it from use in another economic activity. If water cannot be traded, its opportunity cost is bounded by the range of activities that can be undertaken in a given region, which may be limited by soil suitability and distance to markets. However, once trading is permitted, a new set of opportunity costs arise — reflecting the potentially wider range of alternative uses for water in different regions.

Allocation reliability

The model is not stochastic and therefore works on the basis of average annual diversions of water rather than water allocations that vary from year to year. The initial diversions in the base model (before any reform shocks are imposed) are set to match those recorded for each industry and region in the 1996-97 year.

Water sources

The model identifies a bulk water industry supplying irrigated agriculture. This industry supplies water from each of the following sources:

- regulated surface water (river pumping and channels)
- regulated groundwater
- off-allocation water.

Total diversions are drawn from each of these water sources. The delivery cost of water is the retail price charged to end-users, with adjustments made for off-allocation water. Water charges are differentiated between regions and weighted according to the proportion of high security and general security allocation in each region — to take account of differing charges associated with these water ‘products’.

‘Accounting’ and ‘economic’ contributions

In assessing the contributions of irrigation to the economy, it is useful to consider two concepts — the accounting definition of contributions and the economic definition.

The ‘accounting’ approach

One way of measuring the contribution of irrigation to the national economy is to take the direct and indirect *value added* from irrigation and express this measure as a proportion of Australia’s GDP. This approach indicates irrigation’s contribution to or share of the total GDP ‘pie’ and is consistent with an accounting approach.

In concept, this approach defines the total contribution of irrigation to the economy as:

$$\text{Total `accounting' contribution of irrigation to the economy (\%)} = \frac{\text{Direct value added by all irrigation industries} + \left[\text{Value added by industries processing product from irrigation} + \text{All other indirect effects}\right]}{\text{GDP}} \times 100$$

The direct contribution is the sum of value added from all irrigation industries. The indirect effects include the sum of value added from processing irrigation products plus the value added from industries supplying inputs and services to irrigation, those industries that support the processing of products from irrigation, and the flow-on effects of incomes generated by irrigators and associated upstream and downstream activities.

The 'economic' approach

There are shortcomings with the accounting approach because it implicitly assumes that land and other resources used in irrigation have zero opportunity cost. That is, if there were suddenly (in concept) no irrigation in Australia, all the land and resources currently used in irrigation would be idle and have no value. Therefore, the accounting approach will over-estimate the true contribution of irrigation to the economy.

A second, and more meaningful, concept and approach — here referred to as the 'economic' approach — takes into account the opportunity cost of resources used in irrigation, particularly land. In summary, the total 'economic' contribution of irrigation is given by:

$$\text{Total 'economic' contribution of irrigation to the economy (\%)} = \frac{\overbrace{\left\{ \text{Direct value added by all irrigation industries} - \text{Value added from next best alternative 'dryland' enterprises} \right\}}^{\textit{Direct economic contribution}} + \overbrace{\left\{ \text{Value added by industries processing net change in output} + \text{All other net indirect effects} \right\}}^{\textit{Indirect economic contribution}}}{\text{GDP}} \times 100$$

This measure addresses the question, 'What additional value has irrigation given to the economy?' To address this, assumptions need to be made of the next best alternative enterprises to irrigation. In concept, the questions are: 'What would the land now under irrigation be used for if irrigation had never developed?' and 'What contribution would these dryland enterprises make to the economy?' The contribution that these conceptual 'dryland' enterprises in place of irrigation would make to the economy need to be netted out to give a more accurate indication of the true contribution of irrigation to the economy.

In this study the estimation of economic contributions involved an examination of each irrigation industry in each region and asking the question 'What dryland enterprise would be in place in the absence of irrigation on this land — that is, if irrigation had never developed here?' More details and the underlying assumptions are presented in appendix B.

Analysing the effects of water reforms

To assess the impact of water reforms the economywide model is 'shocked' with changes in key parameters associated with each reform scenario. The model then establishes a new equilibrium and the change in value added and employment etc. is calculated relative to the 1996-97 base year or the base case scenario (again, see chart 3.1) The three reference points that were examined are:

- 1996-97 — the base case, which is modelled using the policies, water charges, commodity prices and seasonal conditions that existed in this year;
- 2003-04 — which examines the impact of water reforms since 1996-97 while holding all other conditions constant at the base level; and
- 2009-10 — this reference point comprises a set of modelling runs, which estimate the impacts of various future reform scenarios. All impacts are measured relative to 1996-97.

This modelling approach provides a systematic way of separately quantifying and separating out the direct and indirect impacts of different reforms.

The water reform agenda that has been pursued since 1995 essentially consists of four main elements that exert influence on the behaviour of the water economy. These elements can be regarded as exogenous 'shocks' to the system. The shocks are not mutually exclusive because changing one factor may induce changes to other factors.

Enhanced trading

Over the last five years there has been increased trading activity in all states, although most of the activity has been confined to temporary trades within regions. While some institutional impediments to trading have been removed, various restrictions still apply. See chapter 2 for a review.

While most of the trading activity to date has occurred within regions, the model is not sufficiently detailed to allow an estimation of the benefits of increased *intra region* trade.

The model can, however, examine the value of enhanced trading *between regions* in the southern MDB as trading can be switched on or off in the model. We use this feature of the model to estimate the value of increased inter region trade in conjunction with the potential impact of future reductions in irrigation diversions. That is, we estimate the cost of reducing water allocations to irrigators with and without trading. The benefits of enhanced inter region trade since 1996-97 are not estimated separately because to date there has been minimal trading between regions (relative to total diversions).

Water charges

Higher water charges represent an increase in irrigators' cost of production. Charges are incorporated into the model on a region-by-region basis and weighted according to the amount of water deliveries to a particular region. Account is taken of the different charges that pertain to different reliability products (for example, high security and general security water).

For the period 1996-97 to the present, water charges have, on average, approximately doubled in real terms. In most states full cost recovery at the lower bound is being achieved. The impact of this change is estimated using the model.

Water use efficiency

The technical *WUE* for each commodity type is another model parameter that can be varied. For the base year we start with typical water application rates per unit of output. Post 1996-97 it is expected that enhanced trading opportunities, increased water scarcity (due to imposition of the Cap), higher water charges, R&D and targeted extension programs should have led to improvements in WUE. As there is only limited information available about the productivity improvements in each irrigation industry — and the extent to which these are due to water reforms. We take the approach of running a sensitivity analysis for various levels of WUE improvements. Three points are used for the analysis: 1, 1.5 and 2 per cent per annum increases in WUE. These are measured over and above assumed trend rates of TFP incorporated in the base case.

It is then possible to evaluate what improvement in WUE would be required to offset the economic losses due to potential reductions in water availability (from environmental flows) or increases in water charges.

Restrictions on diversions

As outlined in chapter 2, the MDB Cap and related state-based reforms have reduced the nominal allocations to irrigators by up to 15 per cent — or 1600 GL. That is, without the Cap the irrigation sector would have been able to fully develop their existing entitlements. So the Cap has resulted in a lost 'option value' for irrigators — although this is offset by improved system reliability under the Cap and possibly better water quality outcomes for irrigators (for example lower salinity).

Conceptually, the cost of lost option value would be estimated by 'adding' 1 600 GL to water diversions in the model and examining the consequent increase in value added. But this assessment is not straightforward because assumptions would need to be made about the amount of additional land that would be converted to irrigation and the costs associated with development. Instead, we take a simpler approach by reducing current diversions by 1600 GL. This is likely to produce an upper-bound estimate of lost option value, particularly if the marginal cost of a reduction in water use is greater than the marginal value of an increase.

The Cap is a first step towards restricting water use. Further reductions in diversions are being considered. To date the National Water Initiative has resulted in an agreement to increase environmental flows in the Murray River by 500 GL, which equates to 10 per cent of irrigation diversions in the southern MDB. Rather than limit the analysis to a single cut in diversions, our approach is to estimate a cost-curve for reductions of 5, 10, 15 and 20 per cent. This water is sourced either exclusively from the southern connected MDB system, the whole of the MDB or from all regions of Australia.

The cost to government and the economy in general will depend on how the environmental water is recovered. Two main options are examined:

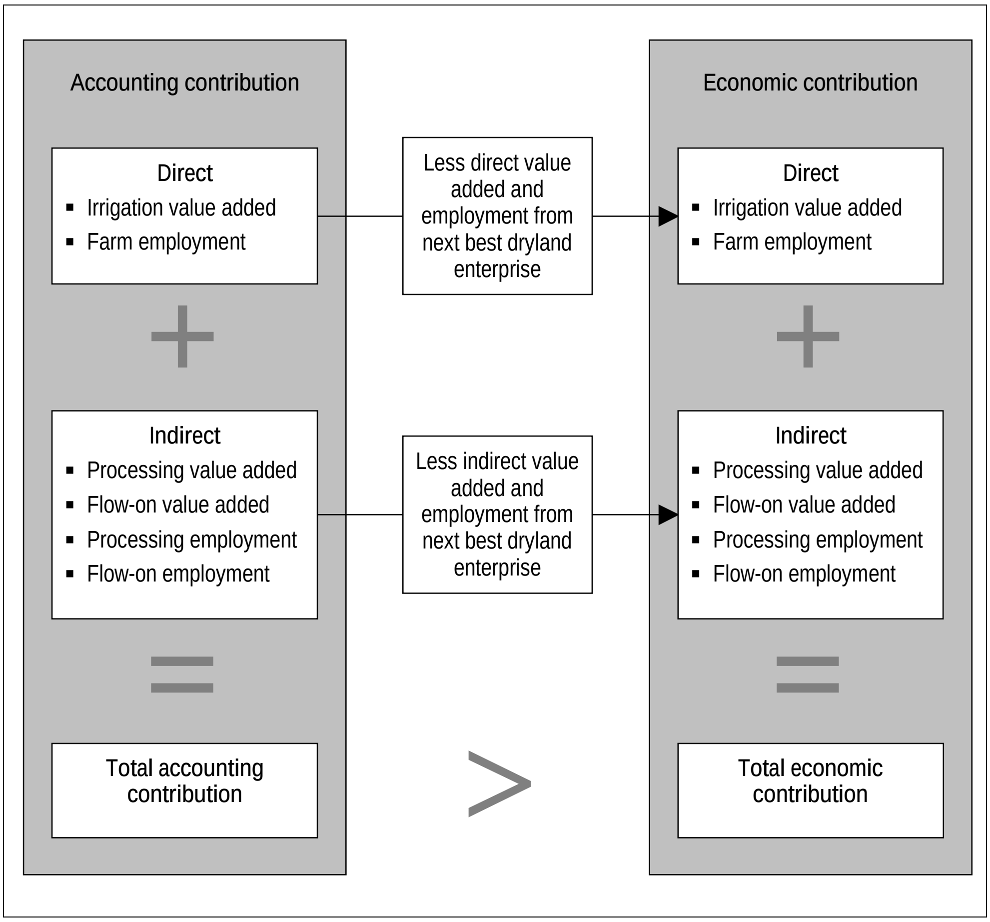
- an administrative across-the-board reduction in water entitlements with no compensation and no opportunity for inter-region trade; and
- a market-based approach whereby government purchases entitlements (or water savings) by tender or on the open market.

Administrative, pro rata reductions are expected to be considerably more costly in terms of direct income losses and flow-on impacts than market-based purchases because it imposes a uniform reduction on all irrigation industries/regions regardless of the marginal value of water as an input into production. The market-based approach is expected to be a lower-cost method because water is sourced from those regions and industries where the marginal cost of giving up water is the lowest. Under the market based approach, the direct cost of water purchases will be met by government but there will be second-round effects on regional employment and income due to less water being available in the system for consumption.

4 Contribution of irrigation to the Australian economy

RESULTS FROM THE ECONOMYWIDE MODEL demonstrate that the irrigation sector makes a substantial contribution to the incomes and standards of living of Australians. This chapter reports the main results and maps out the direct and indirect contributions of irrigation in terms of gross value of production, value added and employment.

4.1 **Accounting and economic contributions**



Data source: CIE.

Recall from chapter 3 that we have used two different measures to examine irrigation's contribution to the economy — the accounting approach and the economic approach. The relationship between these two measures is illustrated in chart 4.1. The economic approach is preferred.

Direct contributions

GVP and value added — accounting approach

Irrigated agriculture is estimated to contribute around one-third (33 per cent) to the total *gross value* of agricultural production and a similar proportion to the total *value added* for agriculture. The direct value added contribution of irrigation to the economy is $5.0 billion or about 1 per cent of GDP. The total direct value added from all agriculture is $15.1 billion — approximately 3 per cent of GDP.

Some complications emerge when dissecting out the value contribution of each irrigation industry (table 4.2). For example, irrigated rice and cotton production systems frequently use winter cereals as a rotational break-crop, utilising stored soil moisture from the preceding rice or cotton crop. The value added from these irrigated break crops is estimated by the model and reported separately (under the heading 'other grains'). Thus, estimates of the economic contribution of the irrigated rice and cotton industries may be slightly understated. But the magnitude of this underestimation should be very small in comparison with the total contribution of rice and cotton.

The estimates presented in table 4.2 are for the base year of the model, 1996-97. Since then, the total gross value of agricultural production has increased by 8.3 per cent, to $39.7 billion in 2001-02 and $31 billion in 2002-03 (a drought year), primarily because of an improvement in the value of output for livestock industries, particularly beef cattle. Relatively few beef cattle are raised or finished on irrigated pastures. Thus, the contribution of irrigated agriculture to total value of agricultural output has fallen slightly to an estimated 32 per cent for 2001-02 (table 4.3). This is consistent with the Cap having been placed on water extractions from the MDB and the recent dry seasonal conditions limiting water availability.

4.2 Accounting contribution of irrigated agriculture to value of agricultural output: 1996-97

Industry	*Gross value of production*				*Value added*			
	Irrigated	*Dryland*	*Total*	*Irrigated as proportion of total*	*Irrigated*	*Dryland*	*Total*	*Irrigated as proportion of total*
	$m	$m	$m	%	$m	$m	$m	%
Wool	0	2 294	2 294	0	0	1 237	1 237	0
Sheep and lambs	140	1 150	1 290	11	72	626	698	10
Wheat	178	4 184	4 362	4	102	2 422	2 524	4
Barley	31	1 040	1 071	3	19	669	688	3
Rice	257	0	257	100	164	0	164	100
Other grains	184	1 127	1 311	14	101	646	747	14
Beef cattle	18	3 058	3 076	1	9	1 616	1 625	1
Dairy cattle	1 904	1 136	3 040	63	761	458	1 218	62
Pigs	0	585	585	0	0	262	262	0
Poultry	0	1 379	1 379	0	0	620	620	0
Vegetables	1 772	0	1 772	100	1 066	0	1 065	100
Wine grapes	528	0	528	100	317	0	317	100
Multipurpose grapes	199	0	199	100	115	0	115	100
Pome and stone fruit	849	0	849	100	511	0	511	100
Citrus	442	0	442	100	264	0	264	100
Other tropical and orchard fruit	661	0	661	100	398	0	398	100
Sugar	528	646	1 174	45	311	389	700	44
Cotton	1 206	77	1 283	94	717	46	763	94
Crops for fodder	193	413	606	32	109	249	358	30
Other agriculture	0	1 548	1 548	0	0	793	793	0
All agriculture	**9 090**	**18 637**	**27 727**	**33**	**5 036**	**10 033**	**15 069**	**33**

Source: CIE irrigation model.

Estimates for 2001-02 of the contribution of irrigated agriculture and total agriculture to the Australian economy, presented in table 4.3, are based on the proportions of irrigated to total value of output for each industry from 1996-97, except where more recent information on each was available. The estimates for 2001-02 (the year 2002-03 was a drought year) should therefore be used with caution. The estimates show that the contribution of agriculture to the Australian economy has increased slightly (based on published ABS data) and that the contribution of irrigated agriculture has also risen slightly over this period. The estimates presented here are consistent with earlier estimates by Thomas et al. (1999), which estimated that ‘irrigated production accounts for some 30 per cent of total rural value added’.

A noteworthy feature of the irrigation sector is that irrigation utilises only 0.5 per cent of the land used for agricultural production or 6.5 per cent of land under crops and improved pasture, but contributes a third of the total value of agricultural output (table 4.4).

4.3 **Direct 'accounting' contribution to GDP**

	Unit	*1996-97*	*2001-02*
Value added			
Irrigation	$m	5 036	7 769
Total agriculture	$m	15 069	24 278
GDP (sum of all sector value added)	$m	529 858	712 980
Irrigation to total agriculture	%	33	32
Contribution to GDP			
Irrigation	%	0.9	1.1
Total agriculture	%	2.8	3.4

Source: CIE irrigation model.

4.4 **Irrigation 'accounting' contributions relative to all agriculture: 1996-97**

	Land use	*GVP*	*Value added*
	Million ha	$m	$m
Irrigated agriculture	2.6	9 091	5 036
Dryland agriculture[a]	37.3	18 637	10 033
Total agriculture	39.9	27 728	15 069
Proportion of irrigated to total (%)	6.5	32.8	33.0

[a] Cropping and improved pasture areas.

Source: CIE irrigation model.

GVP and value added — economic approach

Overall, the direct value added contribution of irrigation to the economy using the 'economic' approach is estimated at $3.45 billion or 0.65 per cent of GDP. By comparison, the accounting approach produces an estimate of $5.0 billion or 0.95 per cent of GDP.

Recall that the economic approach involves removing irrigation activities from the model and replacing them with the next best dryland alternative. In many cases, the next best alternative is the same activity, but, under dryland conditions, with much less yield. This explains why the value added and GVP estimates generated using the economic approach are mostly lower than those calculated using the accounting approach.

For some industries, the next best alternative is some other agricultural industry. The value added of these other alternative dryland enterprises is shown as a separate line item in table 4.5 — the opportunity cost of land — and is netted out in the final 'economic' contribution estimates. For example, in the rice industry, irrigation accounts for 100 per cent of production and, in the absence of irrigation, no rice could be grown. In this case, the assumption is made that, in place of rice, other dryland cereals

4.5 **Comparison of 'accounting' and 'economic' direct contributions**

	Direct accounting contribution		*Direct economic contribution*	
Industry	***Value added***	***GVP***	***Value added***	***GVP***
	$m	$m	$m	$m
Rice	144	257	144	255
Other grains	223	393	160	281
Dairying	761	1 904	528	1 018
Other pasture (lambs and cattle)	81	158	75	157
Vegetables	1 066	1 772	751	1 318
Wine grapes	317	528	242	398
Other grapes	115	199	113	190
Pome and stone	511	849	239	415
Citrus	264	442	234	395
Other tropical and orchard fruit	398	661	104	183
Sugar cane	311	528	158	236
Cotton	717	1 206	726	1 264
Crops for fodder	109	193	71	135
Total	**5 036**	**9 091**	**3 546**	**6 245**
Less opportunity cost of land[a]	–	—	100	223
Total irrigation	**5 036**	**9 091**	**3 446**	**6 022**
Per cent contribution to GDP (%)	0.95		0.65	

[a] In alternative enterprises.

Source: CIE irrigation model.

would be grown on two-thirds of the current rice area and dryland grazing would occur on the other third. The value added from these dryland enterprises is included in the separate line item 'less opportunity cost of land' and is netted out. The assumptions made for dryland enterprises replacing irrigated land use are presented in appendix B.

In the case of cotton the 'economic' contribution is greater than the 'accounting' contribution. The reason for this is that, in the absence of irrigated cotton, it is highly likely that a dryland cotton industry would not be viable because ginning establishments would not have sufficient throughput based on dryland cotton alone, where production is highly variable. This is supported by a long history of failed attempts to establish a cotton industry prior to establishing an irrigation-based cotton industry.

The total opportunity value of land under irrigation amounts to $1.59 billion ($5.04 billion minus $3.45 billion), with most of this being made up of land that would, in the absence of irrigation, still be used in the same industry, but with significantly lower yields. Only $100 million of value adding constitutes the opportunity value of land that would, in the absence of irrigation, be utilised in another dryland industry.

Indirect contributions

Table 4.6 shows the indirect contributions of irrigation to the economy. These include the value added from processing industries and the flow-on effects generated by irrigation activity. The indirect contributions — estimated using the economic approach — are approximately 2.5 times the size of the direct effects, or $9 billion per annum. Of this, value-added from processing contributes $2.5 billion and flow-on effects comprise $6.4 billion.

Taken alone, the direct contributions at the farm level represent just 0.65 per cent of GDP. But the total contribution of irrigation, taking into account all indirect effects is 2.33 per cent of GDP. About half of this is accounted for through flow-on or multiplier effects throughout the economy arising from irrigation farming and processing of product from irrigation.

Indirect contributions under the accounting approach were not estimated because of the difficult additional assumptions which would need to be made.

4.6 **Total economic contribution of irrigation to the Australian economy**

Irrigation industry	*Economic contribution (value added)*			
	Farm	***Processing***[a]	***Indirect flow-on***	***Total***
	$m	$m	$m	$m
Rice	144	379	756	1 279
Other grains	160	1	203	364
Dairying	528	587	1 722	2 838
Other pasture (lambs and cattle)	75	32	79	186
Vegetables	751	530	0	1 281
Wine grapes	242	649	1 761	2 653
Other grapes	113	0	102	215
Pome and stone	239	71	468	777
Citrus	234	146	555	936
Other tropical and orchard fruit	104	27	200	331
Sugar cane	158	65	160	382
Cotton	726	33	658	1 418
Crops for fodder	71	0	24	94
Total	**3 546**	**2 521**	**6 687**	**12 754**
Less opportunity value of land in other dryland production [b]	100	–	267	367
Total net contribution to GDP	**3 446**	**2 521**	**6 421**	**12 387**
Percentage contribution to GDP (%)	0.65	0.47	1.21	2.33

a Early stage processing. **b** In alternative enterprises.

Source: CIE irrigation model.

Employment contributions

Using the economic approach, it is estimated that the irrigation sector accounts for a total of about 171 100 jobs in Australia, or 2.6 per cent of total employment. This refers to employees only (table 4.7). In addition, an estimated 17 300 people can be classed as employers or business owners in the farm irrigation sector that would not otherwise own businesses in the absence of irrigation. Thus, it can be said that the irrigation sector generates additional jobs totalling 188 300.

As with value adding, most of the irrigation jobs are in activities beyond the farm gate. Direct farm employment accounts for 29 000 jobs, which represents about 24 per cent of all direct agricultural jobs. Employment in irrigation processing and flow-on activities accounts for 142 000 jobs. Thus, 75 per cent of the employment generated by irrigation occurs in businesses beyond the farm gate.

4.7 **Employment[a] attributable to irrigation**

Enterprise	*Irrigation farm*	*Processing [b]*	*Indirect flow-on employment*	*Total*
	'000 persons	'000 persons	'000 persons	'000 persons
Rice	0.8	1.1	13.4	15.2
Other grains	0.9	0.0	3.6	4.5
Dairying	2.6	6.3	27.1	36.0
Other pasture (lambs and cattle)	0.6	0.6	1.9	3.0
Vegetables	9.5	3.3	26.2	39.0
Wine grapes	1.9	4.6	18.6	25.1
Other grapes	1.2	0.0	1.6	2.8
Pome and stone	2.7	0.6	6.7	10.0
Citrus	2.5	1.4	8.9	12.7
Other tropical and orchard fruit	1.2	0.3	3.0	4.6
Sugar cane	0.8	1.3	2.7	4.9
Cotton	4.0	0.2	12.5	16.8
Crops for fodder	0.9	0.0	0.3	1.2
Total	**29.6**	**19.8**	**126.4**	**175.8**
Less alternative employment[c]	0.7	0.0	4.0	4.7
Total net employment contribution	**28.9**	**19.7**	**122.4**	**171.1**
Total irrigation employment as a percentage of total economy	0.44	0.30	1.86	2.60

[a] Employees only — full-time equivalents. [b] Early stage processing. [c] In alternative enterprises.

Source: CIE irrigation model.

In summary

Irrigation makes a substantial contribution to incomes and standards of living of Australians. Irrigation contributes:

- directly and indirectly, $12.4 billion or 2.3 per cent to Australia's GDP;
- $2.8 billion indirectly to total household expenditure on goods and services — representing over $530 for each Australian household per year; and
- $7.4 billion to total exports, as well as saving $4 billion in imports.

Using the 'accounting' approach, irrigated agriculture contributed over $5 billion to Australian GDP for 1996-97, representing 33 per cent of all agriculture and 0.9 per cent of GDP. This represents irrigators share of the agricultural and GDP 'pies' respectively.

The 'economic' approach estimates the contribution of irrigation to the economy over and above what would have been the case in the absence of an irrigation sector having developed. The accounting approach does not recognise that without irrigation that land would have been used in the same enterprise or a dryland alternative enterprise.

Using the 'economic approach' irrigated agriculture directly contributed $3.4 billion or 23 per cent in 1996-97 to the value added for all agriculture. This equates to a 0.65 per cent contribution to Australia's GDP.

The flow-on effects to the rest of the economy are significant. Value added in the food and fibre processing sector is estimated to be $2.5 billion. This represents 0.47 per cent of GDP.

The flow-on effects beyond the early stage processing sector, including household incomes are most significant. These flow-on effects are estimated at $6.4 billion or 1.2 per cent of GDP.

In total the direct and indirect economic contribution of irrigation to the economy is estimated at $12.4 billion or 2.3 per cent of Australia's GDP.

In addition, irrigation directly and indirectly contributes around 171 000 employee jobs to the Australian economy, representing 2.6 per cent of total employment in Australia. An additional 17300 persons are estimated to be employers.

5 Impact of water reform scenarios

Impact of reforms to date

Since 1996-97 substantial change has occurred in the rural water industry. As discussed in chapter 2, water charges have approximately doubled in real terms, trading has been facilitated particularly in the southern MDB connected system and there have been improvements in WUE although there is only limited information available on the extent of these improvements. Implementation of the MDB Cap has, on the one hand reduced potential diversions by an estimated 15 per cent or about 1600 GL, and this may have denied irrigators the opportunity to utilise this water in further development of irrigation enterprises. On the other hand, the Cap has most likely prevented further deterioration in water quality, particularly salinity, and prevented additional reduction in reliability of water deliveries within entitlements.

Some quantification of these changes is discussed below. It is important to note that the estimates presented below are derived from model simulations where individual parameters in the model are changed in a systematic way to discover the impacts of those changes. All other factors, such as output prices, input costs and other exogenous factors are held constant. In effect, the simulations are run to address questions such as 'what if variable x changes by a given amount with all other parameters held constant — what are the economic implications'. Thus, the simulations will not replicate history over the period since 1996-97, neither are they designed to do so. But the strength of the simulations is being able to isolate out the effects of key changes, uncontaminated by changes occurring continuously throughout the economy where these changes are not of immediate interest.

Water charges

Since 1996-97, water charges across Australia — on average — have approximately doubled. Table 5.1 summarises the direct and indirect impacts of this change. In calculating the base charges we have made allowances for the proportion of off-allocation water in each region.

With no increase in WUE, the increase in water charges has had only a minor impact on the overall economy. In effect, the increase in charges to irrigators has resulted in a wealth transfer of $114 million each year (for a five year period) from irrigators to IWPs (included in 'other industries' in table 5.1). This has been the main outcome because, at the level of 1996–97 water charges, most irrigators were relatively insensitive to higher prices — in terms of their water demand. The 'flow-on' effects to industries other than IWPs is very small. However, the enhanced revenue to IWPs is likely to have had two additional effects not accounted for by the model estimates. First, there has been less subsidy required from public revenue to IWPs than would otherwise have been the case. If these public funds saved had been spent in other worthwhile areas, there would be a benefit to the rest of the economy. Second, the increased revenue has undoubtedly enabled IWPs to upgrade their infrastructure to an extent that may not have occurred in the absence of the increased water charges. This will have long term benefits for irrigators and the economy in general.

Water use efficiency

With little objective information on increases in on-farm WUE, we illustrate the effects by assuming increases of 1 and 2 per cent a year. The trends in water use discussed in chapter 2 suggest that this is a reasonable assumption. To facilitate the modelling of this 'shock' it is assumed that:

- the percentage changes in WUE are uniform across regions and enterprises within each region; and

5.1 **Annual impact of charging reforms and WUE improvements — Australia**

				100% increase in water charges together with	
	100% increase in water charges[a]	***1% pa increase in WUE***[b]	***2% pa increase in WUE***[b]	***1% pa increase in WUE***	***2% pa increase in WUE***
	$ million	$ million	$ million	$ million	$million
Irrigated agriculture	-114	90	192	-24	78
Dryland agriculture	1	-52	-113	-51	-112
Food and fibre processing	1	43	96	44	97
Other industries[c]	138	124	272	262	410
Total GDP	**26**	**227**	**495**	**253**	**521**

[a] With no increase in WUE. The model 'shock' is a one off doubling of water charges.[b] With no increase in water charges. [c] Includes IWPs.

Source: CIE irrigation model.

- these increases are above the underlying increases in total factor productivity (TFP) that are already being achieved by the irrigation sector.

The impact of increases in WUE on value added is significant in total, when considered in isolation from other variables that contribute to TFP on-farm. Thus, on the assumption of a 1 per cent per annum increase in WUE (or 5 per cent over 5 years), in the absence of any increase in water charges, GDP would have expanded by $227 million each year by the end of the five year period. Of this increase, $90 million is due to extra value-added from irrigated production. Indirect value added from processing and flow-on effects receives a boost of $43 million and $124 million per annum respectively. However, these benefits are partially offset by reduced value added from dryland agriculture (minus $52 million), which suffers from slightly lower commodity prices and higher labour costs due to extra productivity from the irrigation sector. In conclusion, increases in WUE have provided positive benefits to irrigators but the main increase in value adding has come through flow on effects in other sectors of the economy.

Our judgment is that WUE is more likely to have increased by about 1 per cent rather than 2 per cent per year over and above trend rates of increase in total factor productivity. It would be very difficult to be conclusive about how WUE has differed been regions and between enterprises in recent years. However, it is widely acknowledged that WUE is likely to have been of greater priority in those areas with higher charges or those enterprises where water charges comprise a higher share of total costs. In other regions, it is likely that irrigators have been more compelled to focus on increasing yields and improving efficiency of other inputs such as chemicals, fertiliser and hired labour due to their higher contribution to total costs and TFP.

In practice, improvements in WUE can lead to three outcomes:

- an improvement in reliability of existing entitlements (an effective increase in allocation);
- an expansion in irrigated land; and
- sale or trade of water surplus to requirements to other enterprises.

Anecdotal evidence suggests that most irrigators, in the short term, hold on to any water from increases in WUE to enhance reliability of their existing entitlements and to increase cropping area. However, because the model is not stochastic, it is difficult to incorporate the effect of improved reliability between seasons. Therefore we have only simulated the increase in WUE in conjunction with changing enterprise mix, facilitated by water trade within regions.

Combined impact of changes in WUE and charging policies

Many factors could lead to increases in WUE, one of which is increases in water charges. The direct linkage between increases in water charges and WUE is not known. With this understanding, we examine the net effect of higher charges in combination with 1 and 2 percent annual improvements in WUE.

Assuming WUE has increased at 1 per cent each year, this would partially offset the cost to irrigators from higher water charges. But the results in table 5.1 show that irrigators would still have suffered a welfare loss of $24 million per annum. However, if **WUE** has been higher, at say 2 per cent per year, then irrigators would have received a net gain of $78 million per annum.

Impact of the MDB Cap

Recall from chapter 2 that the MDB Cap is estimated to have reduced nominal allocations to irrigators by up to 15 per cent — or 1 600 GL. That is, without the Cap the irrigation sector may have been able to fully develop their existing entitlements. So the Cap has resulted in a lost 'option value' for irrigators — although this must be weighed up against the benefits of improved system reliability under the Cap and possibly better water quality outcomes for irrigators (for example lower salinity). Furthermore, it may not have been economic to develop all of the additional water resource because full use of entitlements would require additional investment and suitable land. That is, the lowest cost land suitable for irrigation has already been developed. Development of this additional land may involve significant costs both on and off-farm.

Nevertheless, it is useful to examine the maximum possible value of the lost opportunity from not being able to fully develop entitlements. As explained in chapter 3, we do this by reducing the amount of *existing* diversions by 1600 GL across the whole MDB — which provides us with an upper bound estimate of the marginal value of water. This approach circumvents the difficulty of 'growing' the irrigation sector in the model — which would require assumptions about rate of conversion of dryland areas to irrigation which then depends on how fast development costs rise as low cost irrigation land is taken up. Therefore we almost certainly over-estimate the true cost of foregone development opportunity.

The maximum opportunity value foregone to the economy from imposition of the MDP Cap — equivalent to a reduction in diversions of 1600 GL — is $428 million per annum, or 3.7 billion net present value over 20 years, which is distributed across the various sectors as follows.

- Irrigated agriculture — $174 million loss Australia wide, which includes:
  - $228 million loss in the MDB
  - $54 million gain to irrigators outside the MDB.
- Dryland agriculture — $91 million gain.
- Food and fibre processing — $63 million loss.
- Other industries — $240 million loss

The results indicate that the incomes of Australian irrigators could have been up to 3.5 per cent higher without the Cap. The majority of the opportunity cost falls on MDB irrigators, whose incomes might have been a maximum of 9 per cent higher had the Cap not restricted further development.

The impact to dryland agriculture is positive due to commodity price effects and wage effects. As the production of irrigated commodities is cut back, prices of these goods on the domestic market increase — principally winegrapes, dairy products and grains other than rice. Thus, the dryland sector benefits from these higher prices. The model also takes into account the lower demand for labour by the irrigation sector as output is cut back. This results in lower wages, which is of benefit to dryland agricultural enterprises.

It is stressed that the losses shown above are maximum gross measures of 'option value' and are not realised losses. Furthermore, the option losses must be weighed up against the benefits of the Cap in terms of better water quality and reliability of supply — relative to what would have been the case. It is also stressed that the full development scenario would require additional investment, which has not been taken into account in this analysis.

Enhanced trading

As discussed in chapter 3, the value of enhanced trading opportunities since 1996-97 has not been modelled. This is because most of the observed increase in trading activity has been *within-region* temporary trades. The model is not equipped to examine the impact of increasing this form of trading. Furthermore, the behavioural theory underpinning irrigators' motivation to transfer water from one enterprise to another is not well developed.

The model is capable of estimating the value of increased trade between regions (or valleys) within the southern MDB. However, because this form of trading is still quite limited, no attempt is made to examine these changes retrospectively.

Future scenarios

The most significant future reform affecting the irrigation sector is likely to be reduced water availability to meet environmental objectives or urban development. The cost of this reform will partly depend on the mechanism used to recover the water.

As discussed in chapter 2, the Snowy Water Agreement has a ten-year target of recovering 282 GL for environmental flows and an additional 500 GL has been targeted for recovery over the next five years consistent with the National Water Initiative. It is envisaged that most of the Snowy Water, and some of the 500 GL for the Murray, will be recovered through water savings projects. In the case where WUE improvements are used to recover water, the irrigation sector will not suffer a reduction in allowable diversions. However, these recovery projects will not be costless. This study does not attempt to put a figure on how much water will be recovered from water savings or the cost of these savings.

Instead, we examine the costs of recovering all water via direct reductions in existing irrigator allocations. The economywide model is used to develop a 'cost curve' for four levels of reduced diversions of 5, 10, 15 and 20 per cent — taken either from the southern MDB, the whole MDB or Australia wide. Note that the 500 GL target for recovery under the National Water Initiative will need to be sourced principally from the southern MDB in order to meet environmental objectives at each of the icon sites.

Water recovery mechanisms

Two different water recovery mechanisms are assessed. Water is assumed to be recovered either through an *administered scheme* — whereby *pro-rata reductions* are imposed across all users — or through a *market-based* buy-back of existing *active* entitlements. The purpose of this analysis is not to advocate a particular policy option but to demonstrate the potential divergence in costs between the different approaches.

Under the administered approach it is assumed that irrigators are not compensated and cannot adjust to the reduced allocations by inter-region trading — although the model allows for water transfers between enterprises *within* a region. In effect, this scenario represents the 'worst case' situation and therefore puts an *upper-bound* on the cost of water recovery. To the extent that some trading is possible between regions in the real world, costs are likely to be less. However, trading is seldom costless. Often transaction costs are involved and the transfer of water can cause externalities, such as redundant assets (where an IWP is stuck with large fixed infrastructure costs and no customers), changes in supply reliability to some users and water quality problems.

An alternative mechanism for recovering water would be for government to enter the market and buy entitlements or it could call for tenders, requiring sellers to put a price on water they are willing to sell. Under this approach water could potentially be recovered at *lower cost*, with less overall impacts to the irrigation sector compared to an administered approach. This is because water is sourced from users who have the lowest marginal value for water. But again, the possible added costs of unwanted externalities would need to be considered before opting for a market-based approach. Consideration may also need to be given to designing the market mechanism so that water is sourced from those regions that will provide the greatest environmental benefits — something that may not necessarily occur if controls are not placed on the market process.

We model the market-based approach by imposing a pro-rata reduction on all existing diversions, then allow irrigators to make costless adjustments through inter region trade. In effect, this simulation produces the same outcome as a market buy-back. That is, an administered scheme which allows unfettered trading and pays compensation to irrigators at the market value of water is equivalent to a market buy-back scheme. The direct cost of reductions under the market-based approach, in terms of reduced value added from irrigation farms, is an estimate of what it would cost the government to buy back entitlement on the water market. The model is also capable of estimating the second-round impacts of reduced diversions — which are additional to the direct cost of lost farm value added.

The two water recovery mechanisms also differ in terms of who bears the cost of reduced diversions. Under an administered approach irrigators bear the direct cost of losses in production (assuming no compensation is paid). Under the market-based approach, irrigators are compensated at the market price for water and the government bears the cost of direct losses. However, the flow-on effects are borne by regional communities.

Some comments have been made that a government buy back scheme would 'swamp the market' and inflate the price of water. The market price of water is determined by supply and demand. Where demand is increased for environmental purposes, the market price of water is likely to rise irrespective of how the government acquires the water. It is expected that governments would take a flexible approach to any buy back scheme — possibly buying up permanent water entitlements in times of plenty and selling temporary water in times of scarcity. Such an approach could have a more stabilising influence on the water market compared with a strict administered approach.

Water recovery from the Southern MDB system

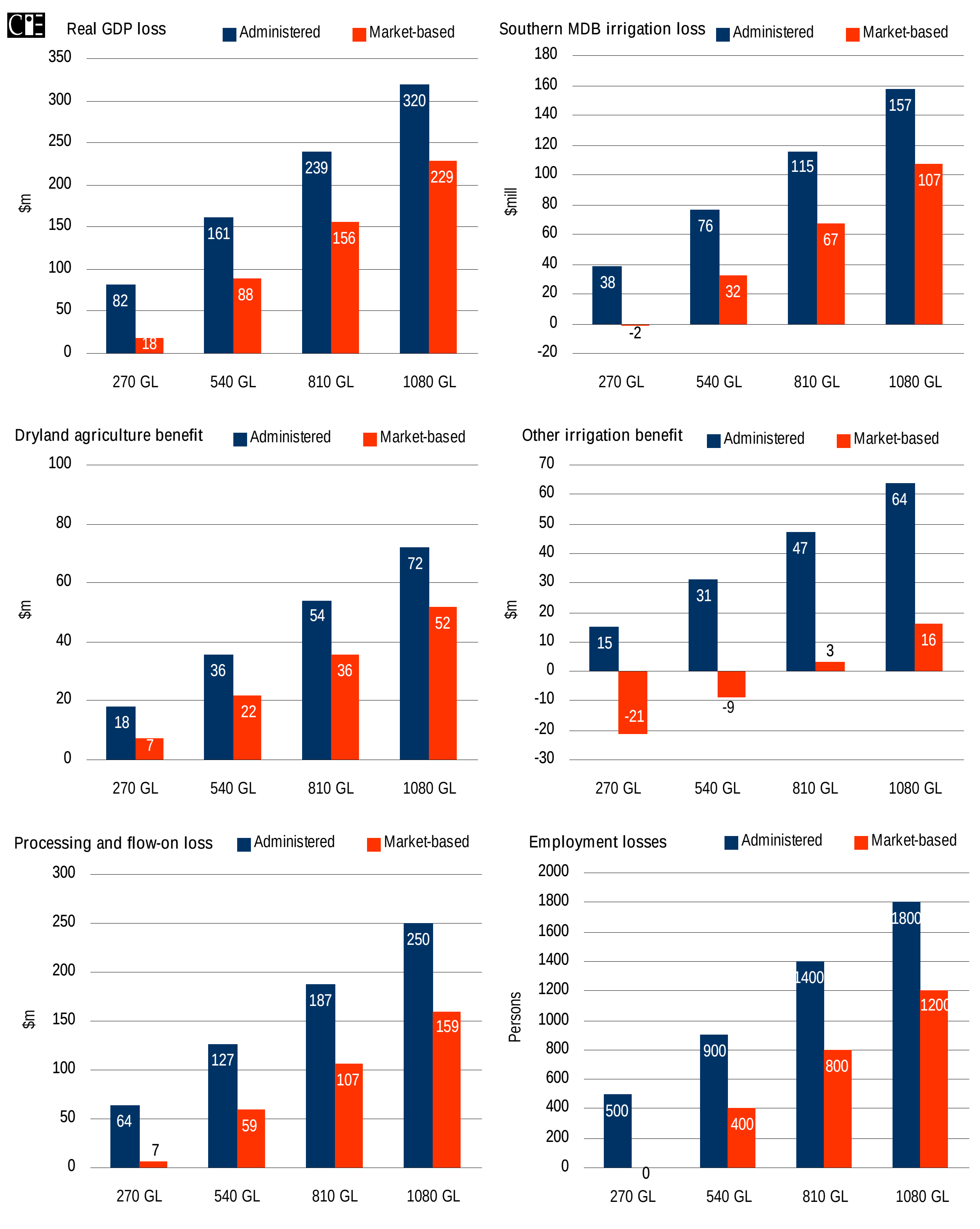
The impacts of reducing diversions to irrigators via an administered or market-based approach are illustrated by the series of charts in chart 5.2. *For example, under a market based approach, a 10 per cent cut in diversions — equal to 540 GL — is estimated to reduce GDP by $88 million per annum.* This is broken down as follows:

- a direct loss in value-added for southern MDB irrigators of $32 million;
- a small loss in value-added by other irrigators of $9 million;
- losses in processing value-added of $12 million;
- losses in flow-on activities of $47 million; and
- benefits to dryland agriculture of $22 million.

The **direct impact** to irrigators in the southern MDB is equivalent to a 2 per cent reduction in annual income. In addition to this, there are **indirect losses** of $59 million per annum due to reduced processing and flow-one activities. The dryland agricultural sector stands to gain $22 million due to higher domestic commodity prices and lower wages. The higher prices come about because of reduced quantities of irrigation products sold on the domestic market. Similarly, the lower demand for labour in the irrigation sector leads to lower wages, which benefits dryland producers.

The total economy-wide loss of $88 million annually is equivalent to a $1.0 billion loss over 20 years in net present value terms, assuming a 7 per cent discount rate. Therefore, the recovery of 540 GL under a market based system would have to result in environmental benefits of at least $88 million *each year,* or $1.0 billion over 20 years, for society to be better off in net terms. The environmental benefits would also have to be weighed up against employment losses due to reduced irrigation activity. This is estimated to be in the order of 400 jobs.

5.2 **Annual impacts of reducing diversions in the southern MDB system**



Data source: CIE irrigation model.

The analysis demonstrates that costs could be even higher if an *administered approach* is used to recover water. For the 540 GL scenario, the loss in GDP is estimated to be $161 million each year, or $1.8 billion net present value over 20 years. Up to 900 jobs are estimated to be lost. The key message here is that reducing diversions proportionately across all regions is almost twice the cost of using a market based approach to recover water.

However, the market based approach would required government to buy-back water entitlements. The taxpayer would bear the cost of compensating irrigators. Based on the modelling results above, the compensation for a 540 GL buy-back would amount to $32 million each year or $460 million lump sum for a permanent recovery of entitlement. Note that these estimates are not too dissimilar from the cost of buying back water entitlement at current market prices. The annual payment of $32 million for 540 GL equates to a price of $60 per megalitre, which is slightly below what water is trading for on the temporary market. Assuming a 7 per cent discount rate, the price of $60 for temporary water — derived from our model — converts to a permanent price of about $860 per megalitre.

While the market based approach is considerably cheaper than administered, pro rata reductions, the buy-back of entitlement could expose some regions to the risk of stranded assets and disruption to affected irrigation communities. Sourcing water using the market based buy-back approach could also make it difficult to target the recovery of water from particular regions, which may be necessary to optimise environmental benefits. These drawbacks of market-based recovery need to be balanced against the potential cost savings.

Breakdown of direct regional impacts

The model is also capable of examining the regional distribution of impacts. The pattern of impacts varies, depending on which water recovery mechanism is used (table 5.3). The recovery of 540 GL using an **administrative approach** requires all regions in the southern MDB to give up about 10 per cent of their existing diversions. Costs are imposed on all irrigators without any opportunity for individuals to employ inter-region trading as a means of adjustment. Under this scenario all irrigators must give up water regardless of how highly they value it.

Table 5.3 shows that most of the water is sourced from the Murrumbidgee, the NSW Murray and the Goulburn Broken Loddon (GBL) — coinciding with the highest water using districts. The **direct** economic losses however are roughly equally distributed across the regions, ranging between $8 million and $21 million per annum in direct value added. Losses from the Murray River regions in Victoria and South Australia are in the order of $8 million to $14 million. Note that other irrigation regions outside the southern MDB stand to gain $31 million a year, principally due to higher commodity prices as a result of lower output from irrigation in the southern MDB. The net effect Australia-wide is a $46 million loss in direct value added.

Under a **market-based approach**, the overall economic impacts within the southern MDB are less severe and the regional distribution of impacts is quite different. This is because irrigators can adjust to the reduced diversions by trading with neighbouring regions. Again, most of the water is recovered from the Murrumbidgee and Murray NSW regions, but less comes out of the GBL. This suggests that irrigators in the GBL, on average, have a higher marginal value for water and are therefore able to retain water in their region. Compared to the administered approach, a greater proportion of the water is sourced from lower NSW — suggesting lower marginal values for water in this region. Unlike the administered approach, value added actually *increases* in Murray River Victoria and South Australia. The reduced diversions stimulates the transfer of additional water into these regions to support horticultural activities. The net effect at the national level is a $41 million loss in direct value added.

5.3 **Direct regional impacts of a 540 GL reduction in the Southern MDB**

	Administered		Market-based	
	Change in water use	***Irrigation value added***	***Change in water use***	***Irrigation value added loss***
	GL	$m per year	GL	$m per year
Southern MDB				
Murrumbidgee River NSW	-217	-20	-191	-27
Murray River NSW	-159	-14	-389	-43
Goulburn Broken Loddon (GBL)	-113	-21	-68	-15
Murray River Vic	-26	-8	41	15
Murray River SA	-28	-14	63	37
Total	*-543*	*-77*	*-543*	*-32*
Northern and Central MDB	0	4	0	1
Rest of Australia	0	27	0	-10
Total irrigated agriculture	**-543**	**-46**	**-543**	**-41**

Source: CIE irrigation model.

While southern MDB irrigators are less severely impacted by the market based approach relative to an administered approach, at the national level the impacts are approximately the same irrespective of which water recovery mechanism is adopted. This is principally because of the offsetting effect of higher commodity prices and lower wages for agricultural producers who are unaffected by the reduced diversions.

Breakdown of direct industry impacts

Table 5.4 summarises the impacts of reduced diversions on an industry-by-industry basis for the southern system. Under the **administered approach**, the amount of water recovered from each industry is proportional to the amount of water used by each industry. The high-using industries in the southern MDB are rice, other grains and pasture based enterprises — and hence most of the water is recovered from these industries. The greatest economic losses are imposed on rice, other grains, lambs and cattle and the grape industries. These industries have relatively high marginal values for water and/or are big users of water, so are impacted the most.

A significantly different result is obtained when water is recovered using a **market-based approach**, which allows for inter-region trading. In this case, most of the water is recovered from industries with the lowest marginal value for water — namely irrigated grazing, rice and other grains. Reducing diversions and the introduction of trading stimulates some industries (grapes and fruit) to buy-in water from other industries. That is, trading is stimulated with increasing water scarcity. Compared to the administered approach, value added losses are more concentrated in the low value added enterprises particularly grazing and rice.

5.4 **Direct industry impacts of a 540 GL reduction in the Southern MDB**

	Administered		**Market-based**	
Irrigation enterprises[a]	***Change in water use***	***Irrigation value added***	***Change in water use***	***Irrigation value added***
	GL	$m/year	GL	$m/year
Lambs and cattle	-111	-8	-91	-6
Rice	-183	-10	-279	-16
Other grains	-127	-16	-150	-18
Dairy	-45	-11	-20	-5
Vegetables	-2	-4	0	0
Grapes	-27	-15	29	15
Other fruit	-9	-10	2	4
Cotton	-11	-3	-20	–5
Lucerne and crops cut for fodder	-29	-1	-13	0
Total	**-543**	**-76**	**-543**	**-32**

[a] Enterprises in the southern system of MDB only.

Source: CIE irrigation model.

Dryland agricultural enterprises, not shown in the table, stand to gain $22 million a year following reduced diversions using the market-based approach. This is due to higher domestic prices for some commodities and lower wages induced by lower demand for labour by the irrigation sector. The main commodities estimated to benefit from higher prices are grains ($8.9 million), dairy products ($3.9 million) and sheep ($6.1 million). While the price increases for these commodities are relatively modest, they apply to relatively large dryland industries.

Water recovery from MDB and rest of Australia

As outlined in chapter 2, the southern MDB is not the only irrigation region in Australia that could experience reduced water availability in the future. Therefore, we explore the direct and indirect impacts of reducing water diversions at a broader level — firstly across the whole MDB and then across the whole nation. As before, cost data are produced for reductions in diversions ranging from 5 to 20 per cent. It is assumed that inter region trading is possible in the southern MDB system.

Table 5.5 summarises the results. It is estimated that if diversions to irrigation were reduced by 10 per cent across the MDB (or 1020 GL), annual GDP losses would be around $195 million or $2.2 billion in net present value terms over 20 years. Employment would fall by 1000 jobs. Direct losses in value added to the irrigation sector would be $103 million each year.

5.5 **Impact of reducing irrigation diversions to the MDB and Australia**

		Reduction in diversions			
		5%	10%	15%	20%
Southern MDB[a]					
Water recovered	GL	270	540	810	1 080
Irrigation direct loss	$m per year	18	41	64	90
GDP loss	$m per year	18	88	156	229
Employment loss	persons	0	400	800	1 200
Whole MDB					
Water recovered	GL	510	1 020	1 530	2 040
Irrigation direct loss	$m per year	49	103	158	215
GDP loss	$m per year	72	195	316	462
Employment loss	persons	330	1 000	1 660	2 490
Australia					
Water recovered	GL	720	1 440	2 160	2 890
Irrigation direct loss	$m per year	75	157	240	316
GDP loss	$m per year	136	324	508	751
Employment loss	persons	810	1 960	3 080	4 570

a Inter-region trading permitted in southern MDB

Source: CIE irrigation model

A 10 per cent reduction in diversions to all irrigation regions of Australia (1440 GL) is estimated to reduce GDP by $324 million annually or $3.7 billion in present value terms over 20 years. Job losses are estimated to be in the order of 1960 jobs. Irrigators would incur direct losses in value-added of $157 million each year.

Regional and industry impacts

Table 5.6 shows that the economic impacts of reduced diversions are not evenly distributed across regions. For example, irrigators in the northern and central MDB are most affected from a 10 per cent reduction in diversions across the Basin. Irrigators in these regions are estimated to incur a $74 million loss in annual net income — representing an 8 per cent reduction on 1996-97 income. By contrast, irrigators in the southern system are estimated to lose $24 million in value added each year. The impacts are higher for northern and central irrigators because the model does not allow inter region trading, which reflects the real world situation where trading in the northern MDB is restricted due to physical and institutional constraints.

Similarly, some industries suffer greater losses than others from a cut in diversions. Table 5.7 summarises the industry impacts of a 10 per cent reduction — at the MDB level and for Australia wide. In the scenario where reductions are restricted to the MDB, the industries incurring the greatest losses in value added are the cotton industry, rice and other grains. Cotton is the hardest hit, with a loss of $59 million per annum, which constitutes over half of the total impact estimated for the MDB. The same industries are affected when water is recovered from irrigators across the whole of Australia with the notable addition of the sugar industry which is located outside the MDB. The sugar industry is estimated to experience a loss of $32 million per annum.

Efficiency improvements required to offset reduced diversions

Increasing **WUE** is one means by which irrigators can minimise the economic impact of lower water availability. Chart 5.8 shows the on-farm WUE gains that are required to offset the cost of reduced diversions Australia wide. The horizontal dotted lines represent the annual losses in value added losses to irrigators due to a specified GL reduction in water availability in the MDB. The upward sloping line represents the direct value added gains each year to irrigators from annual improvements in WUE, ranging from 1 to 2 per cent. The chart shows that a 1.3 per cent improvement in WUE across all irrigators would be required to completely offset the on-farm cost of a 10 per cent (1440 GL) reduction in diversions. For a 15 per cent cut in diversions (2160 GL), WUE would have to increase by at least 1.7 per cent each year.

5.6 Direct regional impacts of a 10 per cent reduction in water diversions

	MDB only		*Australia-wide*	
	Change in water use	*Irrigation value added*	*Change in water use*	*Irrigation value added loss*
	GL	$m/year	GL	$m/year
Southern MDB[a]				
Murrumbidgee River NSW	-196	-26	-211	-21
Murray River NSW	-389	-41	-400	-39
Goulburn Broken Loddon (GBL)	-65	-12	-56	-3
Murray River Vic	42	16	47	21
Murray River SA	65	39	76	50
Total	*-543*	*-24*	*543*	*8*
Northern and Central MDB	-478	-74	-478	-69
Rest of Australia	0	-4	-421	-95
Total irrigated agriculture[b]	**-1 021**	**-103**	**-1 443**	**-157**

a Assumes that trading between regions is permitted. **b** Totals may not add due to rounding.

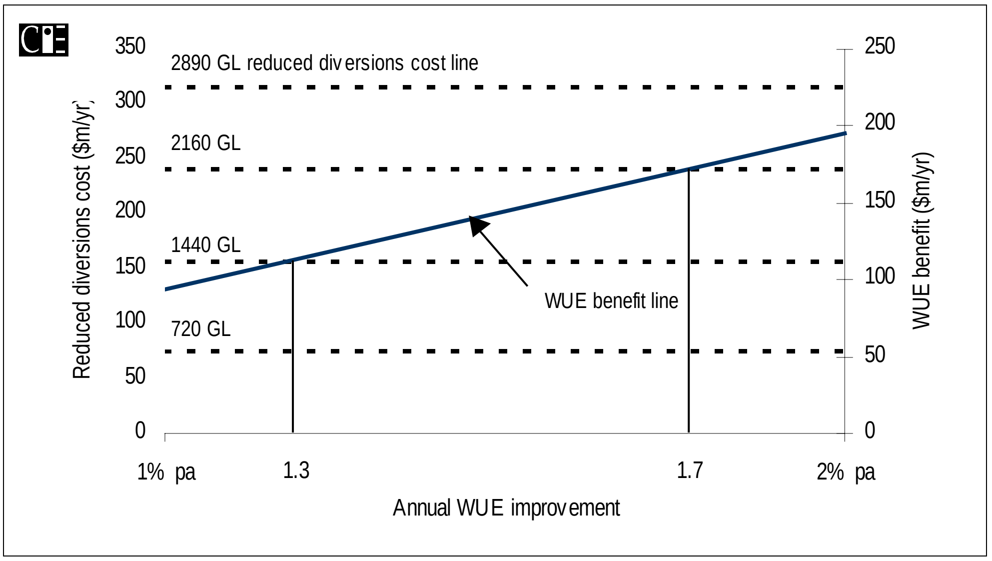
Source: CIE irrigation model.

5.7 Direct industry impacts of a 10 per cent reduction in water diversions

	MDB only		**Australia-wide**	
Irrigation enterprises	*Change in water use*	*Irrigation value added*	*Change in water use*	*Irrigation value added*
	GL	$m per year	GL	$m per year
Lambs and cattle	-107	-7	-130	-8
Rice	-287	-17	-309	-18
Other grains	-191	-23	-222	-27
Dairy	-17	-3	-53	-3
Vegetables	-1	-1	-1	13
Grapes	28	14	9	-1
Other fruit	1	3	-2	3
Sugar	0	0	-139	-32
Cotton	-262	-59	-333	-73
Lucerne and crops cut for fodder	-182	-7	-263	-10
Total	**-1021**	**-99**	**-1443**	**-157**

Source: CIE irrigation model.

5.8 **Value of WUE improvement in offsetting reduced diversions — Australia**



Data source: CIE irrigation model.

In summary

Reforms to date

- A doubling of water charges since 1996-97 has had little impact on the national economy — when considered in the absence of possible associated water efficiency improvements. However, the increased charges have meant that an additional $114 million has been transferred from irrigators to water providers each year in the five years since 1996-97. This has enabled IWPs to rely much less on public funds and undertake investments in irrigation infrastructure.
- There is only limited information about the extent of WUE gains that have been made since 1996-97. But assuming WUE has increased by 1 per cent per annum over and above normal trend rates of increase in on-farm total factor productivity, GDP would have expanded by about $227 million over a five year period — in the absence of any other reform impacts. About 60 per cent of this increase in value added is estimated to come from processing and 'flow-on' effects.
- For irrigators, WUE would have had to increase by around 1.5 per cent a year to counteract the negative impacts of increased water charges on their value added.
- The MDB Cap has resulted in a lost 'option value' for irrigators — although this must be weighted up against the benefits of improved system reliability under the Cap, better water quality outcomes for

irrigators, and the fact that it may never have been economic to fully develop the existing entitlements.

- This lost 'option value' to the economy is estimated to be $428 million per annum including lost opportunity value to irrigators of an estimated $174 million a year. In net present value terms, the total lost option value equates to $3.7 billion over 20 years.
- This represents an *upper bound* estimate of the option value foregone because in using the additional 1600 GL, significant costs could be involved in land development, reduced supply reliability and declines in water quality.

Future reforms

- The cost of reducing diversions for environmental flow purposes to the southern MDB by 540 GL are relatively small in terms of reductions in total GDP. In the case where trading between regions is allowed to occur, it is estimated that GDP would fall by $88 million per annum.
  - The discounted net present value of this loss over 20 years is around $1.0 billion.
  - The value of the annual loss rises to $230 million if there is a cut of approximately 1000 GL in the southern system.
- Recovering water through administered reductions in water use — where every user is forced to take a proportional cut, no trading is allowed and irrigators are not compensated — is considerably more costly than using a market based method.
- For example, a 540 GL cut in diversions in the southern MDB connected system is estimated to reduce GDP by $161 million per annum under an administered approach but only $88 million under a market based approach. But other issues such as asset reductions must also be taken into account.
- The reductions in GDP provide a benchmark against which to compare the environmental benefits of increased flows in the Murray. The $88 million loss in GDP each year equates to a lump sum net present value of $1.0 billion over a 20 year period. In other words, the recovery of 540 GL would have to result in environmental benefits with a present value of at least $1.0 billion.
- The indirect impact of diversions makes up a large proportion of the total impact. For example, under market-based water recovery of 540 GL from the southern system, direct losses are $32 million a year while

losses from processing are $12 million and flow-on losses are $47 million per annum.

- The costs imposed on the irrigation sector are partially compensated by increases in value added generated by dryland agriculture. This is due to a price effect — in particular the higher prices received for wine-grapes, dairy and grains other than rice — and lower wage costs.
- Reducing diversions by 540 GL in the southern MDB connected system under a market based approach is estimated to result in the loss of 400 jobs to the irrigation sector and related industries. However, there may be some off setting job gains in managing environmental flows in some areas.
- If diversions to irrigation were reduced by 10 per cent across the whole MDB, annual GDP losses would be around $195 million or $2.2 billion in net present value terms over 20 years. If the reduction was 20 per cent then this loss would rise to $462 million each year.
- For Australia as a whole, a 10 per cent reduction in diversions could reduce GDP by $324 million annually or $3.7 billion in present value terms over 20 years.
- Ongoing WUE improvements will assist to off set the cost of potential reductions in diversions. The model indicates that an additional annual efficiency improvement of 1.3 per cent across all irrigators in Australia is sufficient to completely off set the direct value added losses from a 10 per cent (1440 GL) reduction in diversions.

Appendixes

A Details of the national model

THIS APPENDIX describes the structure of the economywide model developed by the CIE for this project. The starting point is CIE's own economywide model that is based on the ABS input–output tables that is maintained and updated in-house. The model is a variant of the ORANI model of the Australian economy, which is widely used in economic policy analysis by both government and the private sector. The model describes:

- the demands by industries, households and exports for domestically produced and imported goods and primary factors (labour, capital and land);
- the supplies of commodities (crops and livestock, manufactures and services) by domestic producers;
- the balance between the demand and supply of commodities and primary factors; and
- macroeconomic outcomes (gross domestic product, balance of trade, etc.), which are the sum of their industry and commodity components.

The equations describing these relationships are based on widely accepted economic assumptions about the behaviour of producers and consumers, technology and market structures. The standard ORANI model is described in Dixon et al. (1997) and Dee (1989). A non-technical description is provided by the IAC (1987).

However the standard version of the model does not carry sufficient detail to adequately address the question of water reforms and the impacts on the irrigators and the rest of the economy. For example, it does not distinguish between irrigation by region and dryland enterprises. In addition, the theory of the standard model does not allow for trading of water between irrigation users. Key tasks involved in the construction of the national model for this study were to:

- distinguish between dryland and irrigated enterprises;
- identify a regional dimension of the irrigation sector to capture key aspects of water reforms;

- develop a matrix of water quantities used by industry and region;
- attach charges to water and water costs to industry costs:
  - and recognise that for the base year, that in most regions, the value of water entitlements was embedded in the value of land;
- make assumptions about substitution between water and other inputs of production;
- add the capability to the model to assign water allocations to irrigators; and
- allow, in the theory and database, for trading of water between enterprises within a region and between regions where this is permitted.

The model is implemented and solved by the GEMPACK suite of programs as described by Harrison and Pearson (1996).

Model database

Using data specifically developed for the project, the model's industry and commodity detail was modified to include the significant irrigation activities. The commodity detail of the model is shown in table A.1 and the industry detail in table A.2. The model distinguishes 20 farm level commodities produced by 29 dryland and irrigated industries. In addition, the model recognises 19 industries in early stage food and fibre processing. Where possible, the processing industry immediately downstream of the farm level has been identified.

Important suppliers of inputs into agriculture are identified - such as basic chemicals, fuel and transport. The model also identifies a *bulk water* industry supplying irrigated agriculture. This industry covers water from each of the following sources that equals total use:

- regulated surface water (river pumping and channels)
- regulated groundwater
- off-allocation water.

The cost of water is the retail price charged to end-users with adjustments made for off-allocation water.

A.1 Commodity detail of the national model[a]

Commodities	***Commodities***
Wool	Other food products
Sheep and lambs	Soft drinks, cordials and syrups
Wheat	Beer and malt
Barley	Wine
Rice	Spirits and other alcoholic beverages
Other grains	Tobacco products
Beef cattle	Wool scouring
Dairy cattle	Textile fibres, yarns and woven fabrics
Pigs	Other textile and knitted products
Poultry	Clothing and footwear
Vegetables[b]	Wood and wood products
Wine grapes[b]	Paper and paper products
Multipurpose grapes[b]	Printing and publishing
Pome and stone fruit[b]	Petroleum and coal products
Citrus[b]	Chemicals
Other tropical and orchard fruit[b]	Rubber and plastic products
Sugar cane	Non metallic mineral products
Cotton (lint and cottonseed)	Basic metals and products
Crops for fodder	Fabricated metal products
Other agriculture	Transport equipment
Cotton ginning	Other machinery and equipment
Services to agriculture; hunting and trapping	Other manufacturing
Forestry and logging	Electricity supply
Commercial fishing	Gas supply
Coal; oil and gas	Bulk rural water
Iron ores	Other water supply; sewerage and drainage services
Non ferrous metal ores	Construction
Other mining	Trade and repairs
Services to mining	Accommodation, cafes and restaurants
Meat and meat products	Transport and storage
Dairy products	Communication services
Fruit products	Finance and insurance
Vegetable and other products	Ownership of dwellings
Oils and fats	Property and business services
Rice products	Government and defence
Other flour mill products and cereal foods	Education, health and community services
Bakery products	Cultural and recreational services
Confectionery	Personal and other services
Raw and refined sugar	Non-competing imports
Fish products	

[a] Commodities from irrigated enterprises in italics. [b] Includes value of commodity up to grading and packing stage.
Source: LWA Irrigation Model

A.2 Industry detail of the national model[a]

Industries	***Industries***
Wool — dryland only	Other flour mill products and cereal foods
Sheep and lambs — dryland	Bakery products
Sheep and lambs — irrigated	Confectionery
Wheat — dryland	Raw and refined sugar
Wheat — irrigated	Fish products
Barley — dryland	Other food products
Barley — irrigated	Soft drinks, cordials and syrups
Rice — irrigated only	Beer and malt
Other grains — dryland	Wine
Other grains — irrigated	Spirits and other alcoholic beverages
Beef cattle — dryland	Tobacco products
Beef cattle — irrigated	Wool scouring
Dairy cattle — dryland	Textile fibres, yarns and woven fabrics
Dairy cattle — irrigated	Other textile and knitted products
Pigs	Clothing and footwear
Poultry	Wood and wood products
Vegetables — irrigated only[b]	Paper and paper products
Wine grapes — irrigated only[b]	Printing and publishing
Multipurpose grapes — irrigated only[b]	Petroleum and coal products
Pome and stone fruit — irrigated only[b]	Chemicals
Citrus — irrigated only[b]	Rubber and plastic products
Other tropical and orchard fruit — irrigated only[b]	Non metallic mineral products
Sugar cane — dryland	Basic metals and products
Sugar cane — irrigated	Fabricated metal products
Cotton — dryland	Transport equipment
Cotton — irrigated	Other machinery and equipment
Hay, cereal grasses and fodder — dryland	Other manufacturing
Crops cut for fodder — irrigated	Electricity supply
Other agriculture	Gas supply
Cotton ginning	Bulk rural water
Services to agriculture; hunting and trapping	Other water supply; sewerage and drainage services
Forestry and logging	Construction
Commercial fishing	Trade and repairs
Coal, oil and gas	Accommodation, cafes and restaurants
Iron ores	Transport and storage
Non ferrous metal ores	Communication services
Other mining	Finance and insurance
Services to mining	Ownership of dwellings
Meat and meat products	Property and business services
Dairy products	Government and defence
Fruit products	Education, health and community services
Vegetable and other products	Cultural and recreational services
Oils and fats	Personal and other services
Rice products	Non-competing imports

[a] Irrigated enterprises in italics. [b] Includes value of commodity up to grading and packing stage.

Source: LWA Irrigation model.

Spatial dimension

One of the requirements of the national model detail is that it should be relevant to the key policy questions at hand. The impacts of water reforms will vary by catchments and by jurisdiction. In addition, because of the potential for trading to increasing efficiency — recognising connectivity between regions is an important consideration in the analysis. In an ideal analysis, all irrigation regions would be differentiated by catchment and by state within the national model. However, the amount of data required to complete this task would be prohibitive.

For the national model, the regional detail was chosen to focus on those regions that account for the majority of water use in Australia and are subject to significant water reforms. The detail identified in the model - shown in table A.3 - focuses on the MDB which accounts for around two thirds of water used by irrigation in Australia. Regions 2 to 6 identify the SCS of the MDB — the focus of the Living Murray Initiative and where a trading regime between regions has been established for some years.

The Northern and Central MDB is linked to the SCS through the Darling River and Minindee Lakes system. By agreement between the MDBC and the New South Wales government, these systems become connected when the Minindee storage is greater than 480 GL. Because this threshold is achieved in a minority of years we have assumed that there is no connectivity between the North and Central MDB and the SCS.

Data sources

The published input-output tables, produced by the ABS, do not adequately identify the costs of irrigation or the share of water in total costs, for this project. To address this problem, the national model is supported by a comprehensive database that describes irrigation by state, and for regions of interest, for the base year of 1996-97.

To construct this database it was necessary to collect data or make assumptions concerning:

- irrigated and dryland split of area (hectares) by state and by region;
- application rates of water by regions;
- irrigated and dryland yields by state and irrigated yields by region only; and
- average farm prices and GVP for irrigated and dryland enterprises by state and by region.

A.3 Irrigation regions identified in the national model

Irrigated regions	*ARWC regions*
1. Northern and Central MDB	▪ Border Rivers NSW and QLD ▪ Condamine/Culgoa Rivers NSW and QLD ▪ Warrego/Paroo Rivers NSW and QLD ▪ Gwydir River NSW ▪ Namoi/Peel Rivers NSW ▪ Castlereagh /Bogan Rivers NSW ▪ Macquarie Rive ▪ Barwon/Darling Rivers ▪ Lachlan River
2. Murrumbidgee NSW	▪ Murrumbidgee River NSW
3. Murray River NSW	▪ Upper Murray River NSW ▪ Lower Murray River and Benanee NSW ▪ Lower Darling River
4. Goulburn Broken Loddon	▪ Goulburn River VIC ▪ Broken River VIC ▪ Loddon River VIC
5. Murray VIC	▪ Kiewa/Ovens Rivers VIC ▪ Campaspe River VIC ▪ Wimmera/ Mallee VIC ▪ Murray River VIC
6. South Australian Murray	▪ Mallee SA ▪ Lower Murray SA
7. Rest of Australia	▪ All remaining catchments.

Source: LWA irrigation model.

This database is drawn together from a number of sources — summarised in table A.4. This database is supplemented by detailed information on irrigated land area and application rates for regions identified in the MDB.

This information is then combined with information collected on water charges for 1996-97 to obtain the correct share of water charges in total costs. This was done on a state-by-state basis and for each of the major irrigation areas. Retail charges were observed and allowances were made for the proportion of supplemented and unsupplemented water used by irrigators and each of these regions.

A.4 Data sources for irrigation database underlying national model

Database variable or enterprise	***Source***
General information	
Crop areas, production and GVP by state	▪ ABS 1996-97 Agriculture Australia, Catalogue No. 7113.0
Irrigated areas by crop type by state	▪ ABS Agricultural Statistics 1997. http://audit.ea.gov.au/anra/agriculture/agriculture_frame.cfm?region_type=AUS&region_code=AUS&info=irri_prod
Applications rates for horticulture, pasture, cereal crops and vegetables by Australian region	▪ Personal Communication: Charles Thompson HAL Water Initiative Coordinator.
	▪ CapitalAg (2002), Attachment B: Review of Water Use Efficiency
Gross margin information and WUE information	▪ NSW: http://www.agric.nsw.gov.au/reader/budget
	▪ QLD: http://www.dpi.qld.gov.au/fieldcrops and http://www.dpi.qld.gov.au/horticulture
Additional irrigation information	
Rice	Production application rates and yields.
	▪ Rice Growers Association — Personal Communication 2003.
Other cereals	Areas by state and GVP:
	▪ ABS Agriculture Statistics 1997 — http://audit.ea.gov.au/anra/agriculture/irri_popups/cereals.html
Cotton	▪ Dryland and irrigated production: Raw Cotton Marketing Advisory Committee Estimates.
	Irrigation rates and cost information:
	▪ CRDC, *Australian Comparative Cotton Analysis*, various years
Horticulture	Industry GVP by region, planting densities and irrigation rates:
	▪ Horticulture Australia Limited, Personal Communication ;
Sugar case	Area, yield and GVP by mill areas, irrigation percentage and rates:
	▪ *Australian Sugar Yearbook*, Various Years.
	▪ Ag-trans Research 2002, *Socio-Economic Data for the Queensland sugar industry*, Report to the Department of State Development.
	▪ Hildebrand, C,. 2002, *Independent Assessment of the Sugar Industry,* Appendix B.
Dairy	Regional milk production, herds, yields and water use:
	▪ Dairy Research and Development Corporation (2001), *Sustaining Our Natural Resources – Dairying for Tomorrow*, Review of regional profiles Commentary and regional Comparisons
Murray Darling Basin	
Allocations and diversions by MDBC area.	Murray Darling Basin Commission , *Water Audit Monitoring Reports*, Various Years. Review of Cap Implementation 2001-02, *Report of the Independent Audit Group*, Murray Darling Basin Commission http://www.mdbc.gov.au/naturalresources/the_cap/the_WAM_report.htm
Application rates (ML/ha) by AWRC River Basins by crop type	CapitalAg (2002), Attachment B: Review of Water Use Efficiency
Irrigated areas (ha) by AWRC River Basins by crop type	ABS Agriculture Statistics 1997 extracted from Australian Natural Resources Atlas http://audit.ea.gov.au/anra/agriculture/agriculture_frame.cfm?region_type=AUS&region_code=AUS&info=irri_prod

Modifications to standard theory

A number of enhancements were made to the standard theory of the economywide framework to accommodate the requirements of the project to address specific water reform scenarios. The key areas added to the standard theory of the economywide model are:

- substitution between water and other inputs
- provision for allocation and trading of water.

Substitution between water and other inputs

Standard economic theory suggests that demand for water, given the quantity of land is fixed, will fall in response to the higher cost of water — where costs include charges and pumping costs. At zero cost to users, application of water would be at the 'full irrigation' level — that is, the level that maximises crop yield. But in practice very little is known about the nature of this response curve. Anecdotal evidence suggests that application rates of water depend on soil types, crops and climate. These rates can vary dramatically between crops and even between the same crop in the same locality (CapitalAg 2002). Most enterprises will irrigate conservatively at levels close to full irrigation — to minimise risk — and avoid stress on plants and the chance of subsequent yield losses. This is especially the case where water charges comprise a small share of the enterprises total costs.

At this stage provision for substitution been water and other inputs has been made to the model theory but has not been activated. Changes in WUE, perhaps in conjunction with change in TFP at the enterprise level, are imposed on the model exogenously using technical shift terms already part of the model theory.

Water trading module

As indicated in table A.2, agricultural activities have been disaggregated to include dryland and irrigated, and the irrigated activities have been further disaggregated by region. Water trading can occur at two levels in the national model:

- within the same region
- between regions.

Trading with a region

Each irrigated activity within a region has an initial allocation of water and, in all model simulations, can trade water with other irrigated activities within the *same* region. In practice, water can move within a region between farms with different enterprise mixes — and so trade in water leads to a change in land use. The rate at which water can be moved between different enterprises in the same region is dependent on how land can be switched between these enterprises. The model theory uses a Constant Elasticity of Transformation equation to represent this behaviour — so that land moves imperfectly between alternative uses. How land moves between enterprises is determined by the return to land adjusted for the marginal benefit or return to water (see box A.5).

Trading between regions

Trading between regions is also catered for in the model theory — the user specifies regions that can trade — catering for where there is significant

A.5 **Marginal benefit of water**

A key concept in modelling the economics of the irrigation industry is the marginal benefit of water. This indicates the dollar value of an extra megalitre of water to an enterprise in a region reflecting the scarcity value of that water. The model has been developed such that each enterprise in each region has a different marginal benefit of water — with enterprises with high gross margins per megalitre, such as horticulture, having marginal benefits higher than broadacre crops, such as grains and pastures.

One indicator of the marginal benefit of water is the traded price of permanent water for each region. We have assumed that high value enterprises have a marginal benefit of water close to the observed traded price whereas for other crops — their marginal benefit of water will be lower.

We have assumed in the model's theory that the relativities between marginal benefits by enterprise for each region are fixed, but all can move in line with the marginal benefit of water for the region as a whole — the traded price of permanent water. There are a number of good regions why the marginal benefit of water does not equate across enterprises in any region:

- the investment required, and the significant fixed costs and risks of the high value enterprises per megalitre of water such as horticultural crops;
- the lack of availability of suitable land for a particular enterprise — such as well drained soil for citrus;
- the requirement for rotations between crops for sustainable land management; and
- other factors such as the relative availability of water during different times of the year, and the presence of barriers to other trade between enterprises such as exit fees (see chapter 2).

connectivity between regions. For the simulations in this report trading is possible for regions 2 to 6 listed in table A.3, which are part of the SCS.

With these relationships switched on, trade will occur between regions such that the traded price — the marginal value of water — between regions is equated. For the core set of simulations we restrict inter-regional trading to the SCS.

Output responses

Because changes in output of a particular enterprise cannot result endogenously by changing application rates of water or changing the water and other input mix, response in production in a given region to changes in economic conditions can come through:

- changes in the enterprise mix of land use
- change in the land, by region, developed for irrigation
- changes in WUE.

How the model is used

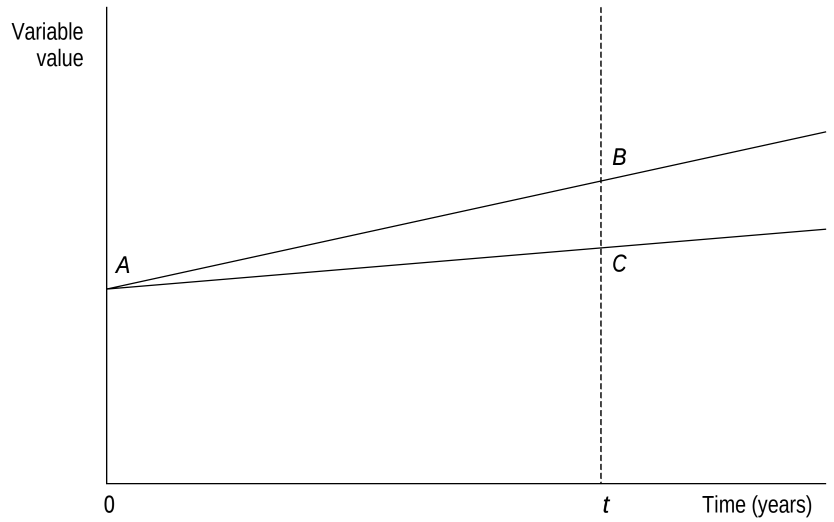
The model is a one-period comparative–static model. This means that it compares two different situations at the same point of time — not how they change over time. The way that comparative–static's works is illustrated in chart A.6. Path AB shows the underlying time path of a particular variable — say production by the irrigation sector — resulting from all economic conditions that affect prices and costs. Suppose that at time 0 a shock is introduced, such as a water reform. Then at time t, after the economy has fully adjsuted to the change, production by the irrigation sector would have reached C. Comparative–static analysis is concerned only with the size of the gap between B and C. That is, it measures the difference between production at time t after the policy change and production at time t had the change no been made (the base case scenario).

Interpretation concerning the number of years for each model simulation depends on the model environment or closure assumed. The closure is the choice of the variables that are declared either endogenous or exogenous.

For the contributions analysis we have used a short run perspective — between two and five years. It is assumed in the short run closure that:

- industry specific capital stocks do not change in response to the policy change so determining each industry's rate of return;

A.6 **Interpretation of comparative–statics**



- aggregate investment is held constant for the economy as a whole determining the economywide rate of return:
  - but within this constraint each industry can adjust its investment decisions but the changes to capital stocks are not implemented during the simulation period;
- nominal wages across occupations are held exogenous determining employment and unemployment rates according to changes in labour force participation rates; and
- government direct and indirect tax rates are assumed to remain unchanged thus determining the net government budget outcome across all jurisdictions.

For the water reform simulations we use a long run closure reflecting adjustments that take place throughout the economy up to a 10 year period and are more suited to the evaluation of policy changes. Key features are:

- industry specific capital stocks and investment by industry adjust to equate after tax rates of return across industries in the economy;
- aggregate real investment in the economy can adjust to maintain the economywide rate of return;
- employment rates by occupation are held exogenous by adjustment in the real wage for each occupation — determined by demand for and changes in participation rates for each occupation; and

- government direct and indirect tax rates are assumed to remain unchanged thus determining the net government budget outcome across all jurisdictions.

Measuring value added

In the analysis we define value added as the return earned by the factors of production used — labour, land and capital and rental to water allocations. Here we define labour to also include both employees and employers — that is, farm owner-operators' labour.

B Assumptions on alternative land uses to irrigation

Cotton

Nearly 95 per cent of cotton is irrigated. Rain-grown cotton is an opportunity crop in Australia, grown only when conditions are suitable. Average yield for rain-grown cotton is only about 2 bales per hectare compared with 7-8 bales per hectare for irrigated cotton (CIE 1995). In the absence of irrigation, it is highly doubtful that a rain-grown cotton industry would survive. Cotton has been in Australia since first settlement but did not become a viable industry until the early sixties when irrigated cotton started at Wee Waa (Stefan Hebggeler 2004).

It is assumed that, in the absence of irrigation for cotton, the land would be used for cereal cropping (two thirds of current cotton area) or grazing (one third) as the next best alternatives (Ralph Schultze, pers. comm., 26 February 2004). There would not be a cotton growing industry. The sporadic and geographically dispersed nature of rain-grown cotton would not support any cotton ginning enterprises. Hence, there would be no cotton lint or cotton seed produced in Australia.

It is assumed, however, that Australia's textile industry would continue to operate based on imported cotton lint purchased at the world price. Similarly, it is assumed that cotton seed would be imported as raw material in the vegetable oil sector.

Wool

Few, if any, sheep raised for wool production are grazed on irrigated pasture. Hence, in the absence of irrigation, the wool industry would not be directly affected. But, indirectly, as a solution of the model, it is expected that wool production would increase because some land currently under irrigation may be used for grazing sheep for wool production.

Sheep and lambs

Some prime lambs are finished on irrigated pasture, but according to ABS estimates, only about 8 per cent of the gross value of sheep and lamb production is based on irrigation. Even less would be based on supplemented irrigation.

It is assumed that, in the absence of irrigation, all lamb production would be based on rain-fed pastures.

Wheat, barley and other grains

Relatively little wheat and barley is produced under irrigation. In the absence of irrigation, it is assumed that what land there is under irrigated wheat and barley would be used for dryland wheat and barley, with appropriate yield reductions.

Rice

All rice produced in Australia is irrigated. In the absence of irrigation, it is assumed that no rice would be grown in Australia. It is also assumed that Australia's rice processing industry would be non-existent and that all domestic demand for rice would be imported in processed form, either as brown or white rice.

Beef cattle

Only about 2 per cent of the value of beef cattle produced in Australia are produced from beef cattle fattened on irrigated pastures. It is assumed that, in the absence of irrigation, all beef cattle would be fattened on rain-fed pastures.

Pigs and poultry

These intensive livestock industries do not directly depend on irrigation and, in the absence of irrigation, would not be directly affected.

Wine grapes

Grapevine enterprises in Australia use a wide range of water application rates, from over 15 ML/ha in some cases to zero. Approximately 10 per cent of Australia's vine area receives no irrigation, producing top premium wines (Stringer and Wittwer 2001). On the other hand, production in the major irrigation areas along the Murray make up 62 per cent of all grapes crushed for wine (ABARE 2004).

Table B.1 summarises the assumptions made for wine grape production under no irrigation and alternative land uses. In brief, it is assumed that all current major irrigation areas along the Murray could not sustain a viable grape growing industry in the absence of irrigation. Nearly all other areas use water at strategic times and in varying quantities, but overall it is assumed that for these regions, in the absence of irrigation, there would be at least a 25 per cent drop in area and overall a 50 per cent drop in production on average. This simplifying assumption takes into account that some enterprises would not be viable, while others would suffer a substantial drop in yield in an average year.

Multipurpose grapes

Multipurpose grapes are mostly grown for table grapes under irrigation in hot dry areas such as the Riverina and St George in Queensland. In the absence of irrigation, these areas would be unsuitable for rain-fed table grape production. Hence, in the absence of irrigation, it is assumed that the land now under multipurpose grapes would be used for dryland grazing of beef cattle.

Table grapes require relatively little additional processing and it is assumed that domestic demand would be met by imports. Multipurpose grapes that end up being crushed for wine are included under wine grapes

Citrus, pome and stone fruits

Fruit industries

Australian production of citrus, pome and stone fruit amounted to approximately 1.3 million tonnes in 1996-97, grown on 76 000 hectares of land. In the main, these crops are grown under irrigation although the amount of water applied varies depending on location. Table 5 summarises

B.1 **Assumptions for wine grapes with removal of irrigation**

State and region	*Approximate water use*	*Area*	*Production*		*Impact of removing irrigation*		
		2002-03	*1996-97*	*2002-03*	*Assumed fall in area*	*Assumed fall in production*	*Alternate land use*
	ML/ha	'000 ha	kt	kt	%	%	
South Australia							
▪ Barossa	2.0	10.8	61.8	58.2	25	50	Cropping
▪ Central (McLaren Vale, Adelaide Hills, Plains, Fleurieu, Langhorne)	2.0	20.2	59.3	123.1	25	50	Grazing/ Cropping
▪ Northern (Clare, Lower Flinders, other)	2.0	0.2	18.3	20.1	25	50	Cropping
▪ South East (Padthaway, Coonawarra, Limestone Coast)	2.0	13.3	66.6	79.7	25	50	Cropping
▪ Murray – Riverland	7.5	22.0	219.3	378.3	100	100	Grazing
Victoria							
▪ Kerang – Swan Hill	7.5	2.6	40.3	49.2	100	100	Grazing
▪ Sunraysia–Mildura	7.5	25.1	123.5	183.8	100	100	Grazing/ Cropping
▪ Other Victoria	2.0	10.6	35.4	73.8	25	50	Grazing
New South Wales							
▪ Hunter Valley	4.0	4.5	20.8	32.7	25	50	Grazing
▪ Murrumbidgee Irrigation Area	7.5	23.0	89.5	196.2	100	100	Grazing
▪ Sunraysia	7.5	23.0	15.9	84.5	100	100	Grazing
▪ Other New South Wales	4.0	9.5	27.5	67.5	25	50	Grazing
Western Australia	4.0	11.7	21.9	642	25	50	Grazing
Total[a]		**157.5**	**800.2**	**1 400.4**			

[a] Includes minor wine growing areas in Tasmania.

Source: ABARE 2004, ABS catalogue No.1329, CIE.

the irrigation requirements for each fruit type in the main regions where citrus, pome and stone fruit are grown. The differing irrigation requirements are principally a function of different evapotranspiration rates — with the hotter, drier regions requiring higher water inputs. In places where irrigation requirements exceed 7 ML per hectare, we assume that production would shut down completely in the absence of irrigation. Based on 1996-97 production levels, this would result in:

- 95 per cent of Australia's citrus production being lost
- 72 per cent production loss in pome fruit
- 85 per cent production loss in stone fruit.

In other areas where irrigation is less critical it is assumed that production would continue but at significantly lower yields. For example, a 80 per cent yield reduction is assumed for crops grown in regions with an irrigation requirement of between 5 to 7 ML per hectare. This corresponds to some high rainfall areas in Queensland, the Sydney-Hunter region in NSW and

B.2 **Impact of suspending irrigation on the fruit industries — model assumptions**

State	*Horticultural region*	*Irrigation requirement (ML/ha)*			*Impact of suspending irrigation*	
		Citrus	Pome fruit	Stone fruit	Yield loss	Alternative land use
Queensland		ML/ha	ML/ha	ML/ha	%	
	Atherton/Mareeba	5.6	N/A	N/A	20	—
	Emerald	8.0	N/A	N/A	100	Cattle grazing
	Mundubbera/Burnett & Bundaberg	8.0	N/A	N/A	100	Cattle grazing
	Sunshine	5.0	N/A	N/A	20	—
	Stanthorpe	N/A	4.2	5.2	20	—
New South Wales						
	Sydney/Hunter	5.4	3.7	4.2	20	mixed sheep-cropping
	Central/Batlow	8.2	6.4	6.6	100	mixed sheep-cropping
	MIA	11.0	9.0	9.2	100	sheep
	Sunraysia	11.0	9.0	9.2	100	sheep
Victoria						
	Goulburn/Loddon	9.5	7.8	8.0	100	mixed sheep-cropping
	Sunraysia	11.0	9.0	9.2	100	sheep
	Rest of Victoria	6.2	4.8	5.1	20	—
Tasmania						
	Northern Tasmania	na	3.1	3.5	10	—
South Australia						
	Riverland	11.0	9.0	9.2	100	sheep
	Rest of SA	8.6	7.0	7.2	100	mixed sheep-cropping
Western Australia						
	South West WA	8.7	7.0	7.2	100	sheep and cattle

[a] N/A (not applicable) indicates that no significant production occurs in the specified region

Source: Queensland irrigation requirements from Barraclough & Co (1999). Other water use data from Charles Thompson, Horticulture Australia, pers. comm., 12 February 2003.

southern Victoria. In Tasmania, where irrigation requirements are typically less than 4 ML per hectare, a 10 per cent yield reduction is assumed.

Table B.2 also outlines our assumptions about the likely 'next best' alternative land use for those areas that go out of fruit production.

Vegetables

Vegetables are grown on about 130 000 hectares, nearly all under irrigation or watering but with varying amounts of water application rates. They are grown in all states with production methods varying from large scale irrigation in supplemented irrigation schemes, to small market gardens close to capital cities. In higher rainfall areas with cooler climates vegetables are generally 'watered' rather than irrigated. About 40–45 per cent of vegetables are produced under large scale irrigation.

In the absence of irrigation the simplifying assumption is made that 80 per cent of vegetable production and area would cease to exist. The land would be used for dry land cropping or grazing (50 per cent each). This takes into account that small scale or commercial market gardener vegetable production near capital cities would continue and indeed could expand in response to higher vegetable prices. Also, homegrown vegetables production would increase as would imports.

Cane

In the absence of irrigation, the area of sugar cane planted would be some 18 per cent lower than at 1996-97 levels and the majority of remaining cane planted would experience 25 per cent lower yields than those in a normal year. In total, it is assumed that cane production would be 30 per cent lower than in a normal year. These effects depend on the balance between rainfall and crop requirements which was evaluated for each mill area in Australia. The key assumptions are summarised below.

- In 1996-97, irrigation accounted for 52 per cent of total cane production.
- Regions dependant on high rates of irrigation (10 ML per hectare and above) would close and revert to cattle. These include all of the Burdekin, some parts of mill areas in the North including the Tableland mill area, and all of the Ord River.
- Regions that currently are not irrigated or lightly irrigated such as the Herbert and the high rainfall mill areas in the North would remain unchanged.
- Remaining mill regions who supplementary irrigate — at rates between 3 to 4 ML per ha — are assumed to experience a 25 per cent reduction in yield on average.

Dairy

To evaluate the size and structure of a dairy industry without irrigation, a database of production, land use and irrigation for 28 dairy regions was constructed from the dairy industry strategic review *Sustaining Our Natural Resources — Dairying for Tomorrow.* Overall, irrigation is responsible for about 60 per cent of milk production.

Currently the industry can be split into seasonal and non-seasonal components. Without irrigation, the seasonal industry centred around Gippsland and WestVic Dairy areas, dairying in Tasmania and the South

East region of South Australia would decline slightly. Some areas in Gippsland and WestVic Dairy are irrigated and these would revert to rainfed pasture base dairy industries. These areas, accounting for 48 per cent of milk production, are characterised mainly by rain fed pastures and are export oriented. Because they are pasture based, these areas are low cost but are heavily dependant on lower value manufacturing sales.

The remainder of the industry is heavily dependent on irrigation and can be split into those areas that are:

- sub-tropical — northern NSW and Queensland; and
- dry temperate areas — those in the Murray and Riverina, the Rivers and Lakes region of South Australia and farms in Western Australia.

For these regions, dairying would either close or suffer significant losses in profitability. The loss in profitability would come through either a loss in productivity per cow or alternatively an increase in (supplementary) feed costs required to maintain milk yield.

Production in the Murray Dairy region and the Rivers and Lakes region of South Australia would not be possible without supplementary irrigation — these regions currently account for around 30 per cent of milk production by volume.

- Land in these areas would revert to traditional grazing/cropping systems.

Remaining regions, which account for 22 per cent of production, would suffer a decline in yield per cow or an equivalent increase in per unit feed costs per cow to maintain yield. To illustrate the value of irrigation for these regions, we reduce yields per cow by 30 per cent under the no irrigation concept.

C Members of the Steering Committee

The Steering Committee

Mr Murray Chapman

Program Coordinator
National Program for Sustainable Irrigation
Land and Water Australia

Mr Ross Dalton

General Manager, Water and Murray Darling Basin,
Natural Resource Management
Department of Agriculture, Fisheries and Forestry

Dr Onko Kingma

Director
Capital Agricultural Consultants Pty Ltd (CapitalAg)
Canberra

Mr George Warne

General Manager
Murray Irrigation Ltd

Ms Sandy Robinson

Manager, Irrigation Regions Program
Murray Darling Basin Commission

Mr Bernie George

General Manager, Auscott
Member, NSW Irrigators Council
Togo Station

Mr Andrew McNab

Board Member, Apple and Pear Australia Ltd
Admona, Goulburn Valley

Mr Shahbaz Khan

Research Director, Irrigation Directorate
CSIRO Land and Water

Glossary

ABS	Australian Bureau of Statistics
Agricultural income	This is the income accruing from agricultural production during the year. It is equal to gross agricultural product at factor cost (gross value of agricultural production less costs) less consumption of fixed capital (depreciation), payments to employees and net rent and interest payments. Published by the ABS as part of the national accounts
Cap	The volume of water that would have been diverted in the MDB under 1993-94 levels of infrastructure development
CIE	Centre for International Economics
CIT	Central Irrigation Trust, South Australia
COAG	Council of Australian Governments
DLWC	Department of Land and Water Conservation
DIPNR	Department of Infrastructure, Planning and Natural Resources, New South Wales
GDP	Gross domestic product: the total market value of goods and services produced in Australia after deducting the cost of goods and services used up in the process of production (intermediate consumption), but before deducting consumption of fixed capital
GL	Gigalitres = 1000
GMW	Goulburn Murray Water
GVP	Gross Value of Production: this is simply the total volume of output from an industry multiplied by market prices at the wholesale or first point of sale level. The prices used exclude GST. The ABS publishes estimates of GVP
Irrigation	This study refers to irrigation as meaning the application of water through pipes or channels to crops, pastures or horticultural plants to promote production on commercial farms — those with an EVAO of at least $5000

IWP	Irrigation water providers
MDB	Murray Darling Basin
MDBC	Murray Darling Basin Commission
MIL	Murray Irrigation Limited
ML	Megalitre = 1 million litres megalitres = 1 000 million litres
NCP	National Competition Policy
Net value of farm production	This is the gross value of farm production less total farm costs and is published as ABARE Farm Surveys
Opportunity cost	Refers to the foregone benefits from using water in one activity, which precludes it from use in another economic activity
Profit at full equity	This is the gross value of production (price x quantity produced) less all variable costs less fixed costs (but excluding interest on borrowed capital). This measure was used by the National Land and Water Resources Audit and estimates were synthesized from basic production, price and cost data for each region
R&D	Research and development
SCS	southern connected system
TFP	Total factor productivity: what value of output for an industry, or production unit, relative to the total value of inputs.
Value added	This is the value of goods and services produced (value and output) less the costs of goods and services used up by the industry in the production process (intermediate consumption). It is equal to the gross value of output less all variable costs less fixed costs, but excluding from fixed costs any payments to land, capital and owner operating labour. Thus, value added is the returns to these fixed factors of production.
WUE	Water use efficiency used in this report is the amount of water applied to irrigated crops or pastures for a given level of production. An increase in WUE refers to the reduction in water use for any given level of production.

References

ACIL Consulting 2002, *Economic Impacts of the Draft Water Sharing Plans, An Independent Assessment for the NSW Department of Land and Water Conservation*, ACIL.

ABS (Australian Bureau of Statistics) 2002, Australian System of National Accounts 2001-02, ABS catalogue No. 5204.0, Canberra.

—— 2000, Water Account for Australia 1993-94 to 1996-97, ABS catalogue No. 4610.0, Canberra

ACIL Tasman (2003), *Scope for Water Use Efficiency Savings as a Source of Water to Meet Increased Environmental Flows — Independent Review*, Report to the Murray Darling Basin Commission, Canberra.

CapitalAg (Capital Agricultural Consultants Pty Ltd) 2002, *The Potential for Improving Water Use Efficiency: A Scoping Study of Opportunities for Change and Possible Policy Approaches for the Murray Darling Basin*, First Paper, Project I2115.

CARE (Centre for Agricultural and Regional Economics) 2003a, *A Socio-economic Analysis of the Impact of the Reduction in Groundwater Allocations in the Namoi Valley, Socio-economic Profile of the Namoi*, http://www.dotars.gov.au/regional/adjustment/namoi/docs/_Toc52958745, Accessed 21 May 2004.

—— 2003b, *A Socio-economic Analysis of the Impact of the Reduction in Groundwater Allocations in the Namoi Valley, The Impact of the Namoi Groundwater Plan*, http://www.dotars.gov.au/regional/adjustment/namoi/docs/impact_report2.doc, Accessed 21 May 2004.

Coleambally Irrigation Cooperative Limited 2003, *Annual Environment Report 2003*, Coleambally, New South Wales.

CRCFE (Cooperative Research Centre for Freshwater Ecology) 2003, *Ecological Assessment of Environmental Flow Reference Points for the River Murray System*, interim report prepared by the Scientific Reference Panel for the Murray–Darling Basin Commission, Living Murray Initiative, Canberra.

Dee, PS 1989, *FH–ORANI: A Fiscal ORANI with Horridge Extension*, Industries Assistance Commission, Impact Project Preliminary Working Paper No. OP-66, Melbourne.

Dixon, PB, Parmenter, BR, Sutton, J and Vincent, DP 1997, *ORANI: A Multisectoral Model of the Australian Economy*, North-Holland Press, New York.

DNRE (Department of Natural Resources and Environment) 2001, *The Value of Water: A Guide to Water Trading in Victoria*, State Government Victoria.

DLWC (Department of Land and Water Conservation) 2002, *Water Management Act 2000, Structural Adjustment for Namoi Groundwater Users*, http://www.dlwc.nsw.gov.au/care/water/groundwater/reforms/namoi_groundwater.pdf, Accessed 21 May 2004.

Harrison, WJ and Pearson, KR 1996, 'Computing solutions for large economic general equilibrium models using GEMPACK', *Computational Economics*, vol. 9, pp. 83–127.

IPART (Independent Pricing and Regulatory Tribunal of New South Wales) 2001, *Department of Land and Water Conservation: Bulk Water Prices*, Determination No. 3, Sydney.

IAC (Industries Assistance Commission) 1987, *A Guide to the IAC's Use of the ORANI Model: Information Paper*, AGPS, Canberra.

Jayasuriya, R, Crean, J and Hannah, R 2001, *Economic Assessment of Water Charges in the Lachlan Valley*, NSW Agriculture report to the Department of Land and Water Conservation, Orange, Australia.

Marsden Jacob Associates 2003, *Improving Water-Use Efficiency in Irrigation Conveyance Systems: A Study of Institutional Arrangements*, Land & Water Australia, Product Number PR030493, Camberwell, Victoria.

MDBC (Murray Darling Basin Commission) 2003, *Water Audit Monitoring Report 2001/02: Report of the Murray–Darling Basin Commission on the Cap on Diversions*.

—— 2000, *Review of the Operation of the Cap, Overview Report of the Murray Darling Basin Commission including four Companion Papers*, August 2000, Canberra.

Nancarrow 1998, *Developing Fair Processes for the re-allocation of Groundwater for Long Term Sustainability in the Namoi Valley*, cited in Wolfenden, J. and Van der lee, J. 2002, *A Social and Economic Assessment of Options/Recommendations for the Upper and Lower Namoi Groundwater Sharing Plan,* A Report Presented to the Namoi Groundwater Management Committee on behalf of the Department of Land and Water Conservation, http://www.une.edu.au/cwpr/waterpol/research/namoi.htm, Accessed 21 May 2004.

NLWRA (National Land and Water Resources Audit) 2001, *Australian Water Resources Assessment 2000*, Land & Water Australia, Canberra.

—— 2002, *Australians and Natural Resource Management 2002*, Land & Water Australia, Canberra.

Nursery and Garden Industry Australia, 2003, '*Australian Garden Market Monitor*, June.

Rendall McGuckian 2002, The Cost of Producing Rice in Australia, RIRDC Project No GUK-2A, Canberra.

Thomas, J. F, Adams, P., Dixon, P, Hall. N and Watson, W. 1999, *Water and the Australian Economy*, a joint study project of the Australian Academy of Technological Sciences and Engineering and the Institution of Engineers, Australia, April 1999.

Wolfenden, J. and Van der lee, J. 2002, *A Social and Economic Assessment of Options/Recommendations for the Upper and Lower Namoi Groundwater Sharing Plan, A Report Presented to the Namoi Groundwater Management Committee on behalf of the Department of Land and Water Conservation*, http://www.une.edu.au/cwpr/waterpol/research/namoi.htm, Accessed 21 May 2004.