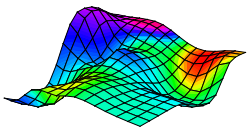
Report to the

Murray Darling Basin Authority

Review of social and economic studies in the Murray Darling Basin

15 March 2010



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The Murray-Darling Basin Authority commissioned this report, amongst a number of consultancy reports, to examine a range of different aspects of the socio-economic implications of reducing current diversion limits. These studies were conducted at specific points in time during the development of the proposed Basin Plan and aimed to analyse the likely implications of a range of potential scenarios for reducing long-term average diversion limits in order to inform the MDBA on options for setting Sustainable Diversion Limits and other aspects of the proposed Basin Plan.

Acknowledgement

The MDBA commissioned BDA Group, in conjunction with Professor Quentin Grafton and Samuel McGlennon, to review social and economic studies in the Murray Darling Basin.

The project team is grateful for the assistance and support provided by officers of the MDBA and State agencies contacted. Despite every effort to verify information and clarify issues raised, any remaining errors or omissions are the responsibility of the authors. Accordingly, this report does not necessarily reflect the views of the MDBA or those who have provided information to us.

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Table of Contents

EXECUTIVE SUMMARY

The aim of this study has been to identify social and economic studies in the Murray Darling Basin, and for each to document the commissioning organisation, author, objectives, scale and scope, methods used and a brief abstract of the work. A list of the identified studies reported since 2000 is provided in Appendix A while the required details of each is provided in Appendix B.

In addition to this task, a brief overarching review and synthesis of the findings and their relevance to assessing the likely socio-economic implications of the proposed Basin Plan was sought.

In our review we identified a growing body of socio-economic research applicable to water use in the Murray-Darling Basin. The economic research includes models of the hydrology and economics of agriculture of the Basin. Models differ in terms of the specification, parameter values, method of solution and their spatial dimensions.

The principal questions evaluated in the economic studies identified include:

- the effects of weather and/or climate-related reductions on returns in irrigated agriculture and water quality (salinity);
- the effects of different environmental flow regimes (including reduced water diversions) and government 'buyback' programs on returns in irrigated agriculture and water quality (salinity); and,
- the effects of water trade, restrictions on water trade, and water pricing reforms on returns in irrigated agriculture and water quality (salinity).

A number of studies have also sought to identify off-farm flow-on impacts associated with these issues, while others have examined the economic and social changes arising from water sharing plans. Some more locally oriented studies have examined the socio-economic impacts associated with irrigation infrastructure retirement.

Several environmental valuation studies have been conducted to derive monetary estimates of the value communities place on riparian assets. The choice modelling techniques has been most prominent in these studies, with valuations being extended to include social values such as rural employment and indigenous heritage values.

Models have been developed with different spatial scales depending on data availability and the research question posed, while from a sectoral perspective, irrigation industry models have been the most numerous.

Most models are short-run in nature in that they assume the irrigation infrastructure is fixed to when the model is calibrated. The investigation of flow-on impacts to other sectors has been characterised by local and regional studies using input-output techniques and Basin-wide studies using general equilibrium models.

Geographically, studies of water use in the lower connected Murray have been most common, in part due to the significance of these regions but also due to the broader policy questions arising with the greater regulation of flows and allocations compared to the northern catchments.

Finally, studies have focussed primarily on surface flows and allocations from rivers and storages, with relatively few studies investigating the use of groundwater resources.

Summary findings across a number of the more prevalent research topics are provided below:

Key findings from studies on water buybacks:

- All water recovery measures cause some social impact. The majority of identified social impacts associated with water recovery measures are likely to be short term as communities are constantly adapting to change;
- Purchasing water is generally the most cost-effective way of transferring water from the irrigation sector for environmental use;
- Hydrological and institutional factors will affect the scale of impacts associated with water buybacks. Net revenue reductions to irrigation will be less where water acquisitions are targeted from low-value regions rather than purchased proportionally from all regions;
- The value of agricultural output is estimated to fall much less than proportionally to reduced water availability *as long as there is unrestricted trade in water to facilitate adjustment;*
- There appears to be some prospect of counter cyclical trading delivering water for environmental use while supporting the financial viability of irrigation;
- Some towns and local economies, notably those in water selling regions that are heavily reliant on irrigated agriculture, could however experience larger impacts; while
- Impacts at the regional and basin level will fall less than proportionally to the irrigated agriculture sector impacts, and may even be positive when the expenditures of income from buybacks in regional economies is included.

Key findings from studies on reduced water availability:

- Water trading has played a critical role in helping to maintain irrigation sector incomes during drought and will play a major role in dampening the impacts from climate change on the irrigation sector;
- As would be expected, declines in water diversions and an increase in the frequency of droughts due to climate change has been estimated to have significant negative effects on irrigation;

- In addition to the effects of lower average water availability, an increasing variability in water availability will have further significant negative effects on irrigation;
- However modelled impacts on irrigation incomes are significantly less than the proportional reduction in water availability (as farmers are able to adapt their practices and trade water) such that farmers can effectively adapt to mild or moderate climate change;
- In more severe climate change scenarios greater costs are estimated, with a shift away from perennial to annual crops identified as the latter can be managed more profitably when water allocations in some years are very low;
- The most vulnerable regional economies will be those where water reductions are greatest, and where the agricultural and related processing industries comprise a relatively large proportion of economic activity; and
- In addition to climate change and greater diversions for environmental purposes, other factors that will contribute to reduced water availability for irrigation include groundwater depletion, bush fires, farm water interceptions, lower return flows from improvements in irrigation efficiency, and afforestation.

Key findings from studies on water market reforms:

- The benefits of introducing trading within irrigation districts are likely to have been greater than the benefits of a further expansion of trade between regions;
- Communities can find change and adjustment to water market outcomes difficult. In particular, communities in regions exporting water experience reduced populations and less local spending. Also, the manner in which supply authorities recoup fixed costs from irrigators remaining in the system will have distributional effects;
- However water trading is commonly considered a catalyst for change that would in any case have happened as a consequence of drought, variation in commodity markets and rural adjustment;
- From an assessment perspective, it is difficult to untangle the effects of water trading from the background of drought. Any approach implying that all impacts associated with changes in water use are attributable to or caused by water trading would be misleading and unhelpful for policy development;
- Limits on water entitlements that can be transferred out of an irrigation district lead to efficiency losses, general market uncertainty and prevents irrigators receiving the proper market value of their water entitlements. Similarly, the elimination of exit and termination fees will boost water trade. Collectively these water market reforms will moderate the negative impacts that may be associated with reductions in water availability; and
- Experience suggests that the nation, regions and communities will be better off if governments remove impediments to adjustment and expedite change; and separately manage the consequences including any adverse effects on third parties, rather than trying to buffer or even counter change. When adjustment is impeded, the most significant adverse impacts are often on the capacity of the most talented in a district or an industry to innovate.

Key findings from studies on the valuation of riparian environmental assets:

- Environmental value estimates have been found to differ across catchments and between residents within and outside of the catchments where the environmental assets are located;
- Available estimates suggest Australians hold significant values for the recreational and environmental assets of the Murray-Darling Basin; and
- These values could be drawn on, via the benefit transfer technique, to make inferences in relation to monetary valuations of environmental impacts arising from the Basin Plan

Key findings from studies on assessment integration techniques:

- Social impacts such as changes in rural employment or the availability of recreation facilities can be valued along with environmental impacts in choice modelling studies; and
- By valuing the full range of economic, environmental and social impacts that may arise from policy changes, such as the MDBA Basin Plan, a truly integrated and comprehensive assessment of the net benefits can be made

In summary, there are sufficient and well developed socio-economic models of the MDB to help answer a range of important questions to assist the MDBA in its Basin planning process. However, when drawing on this capability, care is required to ensure that deliverables are tightly aligned with the needs of the Authority.

As no existing model or suite of models is capable of meeting all likely expectations, ongoing liaison with service providers will be critical to ensure only realistic model development is attempted in the available time and that the modelling effort is targeted to shed the maximum light possible on the policy issues at hand.

Non-market values of the Basin's key environmental assets should be quantified. Benefit transfer could be used, where appropriate, to estimate the possible *range* of values under different assumptions. However given the likely importance of providing decision makers with information on the community's valuation of the benefits of realising the Plan's environmental watering strategy, a primary valuation study may be required for key environmental assets or classes of assets. The Choice Modelling method provides a robust technique which could be employed at modest cost in the available time (around 3 months) and could also provide information on the community's willingness to trade-off, for example, irrigation sector employment or the maintenance of rural communities, for environmental improvements.

A longer-term investment strategy would be to link, and where appropriate, integrate existing models and methods to quantify the trade-offs of different sustainable diversion limits by catchment and across the Basin. One way to link theses models is to iterate back and forth between hydro-economic

models and hydro-ecological models, also linked to non-market valuation studies, to quantify the costs and benefits of different levels of water availability for use and non-use.

A range of different water diversion limits could then be used as inputs into regional economic impact models and existing social impact assessments to assess the broader community and regional impacts of water diversion alternatives. The broader regional effects could then, in turn, be used to re-evaluate the water allocation trade-offs through a further iteration of the hydro-economic and hydro-ecological models.

1 INTRODUCTION

In this section a brief introduction to the Basin Plan and commonly used assessment techniques is provided. This is followed with a brief description of the literature identified and assessment techniques employed in Sections 2 and 3 respectively. In Section 4 a review of the key findings from the literature is provided ahead of recommendations in relation to the relevance of the studies for the MDBA in assessing the emerging Basin Plan.

1.1 The Basin Plan

The National Water Initiative, the Water Act 2007 and the 2008 Water for the Future policy are water reforms that have a major objective of achieving protection and restoration of environmental assets of the Murray-Darling Basin, and outside the Basin where the Commonwealth owns water.

The Water Act 2007 establishes the Murray-Darling Basin Authority (MDBA) and requires it to establish a Basin Plan - a strategic plan for the integrated and sustainable management of water resources in the Basin. This Basin Plan must include an Environmental Water Plan (EWP), which will have the objective to protect and restore rivers, wetlands and other environmental assets, and to protect biodiversity dependent on the Basin's Water holdings in accordance with the EWP.

The Basin Plan is being developed to support the integrated management of the Basin's water resources. The plan will identify key environmental assets and ecosystem functions of water resources that must be protected. It will also identify risks to the condition or continued availability of Basin water resources and provide strategies for managing those risks.

In setting the Basin plan, the MDBA must take account of risk (hydrological, implementation, etc.) and also the possible trade-offs between environmental flows and water diversions. Critical to quantifying these trade-offs are socio-economic and hydrological-economic models of the Basin to assess the losses to agriculture from alternative sustainable diversion limits.

This will require hydrological-economic models that can assess the effects of different sustainable yields on agricultural net returns in the Murray-Darling Basin. In addition, the capacity to undertake risk and simulation analysis to consider different inflow regimes is likely to be important as lower inflows will increase the marginal value of water to irrigators.

The analysis must also go beyond the economic returns to agriculture and consider the potential impacts on communities and trade-offs between alternative environmental assets. This necessitates a wider suite of impact valuation and assessment techniques and introduces considerable challenges in the integration of identified impacts from different models using different metrics and underlying assumptions.

The MDBA will need to carefully consider what suite of techniques, analytical frameworks, datasets and research providers that can best deliver an integrated and robust assessment of the Basin Plan and its component parts.

To assist both the development of the Basin Plan and determination of the likely social and economic implications of the proposed plan, an understanding of the existing and evolving knowledge base and analytical capacity is needed. To this end the purpose of this study is to identify recent social and economic research and analytic work undertaken in relation to the Murray-Darling Basin. In addition, the project seeks to provide an overarching review and synthesis of findings to help guide MDBA's own social and economic impact assessment and to inform further investment in impact analyses.

1.2 Social and economic assessment techniques

The three commonly used assessment techniques relevant to evaluation of the economic and social impacts of water use in the MDB are:

- Benefit cost analysis (economic assessment);
- Regional impact assessment; and
- Social impact assessment.

Each of these evaluation methods is briefly outlined in the following sections together with the relevant indicators and measures of impact.

1.2.1 Benefit cost analysis

Economic analysis is primarily concerned with the efficiency with which resources are used and allocated, and seeks to capture all changes in resource use across the community that affect the overall welfare of society. The purpose of the analysis is to determine whether a proposed policy will deliver benefits to society that exceeds any costs incurred. The main method for analysing economic efficiency is benefit cost analysis (BCA).

The essence of benefit cost analysis is the comparison of the “with” scenario to the “without” or base case scenario and the identification and valuation of the incremental or marginal costs and benefits to the community. In other words, the societal benefits of a change are compared with the societal costs. It aims to encompass the full range of benefits and costs experienced by all members of the community, including those that may not be immediately expressed in monetary terms such as environmental effects. Hence the indicators relevant to benefit cost analysis may be many and varied depending on the specific nature of the effects felt by the community.

The concepts of benefit and cost used in benefit cost analysis are specifically related to the well-being of people and are carefully defined in economic theory. Well-being in economic theory is

defined as arising from both the consumption and production of goods and services. These goods and services may be many and varied and can be both traded in markets or exist outside of traditional markets ('*non-marketed*').

The benefit derived by a consumer of goods and services is valued as the difference between what that person would be willing to pay (WTP) for the good or service and what they have to pay. This net benefit to consumers is the "consumer surplus". Consumer surplus values may be associated with use and non-use of a resource and hence is the relevant measure of value for non-market recreation, biodiversity conservation, ecosystem services etc.

Valuation of the consumer surplus associated with non-market environmental impacts requires implementation of non-market environmental valuation techniques. The key techniques are listed in Table 1.1.

Table 1.1: Main types of environmental valuation techniques

Market based	Revealed preference (or surrogate market)	Stated preference (or survey technique)
Productivity method	Travel cost method	Contingent valuation
Human capital approach	Wage differential method	Choice modelling
Defensive expenditures	Property valuation method	
Replacement or repair cost		
Opportunity cost method		

The producers of goods and services can also generate surpluses. By combining resources in ways that increase their value to society, producers improve the well-being of the community. The producer surplus is the difference between the costs of the inputs used in the production process and the price received for the finished product. Producer surplus values can generally be estimated from market data.

Both the consumer and producer surplus concepts relate to additions to the well-being of the people involved. If a resource re-allocation enables some of the people affected to experience greater consumer or producer surpluses, then these people are beneficiaries of the change. The extent of the change in their consumer and producer surpluses is a measure of their benefits. Conversely, if reductions in these surpluses are experienced, the people so affected are worse off. The extent of the reductions in surpluses is a measure of the community's costs.

To identify changes in consumer and producer surpluses, economists typically employ economic models that can capture changes in input use, production and consumption, with associated changes in prices and in surpluses generated. Of primary interest in this report are the empirical techniques used to estimate market and non-market impacts, rather than the application of benefit-cost assessment per se.

1.2.2 Regional economic impact assessment (REIA)

Regional economic impact assessment (REIA) is concerned with changes in economic activity to a region, State, or country associated with changes in land and resource use. Powell et al (1985)[1] identify a range of methods that can be used to examine the regional economic impacts including economic base theory, Keynesian multipliers, econometric models, mathematical programming models and input-output models. Input-output techniques are the most common, measuring impacts in terms of direct and indirect effects for four main indicators:

- *Gross regional output* – the gross value of business turnover;
- *Value-added* – the difference between the gross value of business turnover and the costs of the inputs of raw materials, components and services bought in to produce the gross regional output;
- *Income* – the wages paid to employees including imputed wages for self employed and business owners; and
- *Employment* – the number of people employed (including full-time and part-time).

These indicators of economic activity are not equivalent to the economic measures of consumer and producer surplus that are relevant in the benefit cost analysis framework.

Gross regional output is a measure of total revenue or turnover. All costs of production would need to be subtracted to make it approximate the measure of producer surplus. Value-added is an indicator of net value to producers, but unlike the producer surplus measure, it does not take account of all production costs – only non-labour costs are subtracted from revenue. Income or wages paid to employees is a cost to the producer in the benefit cost framework and is one of the costs subtracted from revenue or output to calculate the producer surplus or net benefit to producers. Employment is a non-financial indicator identifying the number of jobs associated with an activity. In regional economic impact assessment the employment figure can sometimes be referring to full-time equivalents or simply job numbers, whether they are full-time or part-time.

1 Powell, R., Jensen, R., and Gibson, A. (1985), *The Economic Impact of Irrigated Agriculture in NSW*, A report to the NSW Irrigators' Council Limited.

While full input-output analysis involves the construction of an input-output table for the region (model of the regional economy), often short cut approaches, involving borrowing multipliers from other studies, are used. Multipliers are simply the ratio of induced change in an indicator arising from an initial change in the indicator. So for example, if it had been estimated that investing $1m in Irrigation Area A led to an increase in regional output of $4m, then this would indicate an output multiplier of 4. Of course extrapolating this finding to say Irrigated Area B implicitly assumes that the economies of both regions are very similar.

Regional economic impacts may be associated with a reduction or increase in economic activity in a region. Changes in water use patterns arising from policy changes would normally be associated with both these effects and hence REIA could be undertaken in relation to both the lost economic activity and the gained economic activity.

Unlike benefit cost analysis there are no decision rules to identify whether an increase or decrease in economic activity is desirable, although it is often implicitly assumed that more economic activity is good and less economic activity is bad. However, not all economic activity is desirable from a community welfare perspective since it may be associated with say environmental degradation, loss of employment, etc. Indeed funding digging holes and filling them back up again would stimulate activity, output, value-added, income and employment, but lead to no economic benefit.

Benefit cost analysis is required to consider all the costs and benefits of a proposal that changes the levels or type of economic activity. REIA simply examines the financial and employment stimulus to an economy that occurs as a result of a change in economic activity.

REIA can have important links to social impact assessment since changes in income and employment levels can impact population levels and their ability to maintain community infrastructure (schools, hospitals, housing etc), broader community and cultural value systems and inter-relationships.

While input-output analysis is one of the main techniques for examining changes in economic activity at the local, regional and State level, it is a static approach that may over estimate impacts and hence careful interpretation of results in required. A dynamic computable general equilibrium approach may overcome the limitation of input-output analysis but is unlikely to be warranted at local or regional scale or with small scale impacts.

1.2.3 Social impact assessment (SIA)

Social impact assessment is concerned with “the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs, and generally cope as members of society. The term includes cultural impacts

involving changes to the norms, values and beliefs that guide and rationalize their cognition of themselves and their society"[2]

The process of SIA is often described in terms of a number of core generic procedural stages:

- Scoping – identification of important issues to be addressed in the SIA – via literature reviews and consultation;
- Profiling (baseline social assessment) – should focus on information against which change and impacts may be compared, and should identify other changes that have occurred or are occurring in communities and the extent to which these changes may influence the current impacts of interest;
- Prediction – identify and describe predicted social impacts, based on expert judgements, comparative methods (look at similar projects), numeric projection and quantification (population and employment multipliers etc);
- Evaluation – determination of community acceptability of impacts identified in prediction phase;
- Mitigation – addressing any negative impacts that are above acceptable thresholds;
- Monitoring – monitoring program to ensure that no unforseen impacts occur and that mitigation strategies are effective.

It is however rare to find a SIA that conforms to all these stages. The majority focus on the preliminary stages of scoping and profiling, as it is these stages for which information is often available and which can be readily obtained using existing methods and techniques.

Prediction and evaluation of social impacts is more difficult and the field of SIA lacks rigorous methodological techniques and methods to address these stages. Prediction is mainly based on expert judgement of the SIA practitioner who will draw information from community involvement processes and primary and secondary data.

A core dimension of the procedural framework is the technical – participatory dimension. Technical approaches are based on objective assessments, use of quantifiable indicators and expert judgments. Participatory approaches involve identification and prediction of impacts through the use of local knowledge within communities and amongst those most likely to be affected.

If there is limited community participation, SIA may omit issues of critical concern to communities (e.g. impacts on attachment to community or place, or the fairness and equity of decision making processes, or the micro distributional impacts of development and environmental change).

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2 The Internorganisational Committee on Guidelines and Principles for SIA (2003) Guidelines and principles for social impact assessment. *Impact Assessment* , 12(2), 107-112.

In SIA it also helps to provide an explanatory framework to assist in the identification and understanding of impacts. For instance, there are a number of conceptual frameworks that may be useful in understanding social processes operating in the context of SIA including social capital, social network analysis; social wellbeing, and community and social resilience.

A particularly relevant explanatory framework in the context of irrigation areas is social resilience – the potential for the social system to maintain its structure and function when faced with some disturbance, disruption or change and the ability of the social system to reorganise following the intervention and retain a functional state.

In a similar way to ecological systems, human and organisational diversity within a social system may well be associated with more robust and resilient social systems, while a social system with little diversity in their economic, human or organisational structure may be less resilient to change.

While the scope of SIA is dependent on the type of changes that are likely and the broader environmental, social and institutional context in which these changes occur, several authors have attempted to define the core SIA variables that may be used in the profiling and prediction phase of SIA.

Individual ABS census indicators can be used to provide:

- descriptive information about an area or catchment including population size, the number of occupied private dwellings, occupancy rate, employment by industry; and
- an indication of advantage or disadvantage within the community, or community vulnerability or sensitivity to change including age dependency, unemployment rates, workforce participation and family, occupation, income and educational characteristics.

Composite social indicators such as those provided by ABS (eg: index of relative socio-economic disadvantage), can also provide an indication of relative advantage or disadvantage and sensitivity to change. Fenton (2000)[3] has developed composite indicators of community sensitivity combining profile information on:

- unemployment and income;
- education and occupation;
- family and housing; and
- age dependency.

[3] Fenton, D.M. (2000). Social Catchments and Socio-Demographic profiles for the South Brigalow CRA/RFA Region (NSW). Department of Urban Affairs and Planning, Sydney

Not all variables with the census of population and housing need to be examined and there will often be a core subset of census variables which will be important to meet the specific objectives of the SIA being undertaken. The selection of specific census variables and indicators will be dependent on the social and geographic context of the SIA, the type of change that is being investigated and the conceptual framework that is being used to underpin the SIA.

As well as using social indicators, SIA may examine community infrastructure thresholds, values and place meanings, community attitudes etc.

For assessment of impacts at the community level, existing administrative and statistical boundaries[4] may be used or social catchments can be developed that accounts for much of the inter-town dependencies at the local level. Social catchments can be developed based on

- the number of businesses, industries and other service providers located within specific towns (the number of functional units);
- an examination of the road network within the region;
- distance between towns; and
- the density of towns and communities in the region.

1.2.4 SEA integration techniques

There are significant limitations in integrating assessment results into single metrics both within and across economic, regional and social assessment domains.

Benefit-cost analysis incorporates well developed assessment and valuation approaches that in principle allow a bottom-line economic assessment of changes in water use. However despite the proliferation of non-market valuation techniques, the monetarisation of non-use values held by the community (for example for ecosystem conservation) has practical difficulties, not least of which are the time and cost requirements of available techniques.

The use of changes in regional income is often used as a bottom-line measure of regional impacts. However, these impacts are in themselves only partial in terms of broader social impacts that may be incurred by communities. There are also no commonly supported approaches for aggregating diverse social impacts into a single metric.

Given the limitations in developing single objective measures within the economic, regional and social impact spheres, it is then not surprising that there is no commonly supported technique to aggregate across them to yield a single cardinal measure of impact.

4 For example such as SLAs (statistical local areas) or SSD (state statistical divisions)

To assist decision making (rather than impact assessment per se), there have however been a number of techniques developed to facilitate a consideration of trade-offs between economic, environmental and social impacts to allow alternative policy options to be ranked by a single ordinal metric. Attempts to do this have mostly centred on the use of multi-criteria analysis (MCA), also sometimes referred to as multi attribute analysis.

MCA is a decision support approach rather than a single well defined procedure, and refers to techniques that include the following three key components:

- a number of alternative plans or options that require evaluation;
- a set of criteria by which the alternatives are to be judged; and
- a method for ranking the alternatives based on how well they satisfy the criteria[5].

MCA is sometimes used to integrate the findings of economic and social evaluations or separately evaluate proposals. However, the approach suffers from a number of substantial problems including:

- there is no established theoretical framework or uniform set of principles;
- MCA involves the arbitrary choice of criteria and hence different analysts can apply different criteria to the same project and get different results;
- there is often double counting where the same impact is considered twice or more under different criteria;
- the absence of established principles means that different MCA analysts are unlikely to reach consistent conclusions about a policy measure;
- allocating scores or rankings to identify how an alternative performs against a criteria hides the relative size of impacts;
- MCA attempts to compare impacts that occur at different times with no means of reconciling the timing differences; and perhaps most importantly, and
- applying weights to different criteria is arbitrary, or at best reflective of the analysts or commissioning body's values rather than the community[6].

Alternatively, economists have recently started investigating the potential to use non-market valuation techniques, normally used to assess preferences about changes in environmental conditions, to investigate community's willingness to trade-off welfare gains with alternative distributions of welfare – effectively integrating economic and social impacts into a single assessment metric.

5 Resource Assessment Commission (1992) Multi-criteria Analysis as a Resource Assessment Tool, RAC Research Paper No. 6, AGPS, Canberra.

6 Bureau of Transport Economics (2000) Facts and furphies in benefit cost analysis: transport, Report No. 100.

In a paper by Rolfe and Bennett (2004)[7], community concerns and public values associated with the social consequences of water reform are presented. A contingent valuation survey is used to assess community preferences for different equity outcomes. The authors note:

> *'A key issue for economists is identifying mechanisms to deal with … localised equity and social impacts. This is a common issue in regional and urban economics, where the negative impacts from losing an industry (or a natural disaster event) tend to be localised. There is often pressure placed on governments to offer financial support to regional areas experiencing downturns in order to ameliorate adverse social and equity impacts*
>
> *'Where community concerns about equity impacts are present, one alternative is to … incorporate concerns about social welfare impacts directly into a BCA. This may be done by assessing those concerns in a valuation framework'.*

Specifically, Rolfe and Bennett used the contingent valuation method to estimate community values for providing 'free' allocations of water to under privileged groups in the central Queensland region, and found there were some, albeit small, community values associated with accounting for equity impacts in the water reform process. Their exercise demonstrated that it is possible to place values on community concerns about equity impacts, and that these values are suitable for inclusion in a BCA framework. Further examples in the water resources field are cited later in this report.

7 Rolfe and Bennett (2004), Assessing Social Values for Water Allocation with the Contingent Valuation Method, Valuing FloodplainDevelopment In The Fitzroy Basin Research Report No 11

2 DESCRIPTION OF LITERATURE IDENTIFIED

A literature review of studies reported since 2000 in relation to the socio-economic impacts associated with changes in water use in the Murray Darling Basin has been undertaken. A brief description of more than 100 socio-economic studies and models identified is provided in Appendix A. Further detail in terms of the aims, scale and scope, methods and data, and key findings for each of these studies and models are provided in the Appendix B.

A number of reports identified have not been reviewed for a variety of reasons including due to confidentiality considerations, where there were multiple research papers employing the same model, to answer essentially the same question, where a study had limited relevance (eg: theoretical or descriptive only), and where we have been unable to locate or access a copy of the study.

In this section, a very brief overview is provided in relation to the researchers / organisations undertaking the analysis, the objectives of the studies, and the scale and scope of application. An overview of techniques employed and key findings are then presented in sections 3 and 4 respectively.

2.1 Who has undertaken the more recent socio-economic studies

There is a growing body of socio-economic research applicable to water use in the Murray-Darling Basin. The economic research includes models of the hydrology and economics of agriculture of the Basin. Models differ in terms of the specification, parameter values, method of solution and their spatial dimensions.

Investigation of economic impacts associated with the decision to establish the *Living Murray* for example focussed primarily on the opportunity cost of sourcing water from on-farm uses. Initially this work employed the Water Policy Model - a spatial equilibrium model of farming activities in Victorian irrigation districts maintained by the Victorian Department of Primary Industries - as well as regional farm models developed by the NSW Department of Agriculture (see Eigenraam, Crean, Wimalasuriya and Jayasuriya (Vic DPI and NSW Agriculture) 2003) [ref.26]. However these models were short-run in nature and could not explore the potential for inter-state water trade to mitigate irrigation sector impacts from reduced water allocation / buybacks.

For this purpose, ABARE's SALSA model was employed to provide indicative estimates of likely long-run irrigation sector costs, both under trade and no-trade scenarios. To investigate likely flow-on impacts to other sectors, preliminary investigations drew on a new generation Monash model (TERM) developed by the Centre of Policy Studies with assistance from the NSW, Victorian and South Australian Governments.

However there has been significant development in economic and related models with which to investigate potential impacts from alternative actions that may be incorporated in the Basin Plan and in relation to the Basin Plan overall.

Dixon et al. (2009) [ref.11] used the new-generation TERM-H2O model to analyse the economic impacts of a water buyback (1,500 GL) in the southern MDB, while CSIRO has developed models to assess the effects on irrigated agriculture from increased environmental water allocations in the southern MDB (Mainuddin et al. 2007) [ref.1] as well as the significance of water trading in mitigating these impacts (Qureshi et al. 2007) [ref.2].

Researchers at the Productivity Commission (Peterson et al. 2005) [ref.13] used the TERM-WATER model to analyse the broader impacts of water trading in the southern MDB, while Singh et al (2008) [ref.83] have explored water trading within the NSW irrigation industry, and Bjornlund (2002; 2008) [ref.79, 80] has examined the impacts of water trade in northern Victorian irrigation districts.

Third party impacts from water trading have been investigated by ABARE (Heaney et al 2006) [ref.74], while a number of researchers have examined the impact on water trade of quotas imposed on entitlement trade out of regions (Access Economics 2008 [ref.75], Frontier Economics 2009 [ref.77] and Hyder Consulting 2008 [ref.78]).

Adamson et al. (2009) [ref.3] assessed the economic effects of different climate scenarios and states of nature on irrigated agriculture. Connor et al. (2009) [ref.9] use a different model to evaluate the economic impacts on irrigated agriculture from climate change. They assess the effects of three scenarios - mild, moderate and severe climate change in terms of reductions in inflows in the Basin. ABARE (Goesch et al. 2009) [ref.7] provide another model to assess the effects of climate change in the Basin.

Governments have also engaged a number of studies exploring agricultural impacts at the catchment and irrigation area scale, with examples including studies by Jayasuriya (2004) [ref.18], Jones et al (2007) [ref.27], Aluwihare (2005) [ref.30], Singh et al (2009) [ref.39], and the Centre for Agricultural and Regional Economics (largely in relation to northern catchments of the MDB).

Studies investigating the flow-on impacts of reduced irrigation sector incomes to regional and local economies include Spanswick et al (2007) [ref.44], Powell and Chalmers (2009) [ref.40] and RMCG (2009) [ref.45].

Social research in the Basin primarily involves studies of particular regions or communities. These studies are primarily in the grey literature and include some form of community impact assessment. A study by Hassall and Associates, Professor Helen Ross and Mary Maher and Associates (2003) [ref.128] was commissioned in support of the *Living Murray* investigations, however the analysis is restricted largely to social and economic profiling.

A key report that includes an analysis of both the economic and social impacts of water trading in the Victorian Murray Valley is a report for the Rural Industries Research and Development Corporation (Frontier Economics (2007) [ref.38].

Finally, there have been a number of non-market valuation studies exploring estimating the value of various aspects of improved river health. This includes choice modelling studies by Bennett et al (2008; 2007) [ref.112, 105], Gillespie et al (2008) [ref.107], Morrison and Bennett (2004) [ref.108], van Burean and Bennett (2000) [ref.109] and Whitten and Bennett (2001) [ref.116], while Dyack et al (2007) [ref.117] employ revealed and stated preference techniques to value recreational benefits associated with the Barmah Forest and the Coorong.

A choice modelling study under the *Living Murray* was developed, and included an international peer review of the proposed survey questionnaire, however the field work for the study was not undertaken and hence no values were derived; and

2.2 What have been the objectives of the studies

The principal questions evaluated in the economic studies identified include[8]:

- the effects of weather and/or climate-related reductions on returns in irrigated agriculture and water quality (salinity);
- the effects of different environmental flow regimes (including reduced water diversions) on returns in irrigated agriculture and water quality (salinity); and
- the effects of water trade, restrictions on water trade, and water pricing reforms on returns in irrigated agriculture and water quality (salinity).

A number of social and economic studies have also sought to identify off-farm flow-on impacts associated with these issues, at regional, state and national levels.

A number of studies have examined the economic and social changes arising from water sharing plans, while some more locally oriented studies have examined socio-economic impacts associated with irrigation infrastructure retirement.

Several environmental valuation studies have been conducted to derive monetary estimates of the value communities place on riparian assets. The choice modelling techniques has been most prominent in these studies, with valuations being extended to include social values such as rural employment and indigenous heritage values.

8 The key findings from these studies are addressed in Section 4

2.3 At what scale have the studies been conducted

Models have been developed with different spatial scales depending on data availability and the research question posed. The hydro-economic models developed at the University of Queensland and the Australian National University include all of the Basin. By contrast key economic models developed by CSIRO have limited their analysis to the southern Basin. Scale may also differ at a regional level depending on how catchments are aggregated by modellers.

2.4 What has been the scope of the studies

As the focus of the literature review has been on studies associated with water use, from a sectoral perspective irrigation industry models have been the most numerous. Models incorporating well developed hydrological relationships have been used to assess the economic impacts of changes in rainfall on water availability to the sector while other models have been limited to evaluating the effects of reduced inflows and / or water allocations.

Most models are short-run in nature in that they assume the irrigation infrastructure is fixed to when the model is calibrated. Ideally, models should allow for capital investments so as to permit shifts and possible expansion of irrigated area where it is profitable.

The investigation of flow-on impacts to other sectors has been characterised by local and regional studies using input-output techniques and Basin-wide studies using general equilibrium models such as the TERM model.

Geographically, studies of water use in the lower connected Murray have been most common, in part due to the significance of these regions but also due to the broader policy questions arising with the greater regulation of flows and allocations compared to the northern catchments.

Notably, studies have focussed primarily on surface flows and allocations from rivers and storages, with relatively few studies investigating the use of groundwater resources. Notable exceptions include studies by ABARE (Hafi and Goesh 2006 [ref.25]; Hafi et al 2006 [ref.24]) and by NSW government agencies in support of management plan development (see for example Flavel and Bari (2009) [ref.97] as well as (unsighted) studies by Jayasuriya (2000) [ref.57] and Cordina et al (2001) [ref.56].

3 REVIEW OF ASSESSMENT TECHNIQUES USED

In this section we describe the broad types of assessment techniques that have been applied in the MDB.

3.1 Hydro-economic models of irrigated agriculture

The existing models available on a Basin-wide level focus on surface water diversions rather than surface and groundwater. While this limits their usefulness in assessing the full costs of sustainable diversion limits, most current water diversions for irrigated agriculture are surface water extractions.

Some hydro-economic models capture groundwater interactions to model salinity impacts associated with river management and water use. However there are no current hydro-economic models that can examine the conjunctive use of ground and surface waters. This is a significant deficiency given the scope of the Basin Plan includes groundwater systems. Notably ABARE has identified the modelling options and challenges in developing a conjunctive water management model, and over time such modelling developments will be important[9].

In the past decade several models (Queshi et al. 2007 [ref.2]; Adamson et al. 2009 [ref.3]; Connor et al. 2009 [ref.9]; Goesch et al. 2009 [ref.7]; Grafton & Jiang 2010 [ref.6]) have been developed to evaluate basin-wide and catchment-level impacts of reduced seasonal allocations on irrigated agriculture. These models are catchment-based and link a hydrological model, or set of assumptions about the hydrology, to an economic optimisation model. The models differ in terms of their:

(i) spatial dimensions;

(ii) the data they use to calibrate their parameters;

(iii) the degree to which the hydrological and economic components of the models are linked;

(iv) the control variables and the objective function (gross value, gross margin, or economic profit);

(v) the way uncertainty is incorporated into the model; and

(vi) the research or policy questions that is addressed.

A common feature of the models is that they use an optimisation framework in the economic component and maximise the gross value of production, the gross margin or the economic profits from irrigated agriculture subject to a series of constraints that include the water and land available to irrigated agriculture by catchment.

9 Hafi , A. 2006, Conjunctive Water Management: Economic Tools for Evaluating Alternative Policy and Management Options, ABARE Research Report 06.20. Prepared for the Natural Resource Management Division, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, November

The optimisation component is linked to a hydrological model that provides stream inflows (based upon historical data), and possibly return flows (if coupled to the economic component) and the physical limits of water trading. The economic-hydrological models are calibrated or parameterised to a particular period where inflows and agricultural activities are known.

A heuristic description of the economic and hydrological components of irrigated agriculture models is provided in Boxes 3.1 and 3.2.

The economic component is typically a linear programming model where the objective function is linear in the chosen activities and the relationship between inputs and outputs is determined by fixed coefficients. Such models are optimised by choosing activity levels (a_{ij}), such as the area planted by crop in each catchment, that when multiplied by the weights or values (v_{ij}) associated with these activities, maximises the objective function across *all* irrigated land use and catchments.

Box 3.1: Economic Component of an Irrigated Agriculture Model

Objective Function:

Maximise $V = \sum_{i=1}^{N} \sum_{j=1}^{M} v_{ij} a_{ij}$

Constraints:

(1) water area constraints

(2) land area constraints

(3) other resource constraints

where: v_{ij} = net value of activity *i* in catchment *j*

a_{ii} = activity *i* in catchment *j*

Thus, if water has a higher value in use in one catchment relative to another, and the water can be physically traded, then the optimisation procedure will transfer water between the two catchments to increase the objective function. Constraints in terms of the land available for irrigated agriculture, the water available, and the physical limits to water trade restrict the levels of the activities to ensure the model mimics the actual cropping decisions for the year in which the model is calibrated.

The hydrological component of an irrigated agriculture model is stylised in Box 3.2.

Box 3.2: Hydrological Component of Irrigated Agriculture Models

$$outflow_j = inflow_j + runoff_j - diversions_j - net\ losses_j - \Delta storages_j$$

Where: $runoff_j$ = *f*(catchment size, precipitation, evaporation, etc.) in catchment *j*

$inflow_j$ = measured inflow in catchment *j*

$outflow_j$ = measured outflow in catchment *j*

$net\ lomes_j$ = *g*(direct evaporation, other losses, etc.) in catchment *j*

$diversions_j$ = direct water diversions in catchment *j*

$\Delta storages_j$ = change in water storages in catchment *j*

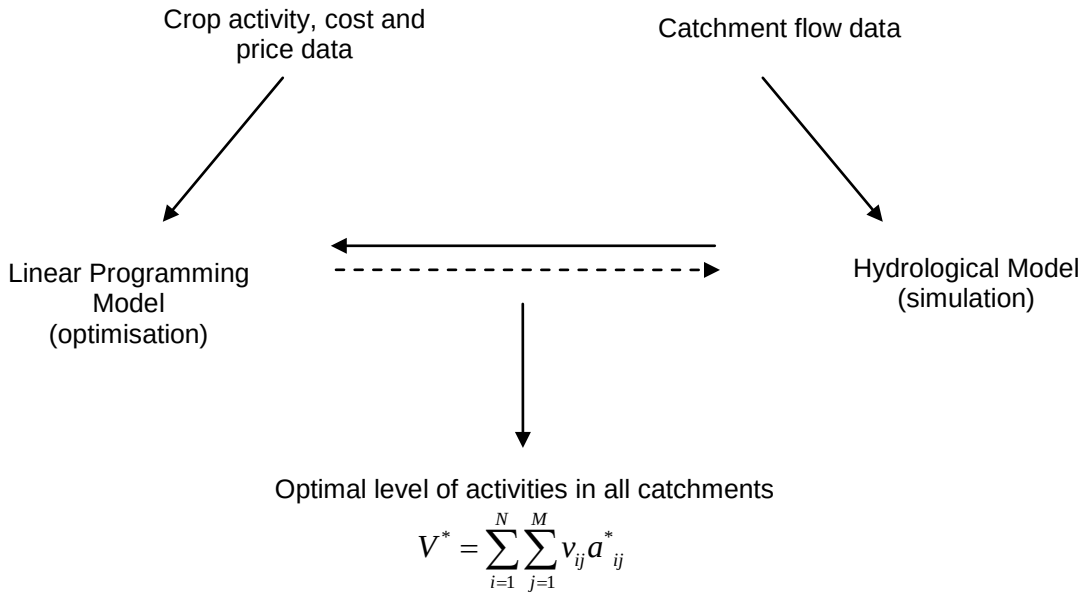
At a minimum, the water available for the activities in the economic component of the model (a_{ij}) must be consistent with hydrological realities. For a given catchment *j* the outflow at the end of the catchment must equal inflow into the catchment from up-river, runoff within the catchment less water diversions, net losses and change in storages within the catchment.

Depending on the sophistication of the hydrological model, consideration of return flows and effects of water use on salinity can also be included (see Adamson et al. 2007 [ref.4]) if there are feedbacks from the economic component to the hydrological component of the model.

The two components (economic and hydrology) may be linked in the sense that the activities from the economic component feedback into the hydrological model, such as in the calculation of return flows. Alternatively, the hydrological model provides information in terms of water availability in the catchments but the optimisation results in the economic component do not feedback into the hydrological component.

The possible links between the two components of these models is presented in Figure 3.1 with a dotted line indicating a possible link back to the hydrology.

Figure 3.1: The economic and hydrological components of irrigated agriculture models



If the components are linked there is feedback from the economic component to the hydrological component of the model. The optimal solution is defined by the optimal choice of activities (a_{ij}^*) that maximise the objective function. The solution not only determines the optimal level of the chosen activities (crop area for each catchment), but also water diversions by crop and catchment because there is a fixed relationship between the activity levels and water use.

The models can be used to assess the change in both the activities and the objective function by varying the constraints, such as the restrictions in terms of water trading and water availability, in each catchment.

Uncertainty can be incorporated into these models in several ways. One approach is to model different states of nature (dry, normal and wet) with defined probabilities where the choice set and inputs used vary according to state of nature (Adamson et al. 2007 [ref.4]). Another approach is to estimate the relationship between model outputs under different constraints, such as water availability, and then use Monte Carlo simulations to obtain a distribution of the value of the objective function based on assigned probabilities for different inflows (Grafton and Jiang 2010 [ref.6]). Whatever approach is used, accounting for uncertainty in terms of model outputs is important in terms of quantifying trade-offs because the marginal values of water by catchment will vary substantially depending on the water available.

Overall, the value of hydro-economic irrigated agriculture models depends for what purpose they are used, and the research or policy question they seek to answer. Their comparative advantage is that

they are able to provide a quantitative evaluation of the economic impacts on irrigated agriculture that results from changes in constraints (such as water availability) and prices.

3.2 Regional economic impact models

Regional economic impact models assess the economic effects of different policy scenarios for well-defined spatial regions, typically in terms of ABS statistical areas. The contribution of these models is that they link on-farm and off-farm activities to provide a broader understanding of effects under a range of scenarios.

These linkages are modelled as input-output relationships. For example, the production of wheat requires inputs, such as labour, while the regional production of wheat would, in turn, help determine the level of activity in the transportation sector. These interconnections and linkages are developed on a regional level with appropriate 'trade' linkages to other regions and the rest of the economy. In more sophisticated regional models, the ability to substitute between inputs may also depend on the relative price of inputs.

Box 3.3 provides a stylised representation of regional economic impact models.

Box 3.3: Regional economic models

(1) Regional Input-Output Table

Economic Activity	Inputs to Agriculture	Inputs to Manufacture	Final Demand	Total Output
Agriculture	x_{AA}	x_{AM}	D_A	Y_A
Manufacturing	x_{MA}	x_{MM}	D_M	Y_M

where:

$$D_A = Y_A - x_{AA} - x_{AM}$$

$$\underbrace{D_M}_{\text{Final Demands}} = \underbrace{Y_M}_{\text{Outputs}} - \underbrace{x_{MA} - x_{MM}}_{\text{Inputs used in producing outputs}}$$

(2) Inter-regional Trade Across Regions

(3) Behavioural Responses (substitution between inputs)

(4) Evaluate Impacts on Inputs and Outputs

At the core of such models is an input-output table that would include multiple inputs and outputs and associated activities (Dixon et al. 2009) [ref.11]. The inputs (*x*) and outputs (*Y*) 'add up' in the form of final demands (*D*) that represent total output in a sector *less* the amount produced and used as input or intermediate input in its own production and other sectors.

These models can be used to assess multiple scenarios, such as supply shocks associated with a drought, by imposing different final demand or outputs in sectors and then assessing the impact across the regional economy.

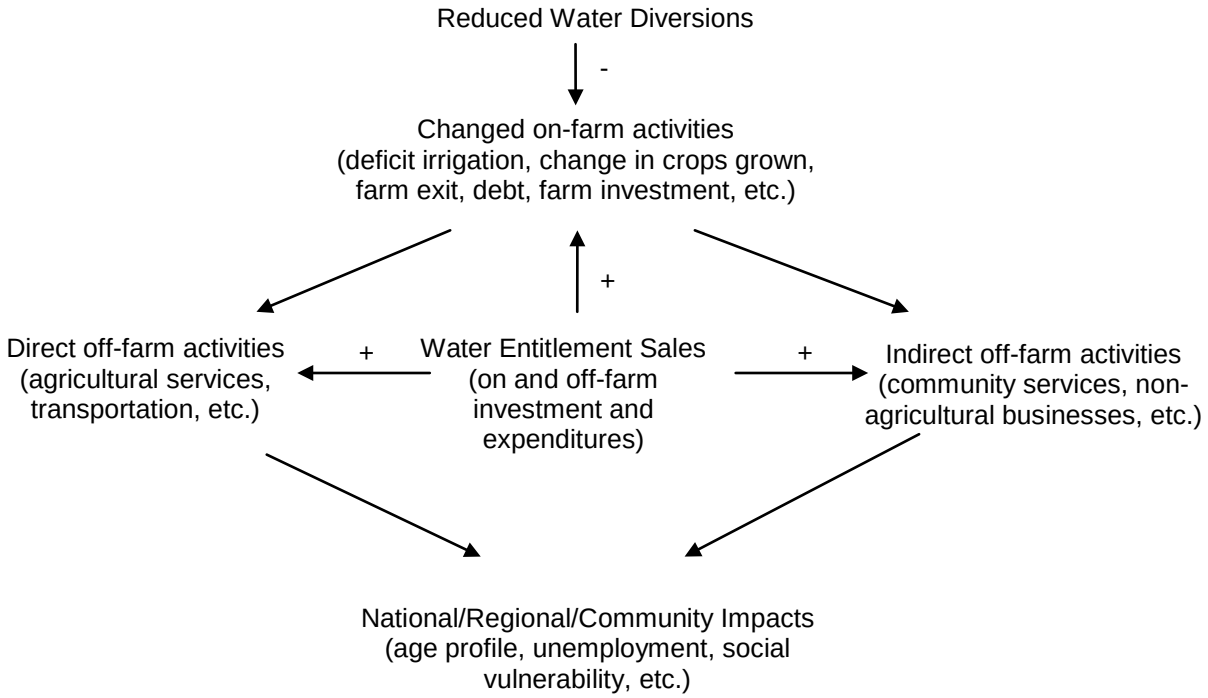
Regional models are typically calibrated or parameterised based on data available from the ABS that may be supplemented with additional information from direct interviews or surveys in the region. In general, the smaller the region and the greater the number of economic activities in the regional model the more difficult it will be to obtain reliable data to generate meaningful scenario analysis.

Water availability may be directly incorporated in regional economic models. This can be done in several ways. For instance, water can be treated as an input or intermediate input to relevant sectors, such as irrigated agriculture, whereby variations in water availability affect the market price of water which, in turn, determines the amount used by irrigated agriculture. Constraints on water trade can be incorporated as limits to trade across regions in the model, or across sectors within regions.

Another way to evaluate the effects of water availability is to incorporate the outputs from hydro-economic models, developed on a catchment level under different levels of availability, as inputs into a regional economic impact model. In this way, the findings from irrigated agriculture models can be used to evaluate the off-farm impacts of changes water availability.

An illustration of what results regional models can provide when quantifying reduced water availability is provided in Figure 3.2.

Figure 3.2: Regional impacts of reduced water diversions



The change in the farm activities from reduced water availability may be modelled directly or could be modelled as outputs from a hydro-economic irrigated agriculture model. The comparative advantage of a regional economic model is its ability to quantify the linkages across all economic sectors and beyond agriculture, both in terms of reduced irrigated agricultural output and also the on and off-farm investments from the proceeds of sales of water entitlements.

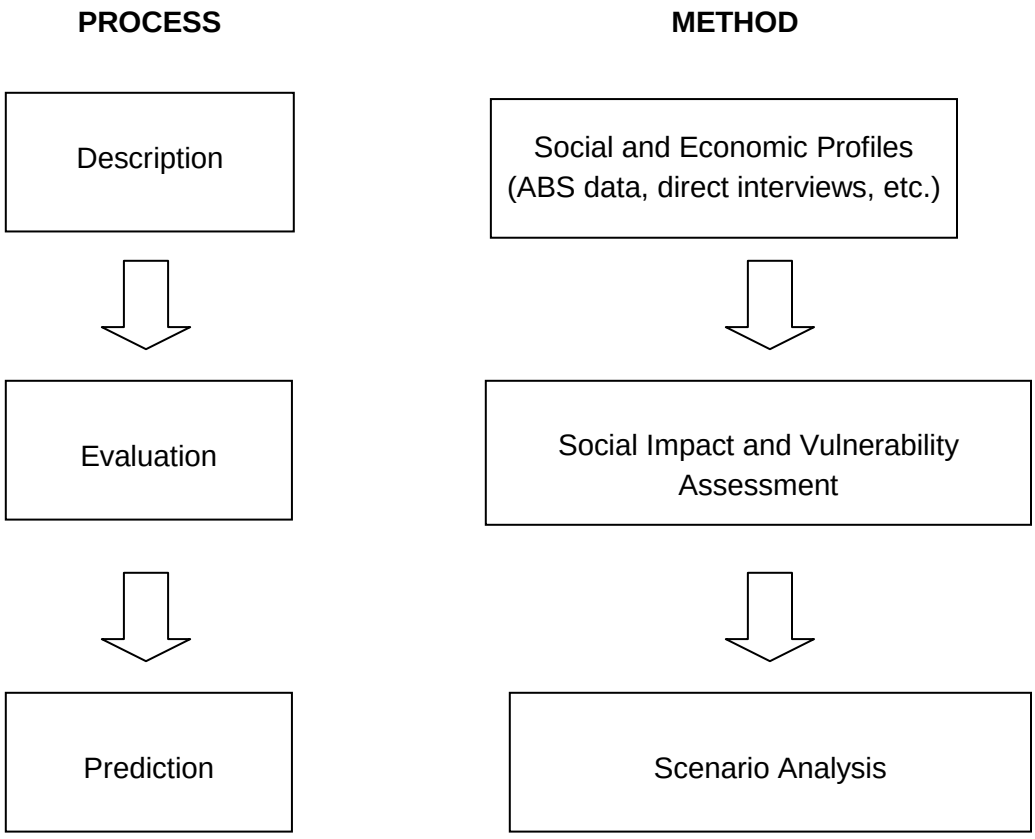
The weakness of regional economic impact models is that they are not designed to provide detailed evaluation of the on-farm impacts of changes in water availability.

3.3 Regional socio-economics studies

Dozens of regional socio-economic studies have been undertaken in the Basin at various spatial scales using a wide-range of methodologies. Some of these studies not only provide a description or profile of the region and its communities, but provide a detailed social impact assessment by mapping disadvantage and its proximate causes. Thus, in addition to providing an understanding about the state of a region, the studies are able to show the key vulnerabilities and challenges to communities of various policy alternatives.

A heuristic of regional socio-economic studies is presented in Figure 3.3.

Figure 3.3: Stylised process and methods of regional socio-economic studies



In the first step, a profiling of the region/communities is undertaken using existing socio-economic data and measures of social and economic disadvantage (ABARE/ABS/BRS 2009) [ref.50]. This may be supplemented with interviews and surveys, especially from vulnerable groups.

The second step is a social impact or vulnerability assessment that uses the available information to assess opportunities and the factors inhibiting socio-economic development.

The third step is scenario analysis that considers how regions or communities might best respond to a policy or other change. In studies that involve action research designed to elicit particular types of change, the analysts involved in the study may even facilitate the communities to adapt to the policy change.

The contribution of socio-economic studies is that they provide a better understanding of those groups that are most at risk in terms of policy change. This understanding and also direct engagement with individuals facilitate community engagement and help them to adapt to change.

3.4 Non-market valuation studies

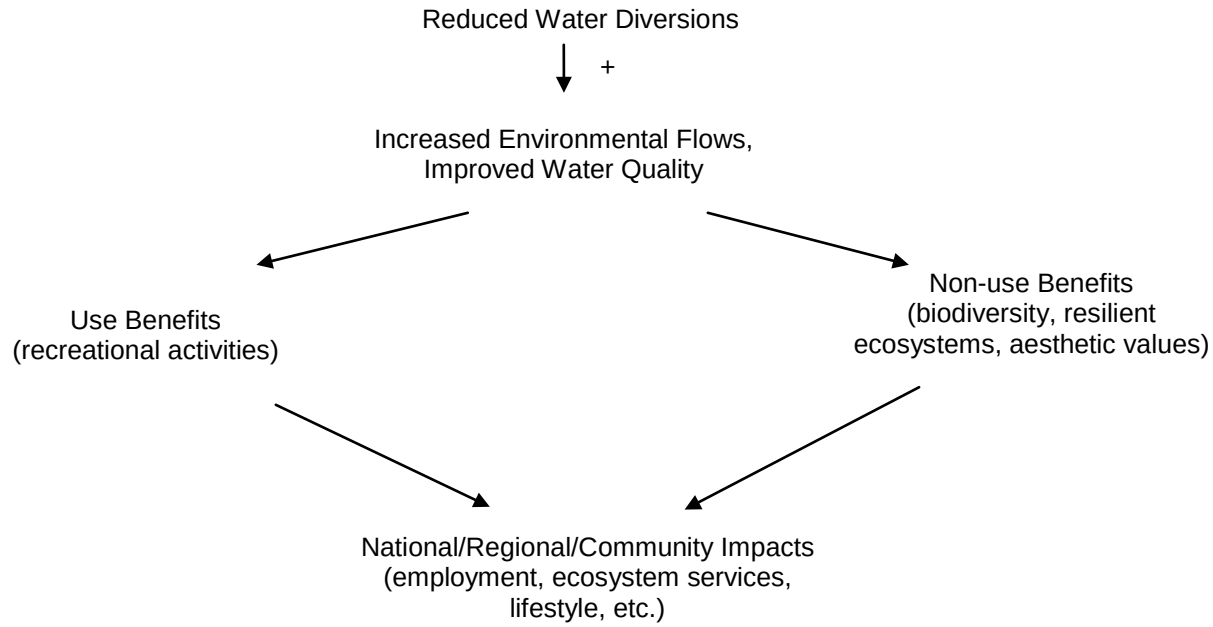
Non-market valuation studies in the Basin include a wide variety of techniques designed to estimate the value associated with attributes of the environment that would not normally be priced in the market place.[10]

These studies are important when comparing the opportunity costs or possible losses from water diversions to the economic benefits from increased environmental flows to streams and to key environmental assets. For example, non-market studies can provide measures of the value of conserving riparian forests or improving water quality across stretches of rivers with the Basin.

These values, in turn, should inform decision makers as to the possible benefits of actions to help maintain or improve environmental assets so these benefits can be compared to the costs.

For example, the possible costs of reduced water diversions (Figure 3.2) should be compared to the possible benefits of increased environmental flows brought about by a reduced consumptive pool, as shown in Figure 3.4. These benefits could include increased employment in tourist and recreational activities, but also non-market benefits in terms of more resilient ecosystems and greater aesthetic values.

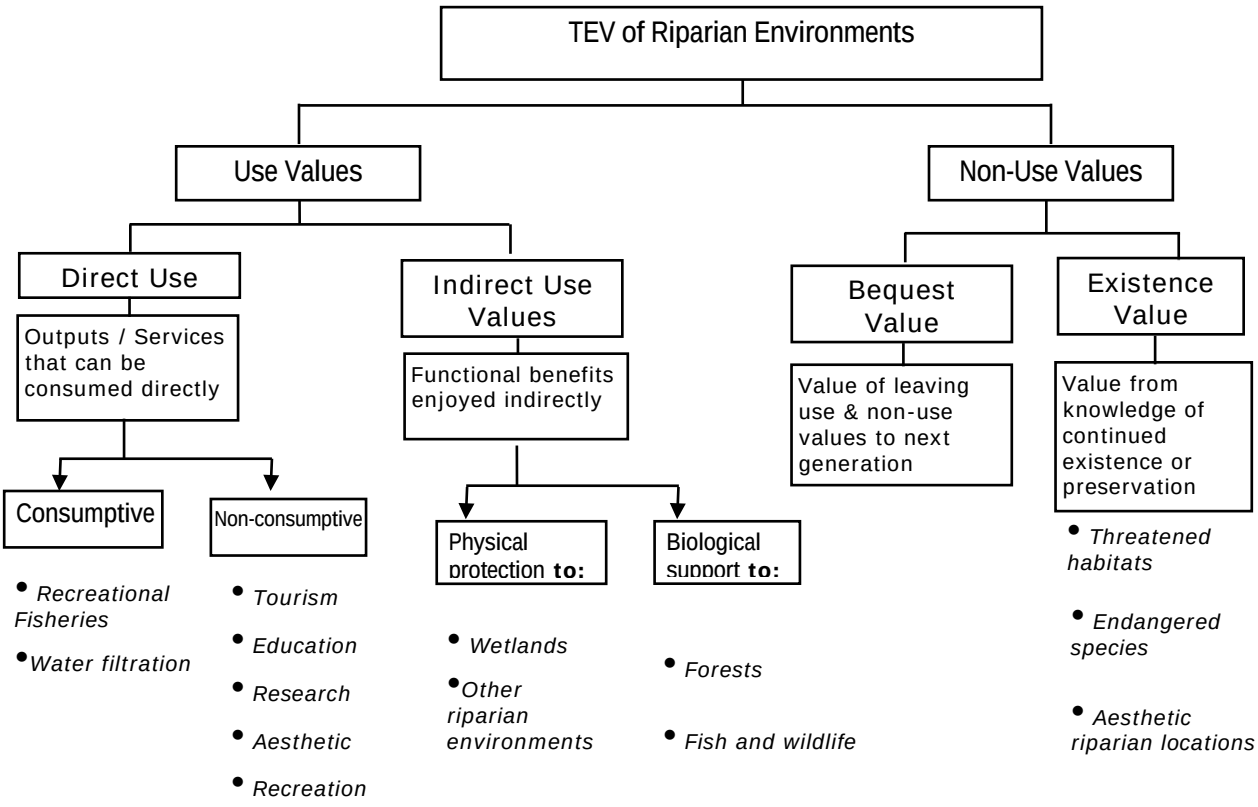
Figure 3.4: Use and non-use benefits of reduced water diversions



10 For example see: Bennett, Dumsday, Lloyd, Sturgess and Van Raalte (2008). "The Economic Value of Improved Environmental Health in Victorian Rivers", *Australasian Journal of Environmental Management,* 15(3): 138-148; Gillespie Economics (2008), River Red Gum Forests Investigation – Socio-Economic Assessment Final Report Prepared for the Victorian Environmental Assessment Council; and Mazur and Bennett (2008), Choice modelling in the development of natural resource management strategies in NSW, Environmnetal Economics Research Hub Research Report #1, ANU

The total economic value (TEV) associated with a riparian environment in the Basin includes both use and non-use values. These different values are summarised in Figure 3.5 and are affected by changes in water quality and quantity.

Figure 3.5: Total economic value of riparian environments



The use values include both consumptive (such as recreational fishing and hunting) and non-consumptive uses obtained from direct use of species for recreational purpose, such as bird watching. Non-consumptive use values arise from activities that do not subtract from or diminish the quality of the environment.

The principal methods to quantify non-market values are:

- stated preference techniques - that require people to respond to a set of questions or choices about environmental attributes and marginal changes to the environment; and
- revealed preference techniques - whereby non-market values are inferred from transactions in the market economy.

The main stated preference techniques are contingent valuation and choice modelling. Contingent valuation uses a direct survey of respondents to obtain a willingness to pay (WTP) measure or a hypothetical payment by an individual to ensure that she or he is as well off in utility or welfare terms

after the provision of desirable good or service, such as improvement in environmental quality, as before.

The choice modelling approach is an alternative stated preference technique that allows the analyst to estimate the values associated with different attributes of an environmental good or service. This is done by presenting respondents with a sequence of choices between alternative goods or scenarios. The goods or scenarios are described by a number of characteristics or attributes at multiple levels that differ among the alternatives. Respondents are then asked a series of questions in which a unique 'choice set' is presented each time. Before the choice sets are presented to the respondents, there is a description of the scenario, the research issues, the proposed policy changes, and the implications for the environmental attributes that are being modelled (Morrison et al. 2010) [ref.120].

The travel cost and hedonic pricing methods are the two commonly used revealed preference techniques.

In the travel cost approach, an analyst first estimates a demand function for recreational travel by accounting for monetary and non-monetary expenditures related to recreational travel (Dyack et al. 2007) [ref.117]. The demand function relates to the number of visits that users / travellers / tourists make, the travel cost incurred, site characteristics, socioeconomic characteristics of the user population and substitute site information. After the demand function is estimated based on available data, estimates of the WTP to visit the site can be calculated and then aggregated over the total tourist population by multiplying by the number of visitors to a site each year.

Hedonic pricing methods assume that consumers' valuations of a good depend upon a number of characteristics embodied within the good. By obtaining measures of these characteristics and incorporating them into a regression model, consumers' WTP for each individual attribute of the good can be estimated. For example, the market price premium for houses located near a wetland or riparian environment, after accounting for other characteristics (lot size, number of bedrooms, etc.) represents a valuation of the attributes of the nearby environment.

The principal weakness of non-market valuation studies in terms of water planning is that they provide values associated with a set of environmental attributes (Morrison and Bennet 2004) [ref.108]. Transforming these into impact values per ML of water when making cost-benefit comparisons about reduced water diversions is much more difficult as it requires a defensible ecological function or relationship between flows and attributes.

Another challenge is how to use or transfer non-market values estimated in one location to another without necessarily incurring the cost or time of replicating the study. Desk-top or benefit transfer studies have been developed to assist in the transfer of values from a study site where a non-market valuation has been undertaken to a policy site where it has not. The challenge with this approach is to account for the transfer error, which can be very large, in the decision making process.

3.5 Water pricing studies

Water pricing models are a fit-or-purpose analytical tool designed to assess the effects of water availability on the price of water entitlements and seasonal allocations. These price effects can be used in other models, and also for predictive purposes.

Water price models can be estimated directly from water market data or constructed indirectly based on the value of the marginal product associated with irrigated agriculture. The directly estimated models use price data from transactions recorded on state registers and then regresses these prices as a dependent variable on a range of independent variables. In terms of seasonal allocation prices, statistically significant coefficients have been estimated for precipitation (-) and announced water allocation (+) (Brennan 2006) [ref.91].

Models can also be constructed to estimate demand price elasticities and supply elasticities provided there exists data on bid and ask prices (Wheeler et al. 2008) [ref.88].

By contrast to price models of seasonal allocations, water entitlement price models (Bjornland and Rossini 2006) [ref.92] are much more limited because the price is determined by future expectations by market participants that will only partially be affected by current market conditions and water availability.

A different type of water pricing model uses the value of the marginal product of different crops in a catchment to derive a market price using agent-based models. In this approach, each cropping activity has its representative 'agent' who trades with other agents within and possibly across catchments. Agents continue to trade until the value of an extra ML of water is identical across all agents accounting for conveyance losses and transactions costs.

3.6 SEA integration techniques

As noted earlier, a robust technique to integrate disparate economic, environmental and social assessments into a single bottom line would greatly assist environmental policy development.

To this end, Choice Modelling has been used to estimate the community's preferences for the relative wellbeing of different groups in society, now or in the future in a way that generates 'weights' suitable for integrating equity concerns into benefit-cost assessments.

A number of recent applications - such as the Gillespie et al (2008) [ref.107] assessment of River Red Gum Forest management options - have demonstrated the method's potential to identify the community's willingness to trade-off various economic gains and alternative social impacts (distributions of costs and benefits). The approach has the potential to measure and value the preferences of people for the process, efficiency and equity impacts of alternative environmental and

social management strategies and in doing so to identify the trade-offs the community would be willing to make.

That is, application of the Choice Modelling technique can allow the non-market, environmental, social and equity impacts of alternative water management options to be integrated into standard cost-benefit analysis and regulatory impact assessment processes. Alternative environmental management options can be ranked and compared through a single objective and empiric measure of net community welfare.

4 REVIEW OF LITERATURE FINDINGS

In this section we describe the key findings from the identified studies across the most common study objectives.

4.1 Assessment of water buybacks

A succinct commentary on four alternative assessments of the economic impact of water buybacks is provided by the Productivity Commission 2009 [135], who review studies by:

- Peterson et al 2004 [ref.12] - use an early version of the TERM model applicable to the southern MDB and investigate the impact of 10, 20 and 30% across-the-board' reductions in water availability (not buybacks per se with no compensation payments included in the modelling);
- Dixon et al 2009 [ref.11] - employ the updated TERM-H2O model again to the southern MDB (but with a more disaggregated model) and investigate the impact of a 1500 GL buyback;
- Qureshi et al 2007 [ref.2] - use a short-run agricultural model of the southern MDB to investigate 500 GL and 1000 GL reductions in water availability under trade and no-trade scenarios and where the water reductions were firstly constant between years and secondly variable around the assumed average.
- RMCG 2009 [ref.45] - consider the impact of reduced water availability to irrigators in the Wakool Shire of NSW. Rather than employing a modelling approach, they extrapolate from a number of assumptions, including the impact of each ML reduction on agricultural output, and the associated flow-on impact to regional production.

The summary provided by the PC illustrates the extent and variation in assumptions, approach and modelling sophistication employed. Notwithstanding the limitations this introduces and care therefore needed in interpreting results, based on the three modelling studies (i.e: excluding the RMCG 2009 [ref.45]):

- the value of agricultural output is estimated to fall much less than proportionally to reduced water availability (with a 33% reduction in water availability estimated to lead to a 7 - 12% reduction in irrigated agricultural output across the southern MDB) *as long as there is unrestricted trade in water to facilitate adjustment*[11];

11 This finding is supported in more recent work by Grafton and Jiang 2010 [ref.6], who use the CSIRO sustainable yields boundaries and develop a linear programming hydro-economic model of the MDB in 2000-2001 and 2005-2006. They find that the decline in profits in irrigated agriculture is much less than the proportional decline in 10, 20, 30, 40 and 50% buyback.

- contraction in irrigated cereals, rice and to a lesser extent dairy can be expected, concentrated in those regions with the lowest marginal value of water, namely the upper and central NSW and Vic Murray regions and the Murrumbidgee, rather than the Mallee and lower Murray regions.

- flow-on impacts to regional and basin economies will fall less than proportionally to the irrigated agriculture sector impacts, such that impacts at the southern MDB level will be only in the order of 2-3%, or effectively zero to slightly positive if the impact of buyback payments on regional consumption is taken into account;
  - however some towns and local economies, notably those in water selling regions that are heavily reliant on irrigated agriculture, could experience large impacts, particularly over the longer term as farmers and attendant resources (including compensation payments) leave the areas.

Economic farm-level and catchment modelling studies support this conclusion. For example, Jayasuriya (2004) [ref.18] modelled the regional and farm-level economic impacts of environmental flows for regulated rivers in NSW. He found that the re-allocation of water from agricultural to environment uses would have a larger net impact on farmers than on the regional economy. He identified differences in terms of impacts between production zones (more active irrigation zones indicate higher impacts) as well as among individual farm types (due to a range of characteristics including the level of irrigation activity).

Hassall and Associates (2003) [ref.128], commissioned in support of the *Living Murray* investigations, describes the social and economic profile for each catchment in the southern MDB against a number of descriptors or variables. It also outlines dependence of the individuals and communities on the water resource and ecosystems of the River Murray. However prediction and evaluations stages of the study were not completed.[12]

As well as studies investigating the broad scale of impacts from water buybacks, several studies have focussed on the relative economic performance of alternative buyback designs. For example, ABARE has used water market models to investigate the performance of option-based buybacks relative to other instruments and in terms of various design parameters.

[12] Other notable studies on social impacts yet to be released include:
- Griffith University and the National Water Commission who have engaged a consortium led by Assoc. Professor Pohling Tan, Griffith University and others. The study objective is to determine likely trigger points for 'farm collapse' resulting from different levels of water allocations.
- *People, Pumps and Pipes: A social study of change in the collaborative supply of irrigation services* - being undertaken by a consortium of Hawke Research Institute for Sustainable Communities, UniSA, Renmark Irrigation Trust, PIRSA Sustainable Systems and the Social Inclusion Unit at Department of Premier and Cabinet (SA).

BDA Group (2006) [ref.65] report the impact on government outlays and irrigation sector returns from alternative buyback designs applicable to water sourcing in the southern MDB to meet environmental demands at a case study *Living Murray* Icon site. The study concluded that no single instrument was superior and tailoring water buybacks to environmental demands would be critical in limiting impacts to all parties.

The Productivity Commission (2009) [ref 135] draft Research Report provides the most recent analysis of the alternative market mechanisms for sourcing water in the Murray-Darling Basin. It is argued in the report that purchasing water is generally the most cost-effective way of transferring water from the irrigation sector for environmental use and that acquiring water directly via water markets where they exist (rather than via tender programs) is likely to be more efficient.

Key findings from studies on water buybacks:

- All water recovery measures cause some social impact. The majority of identified social impacts associated with water recovery measures are likely to be short term as communities are constantly adapting to change;
- Purchasing water is generally the most cost-effective way of transferring water from the irrigation sector for environmental use;
- Hydrological and institutional factors will affect the scale of impacts associated with water buybacks. Net revenue reductions to irrigation will be less where water acquisitions are targeted from low-value regions rather than purchased proportionally from all regions;
- The value of agricultural output is estimated to fall much less than proportionally to reduced water availability *as long as there is unrestricted trade in water to facilitate adjustment;*
- There appears to be some prospect of counter cyclical trading delivering water for environmental use while supporting the financial viability of irrigation;
- Some towns and local economies, notably those in water selling regions that are heavily reliant on irrigated agriculture, could however experience larger impacts; while
- Impacts at the regional and basin level will fall less than proportionally to the irrigated agriculture sector impacts, and may even be positive when the expenditures of income from buybacks in regional economies is included.

4.2 Assessment of drought and reductions in longer-term sustainable yields

Drought

Horridge et al. (2005) [ref.10] developed a 'bottom-up' Computable General Equilibrium (CGE) model (TERM) of Australia and used it to analyse the economic impacts of the 2002-2003 drought on Australian Gross Domestic Product (GDP). They found that the drought directly reduced GDP by 1%, and a further 0.6% indirectly via negative multiplier effects (Horridge et al. 2005, p. 300) [ref.10]. The relatively small impact on the overall economy is because agriculture accounts for only 3.6% of Australian GDP. By contrast, the drought had a large and negative impact on agricultural output that fell by about 30% nationally.

Some regions, however, suffered even larger losses with a fall in agricultural production in New South Wales of about 45% due to the 2002-2003 drought. There have also been significant changes in irrigated agriculture activities such as large reductions in the amount of rice and cotton under production (ABS/ABARE/BRS, pp. 60-61)[13].

The importance of water trading in helping to maintain incomes during droughts is shown by Peterson et al. (2005) [ref.13] who find that the benefits of water trading compared to no trading are much greater in drier years.

Climate change

Adamson et al. (2009) [ref.3] have assessed the effects of irrigated agriculture under different climate scenarios and states of nature (wet with a 30% probability, normal with 50% probability and dry with a 20% probability). They use inflow projections by Jones et al. (2007) [ref.27] for 2030 and find under their global solution (optimal adaptation to reduced water availability), the economic value of production in the Basin declines by $200 million/year and up to $500 million/year (Adamson et al. 2009, p. 363) [ref.3]. The losses occur because of reduced revenues from lower yields due to deficit irrigation, a smaller area in irrigation and because of increased costs from accessing water.

In the optimal adaptation scenario there is a proportionately greater reduction in water use in the upstream parts of the Basin. Their results, in terms of water reductions due to climate change, are broadly consistent with the finding that it is optimal to target water acquisition with buybacks in the upper and south-eastern parts of the Basin. Using a similar modelling approach Quiggin et al. (2008) [ref.15] emphasise that, in addition to the effects of lower mean water availability, an increase in the frequency of droughts has important negative effects on irrigators.

Connor et al. (2009) [ref.9] use a different model to evaluate the economic impacts on irrigated agriculture from climate change. They assess the effects of three scenarios: (1) mild climate change with 13% reduction in inflows in the Basin, (2) moderate climate change with 38% reduction and (3)

13 Australian Bureau of Statistics, Australian Bureau of Agricultural and Resource Economics, Bureau of Rural sciences. (2009). Socio-Economic Context for the Murray-Darling Basin. Descriptive Report MDBA Technical Report Series: Basin Plan: BP02

severe climate change with 63% reduction. They find that farmers can effectively adapt to mild or moderate climate change given unrestricted water markets. As water availability decreases, irrigators apply less water (deficit irrigation) and fallow more land. Provided water markets are unrestricted, they find reductions in profits are proportionally less than the decline in inflows. For example, with moderate climate change net returns in Victorian and South Australian agriculture decline by 5% and 11%, respectively, with unrestricted water trading. By contrast, in the absence of such trades the decline in net returns in Victorian and South Australian agriculture are 19% and 54%.

Goesch et al. (2009) [ref.7] provide another model to assess the effects of climate change in the Basin. They show declines in water diversions would result in a much lower proportional decline in irrigation income as farmers are able to adapt their practices to counter the effects of reduced water availability. Using the CSIRO (2008) medium climate scenario projections where water surface availability falls, on average by 11%, they predict overall diversions would fall by about 4% while irrigators' incomes would drop by about 1%. In this scenario, the largest proportional decline in water use occurs with broadacre agriculture (5.8%), grains (4.5%), dairy (4.2%) and rice (3.4%) with an overall reduction in the area of irrigated farmland of about 1.2%. They also find that if the water sharing plans were changed so that if environment water and water diversions are reduced by the same proportion with climate change, irrigators' income would decline by about 3.2%.

Other factors

Other factors may also contribute to reduced water availability. These include increased groundwater usage, bush fires, farm water interceptions, lower return flows from improvements in irrigation efficiency, and afforestation. The social and economic impacts of reduced availability due to all of these factors have not been quantified but could be done through existing economic models where there are estimates of the surface water losses. Consideration of the economic impacts would also need an evaluation of the benefits associated with accessing groundwater and other surface water.

ABARE has modelled the negative effects of a 20% reduction of water availability while assuming the existing pattern of rainfall remains unchanged. In their assessment, reduction in water availability from other factors would reduce gross regional product in the Basin by about 1%, irrigated farm profit by about 5% and result in a 0.1% decline in gross domestic product. The impacts across the Basin, however, would not be uniform with the biggest reductions in production occurring in eastern Victoria while the least affected region would be South Australia (Goesch et al. 2008) [ref.107].

In two regional studies in Dumaresq River Valley and in the Murrumbidgee Valley, the economic consequences of groundwater extractions have been modelled. The studies indicate that while groundwater extractions can have a substantial impact on downstream surface water availability they currently impose minimal net economic costs (Hafi and Goesch, 2006) [ref.25].

Key findings from studies on reduced water availability:

- Water trading has played a critical role in helping to maintain irrigation sector incomes during drought and will play a major role in dampening the impacts from climate change on the irrigation sector;
- As would be expected, declines in water diversions and an increase in the frequency of droughts due to climate change has been estimated to have significant negative effects on irrigation;
- In addition to the effects of lower average water availability, an increasing variability in water availability will have further significant negative effects on irrigation;
- However modelled impacts on irrigation incomes are significantly less than the proportional reduction in water availability (as farmers are able to adapt their practices and trade water) such that farmers can effectively adapt to mild or moderate climate change;
- In more severe climate change scenarios greater costs are estimated, with a shift away from perennial to annual crops identified as the latter can be managed more profitably when water allocations in some years are very low;
- The most vulnerable regional economies will be those where water reductions are greatest, and where the agricultural and related processing industries comprise a relatively large proportion of economic activity; and
- In addition to climate change and greater diversions for environmental purposes, other factors that will contribute to reduced water availability for irrigation include groundwater depletion, bush fires, farm water interceptions, lower return flows from improvements in irrigation efficiency, and afforestation.

4.3 Impact of water market reforms

Benefits of water trade

As noted above, Peterson et al. (2004; 2005) [ref.12,13] find substantial benefits associated with water trading and that these benefits are much greater in drier years. For instance, they calculate that the increase in the Gross Regional Product (GRP) of the Southern MDB from water trading is about $550m in a dry year with both interregional and intraregional trade while in a wet year the gains from water trading are about $200m. The additional gains, however, from allowing interregional trade (including across states) versus only intraregional trade are less, but are still substantial. For instance, Peterson et al. (2004, p. 45) [ref.12] estimate that the gains in a dry year from interregional and intraregional trade relative to only allowing intraregional trade is about $138 million while Qureshi

et al. (2009) [136] estimate the gains from allowing interregional trade compared to only intraregional trade at some $88 million/year.

Frontier Economics (2007) [ref.38] undertook social impact case studies in three Victorian irrigation areas investigating the impacts of water trade, and found strong community opposition to permanent trading out of a district. Other key findings included:

Removal of trade barriers

Trade barriers in the MDB include direct regulatory restraints on trade imposed by states and also restraints/fees imposed by operators of irrigation infrastructure. State constraints currently include the 4% limit per year on water entitlements that can be transferred out of an irrigation district.

Until October 2009 Victoria also had a 10% cap in terms of the water entitlements that could be held separate from land holdings. While the 4% limit on entitlement trade can be applied in all states, it only became binding in New South Wales in March 2009 and, to date, has not prevented outward entitlement trade from South Australia. The biggest impact on outward water entitlement trade is in Victoria where limits of sales of water entitlements are expected to continue, albeit with progressively higher limits, until 2014.

The effects of the 4% limit of market-based water recovery are mitigated by an exemption the Australian government has negotiated with Victoria. The Australian government has also signed a Memorandum of Understanding (MOU) with the New South Wales government that ended the state's embargo on the sale of water entitlements for environmental purposes. This MOU limits purchases of general security water entitlements by the Commonwealth for environmental purposes to 220 GL over the period 2009-2012.

The ACCC has reviewed the 4% limit and its effects on trade. It concludes that it leads to efficiency losses, general market uncertainty and prevents irrigators receiving the proper market value of their water entitlements.

Frontier Economics (2009, p.44) [ref.77] provide evidence that the 4% limit has reduced Victorian agricultural production by about $5m in 2007/2008, and had an additional negative effect on the Gross State Product of about $6m. The biggest losers from the 4% limit are irrigators who wish to sell their water entitlements. In some irrigation regions irrigators who sell may receive about 25% less for their water entitlements than they would otherwise without the 4% limit.

Price reforms

The other major constraint on trade has been the imposition of exit fees (payable when water entitlements are sold out of an irrigation district in excess of the costs of transfer) and termination fees (payable when a delivery entitlement or delivery right is surrendered to operators of irrigation

infrastructure). Following changes to market trading rules in 2009, irrigation operators can only impose termination fees and a disconnection fee and not an exit fee. Irrigators have the option of paying the annual access fee subsequent to the sale of their water entitlements or pay a capitalised sum equivalent to 10 times the access fee.

Key findings from studies on water market reforms:

- The benefits of introducing trading within irrigation districts are likely to have been greater than the benefits of a further expansion of trade between regions;
- Communities can find change and adjustment to water market outcomes difficult. In particular, communities in regions exporting water experience reduced populations and less local spending. Also, the manner in which supply authorities recoup fixed costs from irrigators remaining in the system will have distributional effects;
- However water trading is commonly considered a catalyst for change that would in any case have happened as a consequence of drought, variation in commodity markets and rural adjustment;
- From an assessment perspective, it is difficult to untangle the effects of water trading from the background of drought. Any approach implying that all impacts associated with changes in water use are attributable to or caused by water trading would be misleading and unhelpful for policy development;
- Limits on water entitlements that can be transferred out of an irrigation district lead to efficiency losses, general market uncertainty and prevents irrigators receiving the proper market value of their water entitlements. Similarly, the elimination of exit and termination fees will boost water trade. Collectively these water market reforms will moderate the negative impacts that may be associated with reductions in water availability.
- Experience suggests that the nation, regions and communities will be better off if governments remove impediments to adjustment and expedite change; and separately manage the consequences including any adverse effects on third parties, rather than trying to buffer or even counter change. When adjustment is impeded, the most significant adverse impacts are often on the capacity of the most talented in a district or an industry to innovate.

4.4 Valuation of riparian environmental assets

A major impediment to the economic assessment of changes in water use in the MDB has been a dearth of empirical information on the value of improvements or losses in environmental asset quality. Some studies investigating 'use' values, such as recreation and tourism, have been available, but few

studies have sought to value 'passive' values such as the value communities place on maintaining healthy ecosystems and species diversity.

Key valuation studies include:

- Dyack et al (2007) [ref.117] who derived recreational values applicable to the Barmah Forest and the Coorong;
- Studies by Professor Jeff Bennett and others who have employed the choice modelling technique (CM) to value the benefits of wetlands and rivers - see for example Bennett et al (2004; 2007; 2008) [ref.106, 105, 112], Gillespie et al (2007) [ref.107], Morrison and Bennett (2004) (ref. no.108), van Burean and Bennett (2000) [ref.109], and Whitten and Bennett (2001) [ref.116],; and
- Hatton MacDonald et al. (2010) [ref.124], who have reviewed available studies of the environmental and recreational values associated with the River Murray, floodplains and wetlands.

Hassall and Associates and Gillespie Economics (2003) [ref.127], who undertook an investigation under the Living Murray initiative, estimated the economic value of non-agricultural river dependent industries in the southern Murray-Darling Basin at $1.62b annually. This included the value of camping and caravan parks, recreational fishing and boating activities. More recent studies cited by Hatton MacDonald at al (2009) [ref.124] suggest that these values, including amenity values and the value of lifestyle properties is growing.

Brouwer (2009) [ref.119] analysed choice modelling studies applicable to Australia's rivers and wetlands of the past 10 years and concluded that Australian's valued the use benefits of water resources (such as swimming and fishing) significantly higher than non-use benefits (such as ecosystem conservation).

Studies cited by Hatton MacDonald at al (2009) [ref.124] indicate that Australians would be willing to pay $1.6b per year for ten years to improve the health of the Coorong, in terms of increased water bird breeding, increased native fish populations and increased area of healthy native vegetation. Significant but lower values were found for the River Murray upstream of the Coorong.

Key findings from studies on the valuation of riparian environmental assets:

- Environmental value estimates have been found to differ across catchments and between residents within and outside of the catchments where the environmental assets are located;

- Available estimates suggest Australian's hold significant values for the recreational and environmental assets of the Murray-Darling Basin; and
- These values could be drawn on, via the benefit transfer technique, to make inferences in relation to monetary valuations of environmental impacts arising from the Basin Plan.

4.5 Application of assessment integration techniques

A number of Choice Modelling (CM) studies in recent years have sought to derive monetary values for both environmental and social impacts associated with changes in water resource use. Once such values are developed, they can be included in conventional cost-benefit analyses that provide an integrated assessment of public policy changes.

In NSW, a study by Mazur and Bennett (2008) [ref.125] generated environmental values, by catchment, to be used by CMAs when evaluating alternative natural resource improvement programs. Environmental asset values estimated include in relation to the area of native vegetation in good condition, number of native species present, length of healthy waterways and agricultural employment.

A study by Bennett et al (2004) [ref.106] estimated the communities willingness to pay to maintain viable rural communities in the Murrumbidgee. A more recent study of the non-use values of the River Red Gum and East Gippsland Forests in Victoria (Bennett, et al 2007) [ref.105] was commission by the Victorian Environment Assessment Council.

The environmental attributes valued in the River Red Gum Forests area were area of healthy River Red Gum forest, breeding pairs of threatened Regent Parrots and Superb Parrots, Murray Cod and other threatened native fish populations, and the provision of recreation facilities for campers along the Murray River. The environmental attributes valued in the East Gippsland Forests area were breeding pairs of threatened Powerful, Sooty and Masked Owls, number of threatened Long-footed Potoroos, area of significant rainforest sites protected and area of old growth forest protected.

Outside of the valuations for various environmental attributes, the key findings from these studies are:

- a significant proportion of Australian households are willing to pay to see rural population levels maintained in the face of water resource reforms. That is, some Australian households perceive depopulation as a cost and are willing to pay 'something' to prevent a loss in community viability. The amount they are willing to pay varies subject to their location (especially urban versus rural), their income and nature of environmental improvements leading to employment losses;
- a significant proportion of Australian households are willing to pay for the provision of recreation facilities for campers along the Murray River; and

- CM studies can be designed to elicit the relative values of economic, environmental and social impacts that may arise from policy changes, such as the MDBA Basin Plan, which would allow a truly integrated and comprehensive assessment of the net benefits.

Key findings from studies on assessment integration techniques:

- Social impacts such as changes in rural employment or the availability of recreation facilities can be valued along with environmental impacts in choice modelling studies; and
- By valuing the full range of economic, environmental and social impacts that may arise from policy changes, such as the MDBA Basin Plan, a truly integrated and comprehensive assessment of the net benefits can be made.

5 RELEVANCE OF IDENTIFIED STUDIES TO ASSESSING THE BASIN PLAN

In this section we distinguish between the various model approaches and applicability to different policy questions, and consider what strategic investments in modelling might assist in the Basin planning process. Recent profiles of communities in the Basin and hydrological-economic models provide indications of those communities most vulnerable to declines in agricultural water extractions. The key point is that although the impacts of reduced diversions may be small in the Basin as a whole, and in some catchments, the impacts may be quite large in some others.

Modelling should, but generally does not, account for the three core aspects of water planning:

(1) environmental sustainability;

(2) economic impacts; and

(3) social and community effects

The effects among these three factors are as important as the individual impacts. For instance, conserving key environmental assets in the Basin provides complementary economic benefits to irrigators in the form of improved water quality while also providing non-use benefits in the form recreation and existence values. In the absence of integrated models findings from separate studies can be synthesised provide they are denominated at the same spatial scale. For instance, CSIRO's work on sustainable yields provides insights into the effects of climate change and water diversions. Using the same boundaries Grafton and Jiang [ref 6] are able to explore the economic losses in irrigated agriculture to assess the costs of lower diversions. Combined the two analyses provide important insights into the costs and benefits of alternative sustainable diversion limits.

5.1 Fit-for-purpose models and modelling

Models are "mental maps" or rules we develop about how the world operates. They help us quantify the feedbacks and interconnectedness that exist in even the simplest systems. Thus, to model an ecosystem, a hydrological system or an economic system, we need tools to help us visualise relationships and to quantify how the parts of the system affect each other.

Models are used for two principal purposes: optimisation and simulation.

Optimisation models include an objective function that needs to be optimized (such as economic profit from irrigated agriculture) subject to a set of constraints (such as the land and water available) using a set of control or choice variables (such as the land area devoted to each crop in each catchment). Optimisation models are prescriptive and are, thus, part of normative analysis and help answer the questions of what *should* happen.

Simulation models (such as hydrological models) are used to represent a system or systems and, to be useful, must adequately reflect the relationships among the variables within the system(s). Such models are often used for predictive purposes and help answer *what if* questions. For example, what are predicted salinity levels with different inflows and water diversions?

Models are often criticized as not being an adequate representation of reality. No matter how complex the model, it must (inevitably) be a simplification of the system being modelled. The art and science of modelling, however, is *not* to include every possible variable or relationship (which is impossible) but to include those variables and links that are important or significant within the system.

In this sense, what is "important" or "significant" will depend on the purpose of the model and availability of data. For instance, a hydro-economic model of irrigated agriculture for assessing the economic effects of different levels of water availability must include water availability as a constraint in the model and as an input into the choice variables or activities. By contrast, a socio-economic study that assesses vulnerable groups within a community does not need a model of water use.

Choosing what should, and what should not, be included in a model (variables and feedbacks), and whether variables should be treated as exogenous (determined outside the model) or endogenous (determined within the model), are questions that all modellers face. Ideally, models should be able to represent a system in as simple a way as possible while still being able to effectively answer the questions for which the model was built.

A key challenge for the MDBA is to link and integrate existing models of the Basin to help address the key policy questions faced in the Basin planning process. Questions regarding the economic impact on irrigated agriculture from reduced diversions require hydro-economic models developed on a catchment basis. Broader queries about the effects of changes in water availability at a regional and community level require:

- socio-economic profiling,
- social impact assessment, and
- regional economic impact models.

Comparisons of the trade-offs between alternative environmental water uses requires non-market valuation (stated and revealed preference approaches) to quantify the marginal values of environmental assets and the monetary benefits of alternative environmental watering plans.

In summary, models and approaches differ and what method or model is preferred very much depends on the policy question being posed. No single model is able to answer all of the questions needed to quantify and evaluate the consequences of different levels of water availability and sustainable yields.

Rather, a mix of models is needed and, where suitable, links across models developed so that the limitations of any one model can be mitigated by the findings or results of different but complementary models. For instance, socio-economic profiling and direct interviews with farmers to determine how they reinvest the proceeds from the sale of water entitlements improve regional economic models in their quantification of multiplier effects.

Similarly, hydro-economic models of irrigated agriculture that quantify the on-farm effects of reduced water availability, and what crops are produced and where, provide valuable inputs into regional economic impact models to quantify both on and off-farm impacts at the community scale. A key insight from past modelling is the importance of consistency in terms of: (1) temporal scales so that evaluations are made using similar inflow and diversions and (2) spatial scales so that impacts can be assessed adequately across models.

5.2 Aggregation to local, regional and basin levels

The individual assessments undertaken within economic, regional and social impact assessments are generally done so at different scales. Economic assessment is undertaken from a national perspective and hence all costs and benefits that accrue to stakeholders in Australia are included. However, many of the costs and benefits may accrue to stakeholders in the vicinity of the policy change (eg: irrigators, neighbour impacts, etc) while others (eg: capital costs of new infrastructure or cost of water buybacks) may accrue to agencies funded at the State or national level. Non-market values for conservation outcomes are likely to accrue to the general community, who predominantly reside in major population centres.

Aggregation of individual economic assessments to estimate the total costs and benefits of a program is possible. However, care must be taken in relation to aggregation of environmental benefits since economic principles inform us that people value the first increment of an environmental outcome greater than they value a subsequent increment (law of diminishing marginal utility). Hence, aggregation of individual estimates of environmental benefits across several amenities may overstate the community benefits.

Regional impact assessment is generally undertaken in relation to a defined region, which can vary from a Local Government Area to a catchment or the entire basin. The regional impacts estimated are a function of the size and diversity of the region and the expenditure pattern. Aggregation of regional analysis results only makes sense if they are aggregated to a larger region within which the separate regional analyses occurred (eg: the State). However, aggregation of regional analyses to a broader region will understate impacts since the larger region (State) would have captured more expenditure than the regional economy and hence impacts in a larger region would be greater.

Social impact assessment is generally focused on impacted individuals and groups in a specified region or social catchment. In contrast to economic and regional impact assessments, social impact

assessments often occur at the local level or what Fenton, Coakes and Marshall (2003)[14] refer to as clusters of interdependent towns and communities through which potential impacts may flow. Because of the diversity of indictor and impact measures used, aggregation of social impacts across different studies is unlikely to be possible or relevant.

Spatial scales or the level of analysis are important in term of assessing the impact of sustainable diversion limits. While community level profiles and vulnerability assessments that describe 'what is' are relevant they must be linked to Basin-wide studies of simulation and optimisation models of 'what can be'. Without these linkages, and in an integrated way, it will be very difficult to assess the impacts different diversions.

5.3 Strategic investment in models and modelling in the MDB

There are sufficient and well developed socio-economic models of the MDB to help answer a range of important questions to assist the MDBA in its Basin planning process. The challenge for the Authority is to:

- access existing hydro-economic models, or to build its own models, along with the development of in-house capacity to use these and to link with the MDBA's existing models (such as MSM-BIGMOD); and
- link and iterate across the approaches and models of the Basin to help in determining preferred diversion limits.

Developing an in-house capacity for the Authority to use either an existing or its own hydro-economic irrigated agriculture model could be done and would enable the Authority to provide on-going support and advice about costs, benefits and trade-offs of reduced water diversions. Regional economic models could also be developed.

However due consideration would need to be given to the time and costs involved, access to IP and development of appropriate in-house skills to apply, update and further develop the models.

The timeframe available for development of the draft Basin Plan is likely to preclude this option in the near term, and the commissioning of external analysis will be unavoidable. Care will be needed to ensure the deliverables from such work are tightly aligned with the needs of the MDBA. As no existing model or suite of models is capable of meeting all likely expectations, ongoing liaison with service providers will be critical to ensure only realistic model development is attempted in the available time and that the modelling effort is targeted to shed the maximum light possible on the policy issues at hand.

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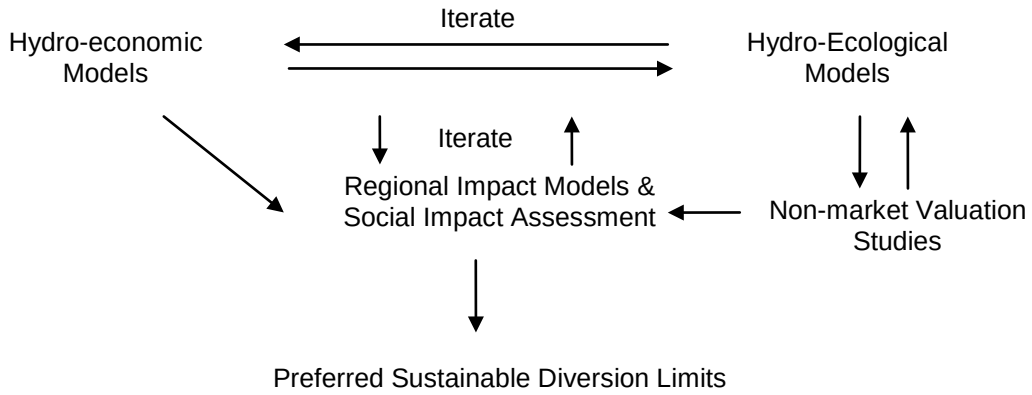
14 Fenton, D.M., Coakes, S., and Marshall, N. (2003). Vulnerability and capacity measurement. In H.A. Becker and F. Vanclay (Eds.) The International Handbook of Social Impact Assessment: Conceptual and Methodological Advances. Cheltenham, Edward Elgar Publishing.

Non-market values of the Basin's key environmental assets should also be quantified. Benefit transfer could be used, where appropriate, to estimate the possible *range* of values under different assumptions. However given the likely importance of providing decision makers with information on the community's valuation of the benefits of realising the Plan's environmental watering strategy, a primary valuation study may be required for key environmental assets or classes of assets. The Choice Modelling method provides a robust technique which could be employed at modest cost in the available time (around 3 months) and could also provide information on the community's willingness to trade-off, for example, irrigation sector employment or the maintenance of rural communities, for environmental improvements.

A longer-term investment strategy would be to link, and where appropriate, integrate existing models and methods to quantify the trade-offs of different sustainable diversion limits by catchment and across the Basin. One way to link theses models is to iterate back and forth between hydro-economic models and hydro-ecological models, also linked to non-market valuation studies, to quantify the costs and benefits of different levels of water availability for use and non-use.

A range of different water diversion limits could then be used as inputs into regional economic impact models and existing social impact assessments to assess the broader community and regional impacts of water diversion alternatives. The broader regional effects could then, in turn, be used to re-evaluate the water allocation trade-offs through a further iteration of the hydro-economic and hydro-ecological models (see Figure 5.1).

Figure 5.1: Integrated modelling for sustainable diversion limits



Appendix A: List of literature identified

Economic models

No	Title	Author(s)	Objectives	Scope	Date
1	*Integrated hydrologic-economic modelling for analysing water acquisition strategies in the Murray River Basin*	M. Mainuddin, M. Kirby and M.E. Qureshi (CSIRO Land and Water). Report prepared for CSIRO Flagships Program: Water for a Healthy Country	To examine the hydrological and economic implications of targeted versus proportional environment water acquisitions	Murray River Basin; impacts on irrigation water use and regional income	2007
2	*Economic assessment of acquiring water for environmental flows in the Murray Basin*	M.E. Qureshi, J. Connor, M. Kirby and M. Mainuddin (CSIRO Land and Water). Report prepared for CSIRO Flagships Program: Water for a Healthy Country	To analyse the economic implications of reallocating water from agriculture to the environment with and without the possibility of inter-regional trade	Murray River Basin	2007
3	*Declining inflows and more frequent droughts in the Murray-Darling Basin: climate change, impacts and adaptation*	D. Adamson, T. Mallawaarachchi and J. Quiggin (University of Queensland, ABARE)	To model two alternative hypotheses about the effects of climate change	Murray-Darling Basin	2009
4	*Water use and salinity in the Murray-Darling Basin: A state-contingent model*	D. Adamson, T. Mallawaarachchi and J. Quiggin (University of Queensland, ABARE)	To adapt linear and non-linear programming models to incorporate a state-contingent representation of uncertainty	Murray–Darling Basin	2007
5	*Catchment behaviour and counter-cyclical water trade: An integrated model*	M. Kirby, M.E. Qureshi, M. Mainuddin and B. Dyack (CSIRO Land and Water). Report prepared for CSIRO Flagships Program: Water for a Healthy Country	To examine the potential of counter-cyclical trading for (government) environmental water holdings	Murray River Basin	2006
6	*Economic of Drought, Water Diversions, Water Recovery and Climate Change in the Murray-Darling Basin*	R.Q. Grafton and Q. Jiang	To assess the impacts Basin-wide of water recovery as a percentage of agricultural surface water diversions in 2000-2001 and 2005-2006.	Murray-Darling Basin (using CSIRO sustainable Yields Boundaries)	2010

7	*Climate change, irrigation and risk management*	T. Goesch, A. Hafi, S. Thorpe, P. Gooday and O. Sanders (ABARE)	To estimate the direct economic impacts of changes in irrigation water availability under the future climate/current development scenario	Murray-Darling Basin	2009
8	*Murray-Darling Basin: Economic implications of water scarcity*	T. Goesch, S. Hone, A. Hafi, S. Thorpe, K. Lawson, S. Page, N. Hughes and P. Gooday (ABARE)	To examine the direct and indirect economic impacts of a reduction in water availability for irrigated agricultural activities	Murray-Darling Basin; medium term; irrigated agriculture only	2008
9	*Impacts of climate change on lower Murray irrigation*	J. Connor, K. Schwabe, D. King, D. Kaczan and M. Kirby (CSIRO, University of California). Report prepared for CSIRO Flagships Program: Water for a Healthy Country	To evaluate irrigated agriculture sector responses and resultant economic impacts of climate change	Lower Murray Region	2009
10	*The impact of the 2002-2003 drought on Australia*	M. Horridge, J. Madden and G. Wittwer (Monash University)	To simulate the short run regional effects of the Australian drought in 2002-2003	Australia-wide	2005
11	*Modelling the Australian Government's buyback scheme with a dynamic multi-regional CGE model*	P. Dixon, M.T. Rimmer and G. Wittwer (Monash University)	To model the effects on regional economies of the Australian Government's environmental water acquisitions	Southern Murray-Darling Basin	2009
12	*Modelling water trade in the southern Murray-Darling Basin*	D. Peterson, G. Dwyer, D. Appels and J.M. Fry (Productivity Commission)	To compare the effects of reductions in water availability across three trading scenarios	Southern Murray-Darling Basin	2004
13	*Water trade in the southern Murray-Darling Basin*	D. Peterson, G. Dwyer, D. Appels and J.M. Fry (Productivity Commission)	To examine the regional effects of expanding trade of irrigation water in the southern Murray–Darling Basin	Southern Murray-Darling Basin	2005
14	*Drought, regions and the Australian economy between 2001-02 and 2004-05*	P.D. Adams, M. Horridge, J. Madden and G. Wittwer (Monash University)	To simulate the prospects for regional Australian economies between 2001-02 and 2004-05	Australia-wide	2002
15	*The implications for irrigation in the Murray-Darling Basin*	J. Quiggin, D. Adamson, P. Schrobback and S. Chambers (Risk	To provide a consistent framework for analysing the responses of land	Murray-Darling Basin; irrigated	2008

		and Sustainable Management Group, University of Queensland). Report prepared for the Garnaut Climate Change Review	and water use, and economic returns to agriculture, under a range of climate scenarios	agriculture only	
16	*The impact of climate change on the irrigated agricultural industries in the Murray-Darling Basin*	A. Hafi, S. Thorpe and A. Foster (ABARE)	To model the effect of reduced water availability	Murray-Darling Basin	2009
17	*Reduced water availability: Impact on agricultural activities and regional economies in the Murray-Darling Basin* (not available to public)	T. Mallawaarachchi, S. Hone, D. Adamson, A. Yainshet, M. Oliver, P. Kokic, J. Quiggin and P. Gooday (ABARE, Risk and Sustainable Management Group, University of Queensland). Report prepared for the Murray-Darling Basin Commission	To gain a more comprehensive understanding of the potential economic impacts of six main risks to water resources identified	Murray-Darling Basin	2008
18	*Modelling the regional and farm-level economic impacts of environmental flows for regulated rivers in NSW, Australia*	R.T. Jayasuriya (NSW Agriculture)	To outline the different approaches taken to quantify economic impacts on irrigators and provide the results of case studies in two regulated river catchments	Murrumbidgee and Lachlan catchments, New South Wales	2004
19	*Water charges and inter-regional trade in the southern Murray-Darling Basin*	A. Heaney, S. Thorpe, N. Klijn, S. Beare and S. Want (ABARE)	To indicate the effect of different charging regimes on the system-wide and regional impacts of trade	Southern Murray-Darling Basin	2004
20	*Modelling the cost of irrigator response to lower Murray River salinity*	A. Chambers, J. Connor and D. King (PIRSA, CSIRO)	To report on an analysis of irrigator water demand and profit changes across varying annual water availability, crop water requirements and river salinity conditions	South Australian portion of Murray River	2006
21	*Weighing up the cost: Economic impact of water scarcity and environmental targets*	L. Lee, T. Ancev and W. Vervoort (University of Sydney)	To determine the optimal allocation of water, irrigation system, source of water, and crop pattern, subject to various environmental and resource targets	Northern New South Wales	2006

22	*Modelling future urban and rural water requirements in a CGE framework*	G. Wittwer (Monash University)	To model the impacts of water trading on the national and regional economies of Australia	Australia-wide	2006
23	*Exit fees and inter-regional trade*	T. Goesch, A. Hafi, A. Heaney and S. Szakiel (ABARE)	To consider the efficiency impacts of an 'ex post' imposition of exit fees on permanent out of scheme water trade	general	2006
24	*Groundwater and surface water use in the Dumaresq River Valley: A hydroeconomic model*	A. Hafi, N. Brownlowe and W. Walsh (ABARE)	To investigate the impact of an increase in demand for groundwater pumping on stream depletion	Dumaresq River Valley, border NSW and Queensland	2006
25	*Groundwater extraction: Economic impacts of stream flow depletion in the Murray-Darling Basin*	A. Hafi and T. Goesch (ABARE)	To investigate the economic impact of stream flow depletion from groundwater use in physically connected water systems	Dumaresq River Valley and Murrumbidgee River	2006
26	*Economic analysis of environmental flow scenarios in the Murray River System*	M. Eigenraam, J. Crean, R. Wimalasuriya and R. Jayasuriya (Vic DPI and NSW Agriculture). Report prepared for SERP	To undertake a preliminary assessment of two mechanisms for water recovery (a Cap reduction and a market-based approach)	NSW, Vic, SA	2003
27	*Economic costs of environmental flows in an unregulated system*	R. Jones, J. Crean, P. Aluwihare and R. Letcher (NSW DPI, Australian National University)	To measure the economic costs to irrigated agriculture of environmental flows through the introduction of a Water Sharing Plan in an unregulated river system	Mooki River subcatchment, Namoi River Valley, NSW	2007
28	*Estimating impacts of climate change on Lower Murray irrigation*	J. Connor, M. Kirby, K. Schwabe, A. Lukasiewicz and D. Kaczan (CSIRO)	To evaluate the irrigated agriculture sector response and resultant economic impacts of climate change using a water balance model	Lower Murray (main stem), Vic and SA	2007
29	*Modelling basin-level allocation of water in the Murray-Darling Basin in a world of uncertainty*	D. Adamson, J. Quiggin and T. Mallawaarachci (Risk and Sustainable Management Group, University of Queensland)	To compare GAMS and Excel modeling approaches to water allocations in the Murray-Darling Basin	Murray-Darling Basin	2005

30	*The farm level impacts of Water Sharing Plans in the Namoi Valley: A stochastic dynamic programming analysis*	P. Aluwihare, R. Jones and R. Letcher (DPI NSW, Australian National University)	To present a bio-economic modelling framework, based on stochastic dynamic programming linked to hydrological and biophysical models, to assess the farm level impacts of different water sharing plans in a sub-catchment of the Namoi Valley	Namoi Valley, NSW	2005
31	*The optimal allocation of water along a system of rivers: A continuous model with sequential bidding*	A. Coram (University of Western Australia) * The analysis in this paper has been extended in Coram, A. and Noakes, L. (2009), The optimal extraction of water along an arbitrarily configured river system, *AJARES, vol.53 pp251 - 264.*	To use a control theory approach to analyse the collectively optimal rate of extraction along a river system	general	2006
32	*Integrating rural and urban water markets in south east Australia: A preliminary analysis*	G. Dwyer, P. Loke, D. Appels, S. Stone and D. Peterson (Productivity Commission)	To undertake a preliminary analysis (using the TERM model) of the effects of expanding the trade of water in south east Australia to include both irrigators and urban users	Southern Murray-Darling Basin (including Adelaide, Canberra and Melbourne)	2005
33	*Environmental water incentive policy and return flows*	M.E.Qureshi, K. Schwabe, J. Connor and M. Kirby (CSIRO)	To provide an empirical comparison of two incentive policies to acquire water for environmental flows for a part of the Murray-Darling Basin (capital and management investments versus buying water on the water market)	Murrumbidgee catchment	forthc-oming
34	*Modelling hydroclimatic uncertainty and short-run irrigator decision making*	M. Griffith, G. Codner, E. Weinmann and S. Schreider (Monash University)	Explores the impact of seasonal hydroclimatic uncertainty on irrigator decision making and temporary	Goulburn irrigation system comprising the Goulburn, Campaspe and	2009

			water markets.	Loddon.	

Other modelling projects (unpublished/under development):

35	*Sustainable Water Allocation. Project 3.1: Integration of Water Balance, Climate and Economic Models*	CRC for Catchment Hydrology (1999-2006). Led by G. Codner (Monash University)	To integrate bio-physical and socio-economic models (using IQQM and REALM)	Murray-Darling Basin	
36	*The Water Planning Tool (unpublished)*	Griffith University and the National Water Commission (led by P. Tan)	To determine what the trigger points there might be for farm collapse resulting from different levels of water allocations	River Murray regulated areas (SA) and Condamine (QLD)	Current project began 2009

Socio-economic impacts/studies

No	Title	Author(s)	Objectives	Scope	Date
37	*Broad interim assessment of the socio-economic impact of water recovery in the Living Murray*	Access Economics in association with Hyder Consulting, report prepared for the Murray-Darling Basin Authority	To provide a framework for assessing the socio-economic impacts of water recovery in the Living Murray Initiative	Living Murray environmental water purchases only (Murray Basin)	2009
38	*The economic and social impacts of water trading: Case studies in the Victorian Murray Valley*	Frontier Economics in association with Tim Cummins and Associates, Dr Alistair Watson, and Dr Elaine Barclay and Dr Ian Reeve of the Institute for Rural Futures (University of New England). Report prepared for the RIRDC, NWC, and MDBC	To quantify and report on the impacts of water trading on individual water entitlement holders, industries and communities in the Murray Valley	Victorian Murray Valley	2007
39	*Coopers Creek water sharing plan: Socio-economic impact assessment of changes to the flow rules*	I. Singh, N. Flavel and M. Bari (NSW Department of Water and Energy)	To provide socio-economic impacts of recommended changes to the flow rules for the Coopers Creek Water Sharing Plan	Coopers Creek, New South Wales	2009
40	*The socio-economic impact of the Australian cotton industry on regional communities in New South Wales and*	R. Powell and L. Chalmers (Centre for Agricultural and Regional Economics)	To develop and interpret a range of socio-economic indicators for a sample of communities with	Cotton-growing areas in New South Wales and	2008

	Queensland		significant cotton industries	Queensland	
41	*Reclaiming the balance: Social and economic assessment – lessons learned after ten years of water reforms in Australia*	C. Baldwin, V. O'Keefe and M. Hamstead (University of the Sunshine Coast and Hamstead Consulting)	To review the lessons learned about water sharing planning around Australia	Australia-wide	2009
42	*The diversity of the north: Socio-economic profiles of the river basins in the northern Murray-Darling Basin*	Frontier Economics in association with Tim Cummins and Associates, Dr Alistair Watson, and Dr Richard Stayner of the Institute for Rural Futures (University of New England). Report prepared for the MDBC (Northern Basin Program)	To provide a better understanding of the linkages between water use and socio-economic outcomes	Twelve major river basins in the northern Murray-Darling Basin	2008
43	*Managing change: Australian structural lessons for water*	J. McColl and M. Young (CSIRO)	To highlight opportunities to facilitate and expedite structural adjustment, including securing water for the environment through the market place	general	2005
44	*The impact of drought on small business – A pilot study on Wee Waa*	S. Spanswick, G. Roth, T. Drew and P. Jones (Cotton Catchment Communities CRC)	To quantify the impact of the drought on Wee Waa's small businesses and capture additional information on its impact on rural community issues such as health and education	Wee Waa, New South Wales	2007
45	*Socio-economic impacts: Closure of Wakool irrigation districts (or parts thereof)*	RMCG. Report prepared for Wakool Shire	To undertake a desktop evaluation of the socio-economic impacts on the community should part or all of the irrigation network be permanently decommissioned	Wakool Shire, NSW	2009
46	*Monitoring economic and social changes in NSW water sharing plan areas: Irrigators' survey 2005-06*	NSW Department of Water and Energy	To collect primary quantitative social and economic data that will enable future monitoring of water	New South Wales	2007

			sharing plans		
47	*Monitoring economic and social changes within NSW Water Sharing Plan areas: A participatory approach*	M. Bari, I. Singh and N. Flavey (NSW Department of Water and Energy)	To present a methodology as applied to monitor the changes in economic and social indicators within the irrigation industry in the Water Sharing Plan areas in NSW	New South Wales	2008
48	*An assessment of the economic, environmental and social impacts of NSW Agriculture's advisory programs in water-use efficiency*	J. Crean, A. Shaw, R.P. Singh and J.D. Mullen (NSW Department of Primary Industries)	(as indicated by title)	Four industry/regional complexes in New South Wales	2004
49	*Economic and social impact assessment of water quality improvement*	A. Khorshed, J. Rolfe and P. Donaghy (University of Southern Queensland, Central Queensland University and QLD Department of Primary Industries and Fisheries).	To demonstrate how setting more stringent water quality objectives can enhance and protect environmental assets of water resources	Queensland (including but not limited to the northern Darling Basin)	2006
50	*Socio-economic context for the Murray-Darling Basin*	ABARE/ABS/BRS. Report prepared for the Murray-Darling Basin Authority	To describe the context within which Basin water resources are used	Murray-Darling Basin	2009
51	*Socio-economic impact assessment: Condamine-Balonne WAMP*	Price Waterhouse Coopers. Report prepared for the Balonne Community Advancement Committee	To assess the impacts of the Condamine-Balonne WAMP	Condamine-Balonne, NSW and QLD	2000
Copies not readily available:					
52	*The impact of the current drought on Bourke economy and community*	Western Research Institute (Charles Sturt University). Report prepared for the Department of State and Regional Development	To assess the extent of the economic reversal in Bourke as a consequence of the drought and to highlight the resulting social impacts	Bourke (Barwon Darling region)	2006
53	*The role of monitoring, evaluation, reporting and improvement (MERI) as an integrated assessment tool: Improving socio-economic and biophysical outcomes from investment decisions in natural*	R. Gale and N. Milham, Economic Policy and Research Branch, Department of Industry and Investment NSW	To demonstrate that there is a role for socio-economic MER/MERI as an integrated assessment tool that can be applied at the regional and local level	General applicability, uses case study of Coffs Harbour Coast sub-catchment of	2009

	resource management			Northern Rivers CMA	
54	*Catchment Action NSW 2008/09, Mid-Term Project Report, Socio-Economic Monitoring, Evaluation and Reporting: Beyond the Biophysical*	R. Gale, R. Thomason and N. Milham, Socio-Economic Evaluation Unit, Economic Policy and Analysis Branch, NSW Department of Primary Industries	*Inter alia,* to develop and test methods for integrating socio-economic and biophysical MER at the sub-catchment scale	Sub-catchments of the Northern Rivers, Lachlan and Murray CMA regions	2009
55	*A socio-economic analysis of the impact of the reduction in groundwater allocations in the Namoi Valley. The impact of the Namoi Groundwater Sharing Plan*	Report prepared by the Centre of Agricultural and Regional Economics Pty Ltd, Armidale, NSW	To assess the impactions of the proposed reduction of ground water allocations on irrigation communities	Namoi catchment	2003
56	*Short term impacts of resource re-allocation in the lower Macquarie groundwater management area 008*	D. Cordina, J. Crean and R. Young prepared for Lower Macquarie Groundwater Management Committee			2001
57	*The on-farm impacts of groundwater management scenarios in the lower Murrumbidgee*	R. Jayasuriya prepared for the Murrumbidgee Groundwater Management Committee			2000
58	*Evaluation of environmental flow rules in the Murrumbidgee Valley*	R. Jayasuriya, J. Crean and R. Jones prepared for the AARES conference 2001			2001
59	*The on-farm impacts of environmental flow rules in the Murrumidgee Valley*	R. Jayasuriya and J. Crean prepared for the Murrumbidgee River Management Committee			2001
60	*Impact of variable ctp on stream flow extractions in the Coopers Creek Catchment*	P. Aluwihare and J. Crean prepared for the Northern Rivers Water Management Committee			2002

Economic impacts/studies: Environmental water purchases

No	Title	Author(s)	Objectives	Scope	Date
61	*Review of the 2007-08 water entitlement purchases*	Hyder Consulting in consultation with Access Economics. Report prepared for the Department of the Environment, Heritage and the Arts	To review the Australian Government's 2007-08 water entitlement purchases	First round of the Australian Government's water purchases (2007-08)	2008
62	*Purchasing water in the Murray-Darling Basin*	S. Page, T. Goesch, B. Dyack, S. Hone and N. Hughes (ABARE). Report prepared for the Department of the Environment, Heritage and the Arts	To identify and assess the main mechanisms for buying back water entitlements, including their impacts	Examines a range of purchase mechanisms, incl. open market and auction/tender	2007
63	*Scoping of the economic issues in the Living Murray, with an emphasis on the irrigation sector* (incl. brief discussion of social impacts)	Social and Economic Reference Panel report prepared for the Murray-Darling Basin Commission	To outline the economic costs and benefits of the Living Murray program and the scale of key impacts associated with sourcing environmental water	Living Murray program (Murray Basin)	2004
64	*Review of 'Scoping of the economic issues in the Living Murray, with an emphasis on the irrigation sector'*	D. Brennan (REAP Research). Report prepared for the Murray-Darling Basin Commission	To provide an independent peer review of the original study	Living Murray program (Murray Basin)	2004
65	*Issues and options in applying market based measures in the Living Murray first step*	BDA Group. Report prepared for the Murray-Darling Basin Commission	To explore the use of market based measures in achieving water recovery targets	General discussion	2006
66	*Brief assessment of the merits of purchasing water entitlements during a time of low water availability*	Report prepared by the Social and Economic Reference Panel for the Murray-Darling Basin Commission	To investigate the merits of market-based purchases of water during a time of low-water availability	Living Murray environmental water purchases only (Murray Basin)	2008
67	*Rural water use and the environment: The role of market mechanisms*	Productivity Commission Research Report	To examine the feasibility of establishing market mechanisms to encourage	general	2006

			economic efficiency of rural water use, including managing environmental externalities		
68	*Meeting environmental water demands under uncertainty*	S. Beare, R. Hinde, A. Heaney, N. Che and T. Hillman (ABARE and LaTrobe University)	To develop an optimal water release strategy through a constrained cost minimisation framework	Murrumbidgee River	2006
69	*A preliminary assessment of the economic and social implications of environmental flow scenarios for the Murray River Systems*	M. Young, D. Young, A. Hamilton and M. Bright (CSIRO and PIRSA Rural Solutions). Report prepared for the Murray-Darling Basin Commission	To provide a preliminary assessment of the economic, financial and social implications of environmental flow enhancement	Southern Murray-Darling Basin	2002
70	*Water options for environmental flows*	A. Hafi, S. Beare, A. Heaney and S. Page (ABARE)	To explore water options contracts as a method for securing water for environmental releases	Murrumbidgee River	2005
71	*Market-based opportunities to improve environmental flows: A scoping paper*	E. Siebert, D. Young and M. Young (CSIRO). Report prepared for Environment Australia	To promote discussion relating to the trading and banking of environmental water allocations	general	2000
72	*Screening options and setting priorities for River Murray floodplains*	B. Dyack, J. Connor and D. MacDonald (CSIRO)	To describe how economic analysis can contribute to a screening process for seeking this balance that incorporates biophysical information as well as market and non-market benefits for a range of possible investments in floodplain health	Murray River basin	2005
73	*Natural resource 'buybacks' and their use to secure environmental flows*	M. Scoccimarro and D. Collins (BDA Group). Report prepared for Land and Water Australia	To demonstrate the range of available buyback instruments, including irrigators' attitudes to them, in order to stimulate policy debate surrounding their potential use	general, with Gunbower-Koondrook-Perricoota Forests case study	2006

Economic and social studies: Water trading

No	Title	Author(s)	Objectives	Scope	Date
74	*Third-party effects of water trading and potential policy responses*	A. Heaney, G. Dwyer, S. Beare, D. Peterson and L. Pechey (ABARE and Productivity Commission)	To identify key potential third-party effects of water trade under existing property rights structures in Australia, and to examine policy responses to address these effects	Murray-Darling Basin	2006
75	*Economic impacts of the 4 per cent interim threshold limit*	Access Economics. Report prepared for the Department of the Environment, Water, Heritage and the Arts	To determine the economic impacts of the 4 per cent interim threshold limit on water trade	Victoria	2008
76	*Missing markets for storage and the potential economic cost of expanding the spatial scope of water trade*	D. Brennan (University of Western Australia)	To evaluate the economic costs of missing markets for water storage in the context of broadening trade	Victoria	2008
77	*Volumetric restrictions on water entitlement trade*	Frontier Economics. Report prepared for the Australian Competition and Consumer Commission	To undertake an assessment of the effect of volumetric restrictions on water trade	Murray-Darling Basin; economic efficiency, social and distributional impacts	2009
78	*Review of interim threshold limit on permanent water trade* (unpublished)	Hyder Consulting. Report prepared for the Department of the Environment, Water, Heritage and the Arts	To assess the application, operation and impacts (economic, environmental, social) of the (4 per cent) interim threshold limit on permanent water trade	Water trades in Victoria, NSW and SA	2008
79	*The socio-economic structure of irrigation communities: Water markets and the structural adjustment process*	H. Bjornlund (University of South Australia)	To investigate the structural adjustment impact of temporary water markets	Pyramid-Boort and Torrumbarry districts, northern Victoria	2002
80	*Water markets and their environmental, economic and social impacts in Australia*	H. Bjornlund (University of South Australia)	To analyse water markets and their impacts in Australia	Goulburn-Murray Irrigation District (and general MDB)	2008

81	*Dealing with irrigation drought: The role of water trading in adapting to water shortages in 2007-08 in the southern Murray-Darling Basin*	T. Mallawaarachchi and A. Foster (ABARE). Report prepared for the Department of the Environment, Water, Heritage and the Arts	To capture insights on the nature of water transactions, including the volume and price of trades and the direction of these trades in the 2007-08 irrigation season	New South Wales, Victoria and South Australia	2009
82	*Irrigation in the Murray-Darling Basin: Farms trading temporary water in 2006-07*	M. Oliver, B. Dyack and D. Ashton (ABARE). Report prepared for the Department of Forestry, Fisheries and Agriculture	To undertake a detailed analysis of irrigation farms involved in temporary water trading in 2006-07	Murray-Darling Basin	2009
83	*Water trading within NSW irrigation industry: An empirical evaluation of scale, reasons and attitudes*	I. Singh, M. Bari and N. Flavel (NSW Department of Water and Energy)	To discuss the level of water trading within the NSW Irrigation Industry along with water prices, reasons, attitudes and knowledge of both permanent and temporary water trading	NSW	2008
84	*Revisiting the Goldshmidt hypothesis: Community members' beliefs about water trading and the future of rural communities*	J. Edwards, H. Bjornlund and B. Cheers (University of South Australia)	To report on the attitudes and beliefs of the residents of community concerning the impact of water trading on the long-term viability of their community	Undisclosed town of 4000 inhabitants	2007
85	*Inter-state water trading: A two year review*	M. Young, D. MacDonald, R. Stringer and H. Bjornlund (CSIRO and University of South Australia)	To investigate the economic, social and environmental impacts of inter-state water trading	Murray-Darling Basin	2000

Economic impacts/studies: Water pricing (including models)

No	Title	Author(s)	Objectives	Scope	Date
86	*Price formation on the northern Victorian water exchange*	D. Brennan (REAP Research)	To present a preliminary analysis of market data on the last 5 years of trade on the Victorian water exchange, including the impacts of	Victoria	2004

			water allocations and seasonal conditions		
87	*Fundamentals determining prices and activities in the market for water allocations*	H. Bjornlund (University of South Australia)	To provide insight into which factors drive activity in the water allocations market	Goulburn-Murray irrigation district, Victoria	2005
88	*Price elasticity of water allocations demand in the Goulburn-Murray Irrigation District*	S. Wheeler, H. Bjornlund, M. Shanahan and A. Zuo (University of South Australia)	To understand irrigators' responsiveness to changes in water prices, as an essential element in evaluating the effectiveness of using water markets as a policy instrument	Goulburn-Murray Irrigation District, Victoria	2008
89	*The responsiveness of Australian farm performance to changes in irrigation water use and trade*	R. Bell, J. Gali, P. Gretton and I. Redmond (Productivity Commission)	To assess the links between farm performance and water use practices, involvement in water trading and other farm characteristics	Murray-Darling Basin	2007
90	*Responsiveness of demand for irrigation water: A focus on the southern Murray-Darling Basin*	D. Appels, R. Douglas and G. Dwyer (Productivity Commission)	To explore the determinants of the elasticity of demand for irrigation water (in rice, dairy and horticulture)	Southern Murray-Darling Basin	2004
91	*Water policy reform in Australia: Lessons from the Victorian seasonal water market*	D. Brennan (CSIRO)	To present a discussion on the nature of temporary water markets from a conceptual viewpoint and by examining evidence from the market	Goulburn-Murray region, Victoria	2006
92	*An empirical analysis of factors driving outcomes in markets for permanent water – An Australian case study*	H. Bjornlund and P. Rossini (University of South Australia)	To explore the existence of empirical evidence of factors influencing farmers' willingness to pay for water entitlements and the factors driving the level of activity in the market	Goulburn-Murray region, Victoria	2006
93	*Comparing implicit and explicit water*	H. Bjornlund and M. Shanahan	To trace prices through the	Victoria, NSW and	2007

	prices in three Australian states	(University of South Australia)	transition from an 'immature water market' to an early maturing stage	SA	
94	*Impacts of changing water price and availability on irrigated dairy farms in northern Victoria*	C. Ho, D. Armstrong, P. Doyle and B. Malcolm (DPI Vic, University of Melbourne)	To evaluate how changes in irrigation water price, availability and policy will impact on the viability of dairy farming in the region	Northern Victoria	2004

Economic impacts/studies: general

No	Title	Author(s)	Objectives	Scope	Date
95	*Economic impacts of the draft water sharing plans: An independent assessment*	ACIL Consulting. Report prepared for the NSW Department of Land and Water Conservation	To assess the state-wide economic impacts of the draft New South Wales water sharing plans	Eight surface water and five groundwater sources in New South Wales	2002
96	*Forecasting the regional impact of climate variability on Australian crop farm incomes*	R. Nelson and P. Kokic (ABARE)	To simulate the regional impact of climate variability on farm incomes	Australia-wide	2004
97	*Economic assessment relating to the draft water sharing plan for the Peel Valley: Changes to the alluvial groundwater access rules for Cockburn River and Goonoo Goonoo Creek.*	N. Flavel and M. Bari, NSW Office of Water Sydney	To estimate the economic impact of lost pumping opportunities in the Cockburn River and Goonoo Goonoo Creek alluvial management zones of the Peel Alluvium water source.	Cockburn River and Goonoo Goonoo Creek in the Peel Valley	2009
98	*Irrigation externalities: Pricing and charges*	G. Dwyer, R. Douglas, D. Peterson, J. Chong and K. Madden (Productivity Commission)	To examine the extent to which charges imposed by irrigation water utilities can address externalities from irrigation water supply and use	Murray-Darling Basin (general)	2006
99	*Stranded Irrigation Assets*	H. Roper, C. Sayers and A. Smith	To present options to address the	general	2006

		(Productivity Commission)	perceived adverse financial consequences of stranded irrigation assets		
100	*Mathematical optimisation of drainage and economic land use for target water and salt yields*	T. Nordblom, I. Hume, A. Bathgate and M. Reynolds (DPI NSW)	To present a method for calculating technically feasible options for changes from current to future mean water yields and salt loads from upstream catchments, and the land-use changes to attain each of these options at minimum cost	Little River subcatchment, Macquarie River, NSW	2006
101	*Economic and Environmental Impacts of Development on the Condamine, Moonie and Border Rivers in Queensland on the Murray and Lower Darling Rivers*	Murray Darling Basin Commission	To evaluate the effects of additional developments on the Condamine, Moonie and Border rivers in Queensland on water availability and its economic and environmental interests downstream in the River Murray and the Lower Darling	Murray-Darling Rivers	2000
Copies not readily available:					
102	*Economic assessment of water charges in the Peel Valley*	J. Crean, F, Scott, A. Carter, DLWC	To estimate the impact of increased water price charges on irrigators in the regulated river section of the Peel Valley.	Peel Valley	2000

Economic impacts/studies: Non-market valuation

No	Title	Author(s)	Objectives	Scope	Date
103	*The future of the Murray River: Amenity reconsidered?*	J.L. Howard (Charles Sturt University)	To review studies showing the importance of amenity (tourism, recreation and lifestyle) values of the Murray River	Murray River	2008

104	*Realising environmental demands in water markets*	J. Bennett (ANU)	To address whether governments are setting environmental flows at economically efficient levels and the role of markets in determining environmental allocations of water	general	2005
105	*Non-use values of Victorian public land: Case studies of river red gum forests and East Gippsland forests*	J. Bennett, R. Dumsday, C. Lloyd, M. Kragt and URS Australia. Report prepared for the Victorian Environmental Assessment Council	To apply choice modelling to river red gum forests	River red gum forests, Murray Valley [and East Gippsland forests]	2007
106	*Estimating society's willingness to pay to maintain viable rural communities*	J. Bennett, M. van Bueren and S. Whitten (ANU, Centre for International Economics, CSIRO).	To estimate the value of the benefits associated with maintenance of rural communities (choice modelling)	*Inter alia*, Murrumbidgee floodplain, NSW	2004
107	*River red gum forests investigation – Socio-economic assessment*	Gillespie Economics, DCA Economics and Environmental & Resource Economics. Report prepared for the Victorian Environmental Assessment Council	To outline a social and economic assessment of VEAC's recommendations for the river red gums investigation	River red gum forests, Murray Valley	2007
108	*Valuing New South Wales rivers for use in benefit transfer*	M. Morrison and J. Bennett (Charles Sturt University, ANU)	To value improved river health in NSW	NSW	2004
109	*Estimating community values for land and water degradation impacts*	M. van Bueren and J. Bennett (ANU). Report prepared for the National Land and Water Resources Audit	To estimate non-market environmental and social impacts of land and water degradation (choice modelling)	Australia-wide	2000
110	*A travel cost study of duck hunting in upper southeast South Australia*	S. Whitten and J. Bennett (UNSW, ANU)	To estimate the consumer benefits of duck hunting as one component of wetland values	Upper southeast South Australia	2001
111	*Report 1: Valuing the Environmental Attributes of NSW Rivers*	J. Bennett and M. Morrison (Environment and Resource Economics). Report prepared for the NSW Environmental Protection Authority	To provide information on the values of NSW Rivers (choice modelling)	Bega, Clarence, Georges, Gwydir and Murrumbidgee Rivers, NSW	2001

112	*The economic value of improved environmental health in Victorian rivers*	J. Bennett, R. Dumsday, G. Howell, C. Lloyd, N. Sturgess and L. van Raalte (ANU, DCA, DSE, University of Melbourne, URS)	To generate benefit estimates for a selection of Victorian rivers (choice modelling)	Goulburn, Broken and Corangamite catchments, Victoria	2008
113	*Potential social and economic effects of recommendations for Victoria's box-ironbark forests & woodlands area, Stage 3*	Midas Consulting. Report prepared for the Environment Conservation Council, Melbourne	To provide an assessment of the potential social and economic impacts which may arise from implementation of the ECC's final recommendations	Box-ironbark forests, Victoria	2001
114	*Valuing improved wetland quality using choice modelling*	M. Morrison, J. Bennett and R. Blamey (Charles Sturt University, UNSW)	To use choice modelling to estimate the nonuse values of the Macquarie Marshes, NSW	Macquarie Marshes, NSW and general discussion	1999
115	*Understanding local community preferences for wetland quality*	M. Morrison (Charles Sturt University)	To estimate the value of improved wetland quality	Macquarie Marshes, NSW	2002
116	*Non-market values of wetlands: A choice modelling study of wetlands in the upper southeast of South Australia and the Murrumbidgee River floodplain in NSW*	S. Whitten and J. Bennett (UNSW, ANU)	To estimate the non-monetary benefits of wetlands	Upper southeast South Australia and the Murrumbidgee River floodplain, NSW	2001
117	*Valuing recreation in the Murray: An assessment of the non-market recreational values at Barmah Forest and the Coorong*	B. Dyack, J. Rolfe, J. Harvey, D. O'Connell, N. Abel and S. Ryan (ABARE/CSIRO). Report prepared for the CSIRO Flagships Program: Water for a Healthy Country	To estimate the value of recreation and identify how recreational values might vary with changes in management	Barmah Forest and the Coorong (Murray River)	2007
118	*Cost of algal blooms*	Atech Group. Report prepared for the Land and Water Resources Research and Development Corporation and the Murray-Darling Basin Commission	To identify the principal water groups affected by freshwater algal blooms and quantify the direct and indirect costs of these algal blooms	Australia-wide (excluding Northern Territory and Tasmania)	2000
119	*Multi-attribute choice modelling of Australia's rivers and wetlands: A meta-analysis of ten years of research*	R. Brouwer (CSIRO)	To investigate the suitability of using existing willingness to pay values derived from estimated choice models for the purpose of	Australia-wide (including MDB)	

			benefits transfer		
120	*Ecological Values for a Major River System at Risk:: Australia's Murray-Darling River System*	M. Morrison, D. Hatton-MacDonald, J. Rose and K. Boyle	The focus of the study is key environmental quality indicators along the length of the River Murray.	MDB	2010
Other known studies:					
121	*Quantifying the economic value of river dependent industries in the southern Murray-Darling Basin*	Hassall and Associates			2004
122	*Non-market valuation scoping study*	J. Bennett (Australian National University). Report prepared for the Murray-Darling Basin Commission	To set out the potential to apply stated preference techniques in the context of policy decisions regarding environmental flows in the Murray River	Murray River	2002
123	*The Impact of Water Quality and Water Level on the Recreation Values of Lake Hume. Australasian Journal of Environmental Management 15: 21-29.*	Crase, Lin and Gillespie, Rob			2008
124	*Review of the Social-Economic Values associated with the River Murray, floodplains and wetlands. Milestone Report. CSIRO: Water for a Healthy Country National Research Flagship*	Hatton MacDonald et al (2009)			2008
125	*Choice modelling in the development of natural resource management strategies in NSW, Environmental Economics Research Hub Research*	Mazur K. and J. Bennett (2009)			2008

Report No 1

Social and cultural studies: general

No	Title	Author(s)	Objectives	Scope	Date
126	*Development of a framework for social impact assessment in the Living Murray: Water recovery in the Murray Irrigation Area of NSW*	M. Fenton (Environment and Behaviour Consultants). Report prepared for the Murray-Darling Basin Commission	To develop a conceptual framework for undertaking social impact assessment of water recovery in the context of the Living Murray program	Murray Irrigation Area, NSW	2003
127	*Scoping study: social impact assessment of possible increased environmental flow allocations to the River Murray*	Hassall and Associates, Professor Helen Ross and Mary Maher and Associates (University of Queensland). Report prepared for the Murray-Darling Basin Commission	To profile the social and economic context of communities that may be affected by possible increased environmental flows, and scope the possible impacts from changed flow regimes	River Murray and lower Darling (8 catchments)	2003
128	*Profiling social and economic context: Social impact assessment of possible increased environmental flow allocations to the Murray River System*	Hassall and Associates, Professor Helen Ross and Mary Maher and Associates (University of Queensland). Report prepared for the Murray-Darling Basin Commission	To present a social and economic profile of each of the catchments within the study area	River Murray and lower Darling (8 catchments)	2003
129	*Social impact of changing water regimes: Framework and Echuca case study*	National Academies Forum	To examine the impact of changed water management regimes on a community highly dependent on irrigation	Echuca (Murray River)	2005
130	*Provision for cultural values in water management: The Anmatyerr story*	N. Rea and the Anmatyerr project team (Land and Water Australia)	To demonstrate a methodology for the documentation and recognition of cultural values of water and their translation into meaningful outcomes through cultural water provisions	Northern Territory (but with general application)	2008

131	South Australian Murray-Darling Basin Environmental Values Report	Cast, A. et al,.. CSIRO: Water for a Healthy Country National Research Flagship	To elicit environmental, economic and social values held by regional community policy advisors for inclusion in determining NRM investment priorities	South Australian portion of the MDB	2008
Other known studies:					
132	*Scoping study on Indigenous involvement in natural resource management decision making and the integration of Indigenous cultural heritage considerations into relevant MDBC programs*	Forward NRM and Arilla-Aboriginal Training and Development. Report prepared for the Murray-Darling Basin Commission		Murray-Darling Basin	2003
133	*Water perspectives: Outcomes of an expert workshop scoping social and institutional research questions in support of the National Water Initiative*	Land and Water Australia	To discuss opportunities for social and institutional water research	general (National Water Initiative focus)	2006
134	*People, Pumps and Pipes: A social study of change in the collaborative supply of irrigation services*	Consortium of Hawke Research Institute for Sustainable Communities, UniSA, Renmark Irrigation Trust, PIRSA Sustainable Systems and the Social Inclusion Unit at DPC. Funded by the Australian Research Council	To investigate the way in which recent legislative change to allow irrigation licences in the Renmark Irrigation Trust to be individually owned and traded (rather than collectively owned) will affect the role of the RIT, future land use and the efficacy of policy initiatives	Renmark Irrigation Trust in South Australia	2010 to 2012
135	*Market Mechanisms for Recovering Water in the Murray-Darling Basin*	Productivity Commission	Draft report prepared for public consultation	Review the mechanisms to purchase water entitlements.	2009
136	*Removing barriers to facilitate efficient water markets in the Murray-Darling basin of Australia.*	E. Qureshi, T. Shi, S.E. Qureshi and W. Proctor	To investigate the costs of water restrictions in the Murray-Darling Basin	Study of the costs of water restrictions in the MDB.	2009

Appendix B: Summary of each study

1. *Reference:* M. Mainuddin, M. Kirby and M.E. Qureshi (2007). 'Integrated hydrologic-economic modelling for analysing water acquisition strategies in the Murray River Basin', Agricultural Water Management vol.93 pp123-135.

Owner: CSIRO Flagships Program: Water for a Healthy Country.

Authors: M. Mainuddin, M. Kirby and M.E. Qureshi (CSIRO Land and Water).

Objectives: To examine the hydrological and economic implications of targeted versus proportional approaches to acquiring water for the environment.

Scale and scope: Murray River Basin only; targeted (least cost) vs. proportional acquisitions of environmental water, including impacts on irrigation water use and regional agricultural income; ***

Methods and Data: Authors use an optimisation model (two-way, iterative, linked non-linear hydrologic- linear economic) to maximise sub-catchment profit, diversions and flows across seven policy scenarios. Model was calibrated with data from the Water Audit Monitoring Report (MDBC 2002) and crop land use data from Bryan and Marvanek (2004)

Results: The optimal approach for acquiring environment water depends on hydrological, institutional and economic factors. Hydrological factors – eg. connectivity, transmission losses – affect the volume and location of water that needs to be acquired for a given increase in water at an environmental site. Institutional factors – eg. restrictions on trade between sub-catchments – affect both the volume and the opportunity costs associated with that water. Large differences in Murray River flows and opportunity costs result from targeted (least cost) acquisitions versus proportional acquisitions. Targeted environmental water acquisitions may not incur large opportunity costs across the irrigation industry, although some sectors (pasture for dairy, beef) and regions (Murray-Riverina, Upper Murray) are likely to be affected considerably.

2. *Reference:* M.E. Qureshi, J. Connor, M. Kirby and M. Mainuddin (2007) 'Economic assessment of acquiring water for environmental flows in the Murray Basin', *Australian Journal of Agricultural and Resource Economics, vol. 51 pp283-303*.

Owners: CSIRO Flagships Program: Water for a Healthy Country.

Authors: M.E. Qureshi, J. Connor, M. Kirby and M. Mainuddin (CSIRO Land and Water).

Objectives: To analyse the economic implications of reallocating Murray River Basin water from agriculture to the environment with and without the possibility of inter-regional trade.

Scale and Scope: Murray River Basin only (13 catchments); variables are inter-regional trade (restricted versus unrestricted) and acquisition approach (targeted versus proportional); includes salinity impacts of water trading.

Methods and Data: Authors use an optimisation model (non-linear programming, one-way, hydrologic-economic, allows deficit irrigation and expanding/contracting land area) to maximise catchment profit. Spatial distribution of water allocations are calculated from a combination of BigMod-MSM (MDBC) and single year

distribution of irrigated land and water use (Bryan and Marvanek 2004). Salinity impacts per region analysed using a prior assessment (Heaney et al. 2001) coupled with the above hydrological modelling.

Results: Net revenue reductions to irrigation are less if water acquisitions are targeted from low-value regions rather than taken proportionally from all regions. In all scenarios considered, net revenue gains from freeing trade are estimated to outweigh the negative revenue effects of reallocating water for environmental flows. Net irrigation revenue is estimated to be less when volumes of environmental water acquired are allowed to vary over wet and dry years. The salinity-related externality costs of water trading are estimated to be quite modest compared to the direct benefits of trade.

3. *Reference:* Adamson, D., T. Mallawaarachchi and J. Quiggin (2009). 'Declining inflows and more frequent droughts in the Murray-Darling Basin: climate change, impacts and adaptation', *Australian Journal of Agricultural and Resource Economics*, *vol.53 pp345-366*

Owner:

Authors: D. Adamson, T. Mallawaarachchi and J. Quiggin (University of Queensland, Australian Bureau of Agricultural and Resource Economics).

Objectives: To analyse the effects of climate change in the Murray-Darling Basin across two alternative hypotheses (that changes in inflows will be proportionate across states of nature; and that changes in inflows will be driven primarily by changes in the proportions of states of nature).

Scale and Scope: Entire Murray-Darling Basin (18 catchments plus Adelaide); 3 states of nature (drought, normal, flood); 9 commodities; flexible land areas.

Method and Data: Authors use a simulation model developed in Adamson et al. (2007; see below), incorporating a state-contingent representation of uncertainty.

Results: "The adverse impacts of climate change are significantly greater if change takes the form of more frequent droughts, rather than a uniform reduction in inflows across all states of nature. However, these adverse impacts may be partially offset by adaptation."

4. *Reference:* Adamson, D., T. Mallawaarachchi and J. Quiggin (2007). 'Water use and salinity in the Murray-Darling Basin: A state-contingent model', *Australian Journal of Agricultural and Resource Economics*, *vol.51 pp263-281*.

Owner:

Authors: D. Adamson, T. Mallawaarachchi and J. Quiggin (University of Queensland, Australian Bureau of Agricultural and Resource Economics).

Objectives: To show how linear and non-linear programming models for the Murray–Darling Basin may be adapted to incorporate a state-contingent representation of uncertainty.

Scale and Scope: Entire Murray-Darling Basin (18 catchments plus Adelaide), 8 commodities.

Method and Data: Authors use a model which optimises land and water allocations by region (linear programming), before optimising for the 'network' or system as a whole (non-linear programming). Data on

flows of water and salt are derived from the MDBC and supplemented by other sources including Catchment Management Authority publications.

Results: "The state-contingent approach provides the best way to model flexible responses to uncertainty and the effects of alternative property rights regimes".

5. *Reference*: Kirby, M., M.E. Qureshi, M. Mainuddin and B. Dyack (2006). 'Catchment behaviour and counter-cyclical water trade: An integrated model', Natural Resource Modelling vol.19 no.4.

Owner: CSIRO Flagship Program: Water for a Healthy Country.

Authors: M. Kirby, M.E. Qureshi, M. Mainuddin and B. Dyack (CSIRO Land and Water).

Objectives: To examine the potential of counter-cyclical trading for (governments') environmental water holdings.

Scale and Scope: Murray River Basin only (13 sub-catchments); trading permitted across 3 commodities (plus environment); 4 scenarios (including climate change, upstream afforestation, irrigation efficiency, base case).

Method and Data: Authors use a simulated model (one-way, linked hydrologic-economic) with temporary water trading only and individual decision-makers. Rainfall data taken from SOIL datasets (Bureau of Meteorology), land use from National Land and Water Resources Audit.

Results: "There appears to be good prospect of counter cyclical trading delivering water for environmental use while maintaining financial viability".

6. *Reference:* Grafton, R.Q. and Q. Jiang. (2010). 'Economics of Drought, Water Diversions, Water Recovery and Climate Change in the Murray-Darling Basin'. Centre for Water Economics, Environment and Policy (CWEEP), Research Paper 10-01. Available for download at http://cweep.anu.edu.au/

Owner: Grafton and Jiang

Authors: R. Q, Grafton and Q. Jiang.

Objectives: To assess the economic costs to irrigated agriculture in the Murray-Darling basin from reductions in surface water diversions.

Scale and Scope: The authors develop and use a hydro-economic model of the Basin (based on CSIRO sustainable yields) and at two different time periods provide an economic assessment of the changes in irrigated agriculture profits.

Methods and Data: Employ a linear programming approach to develop the results.

Results: To acquire extra volumes of water for the environment a 50% buyback (based on 2005-2006 agricultural surface water diversions), would require additional funding of between $6.05 and $8.64 billion over and above the $3.1 billion allocated under the *Water for the Future* package. To acquire volumes consistent with a 40% buyback (based on 2005-2006 agricultural surface water diversions), it would require additional funding of between $4.21 and $6.23 billion over and above the funds currently allocated for buyback.

7. *Reference:* Goesch, T., A. Hafi, S. Thorpe, P. Gooday and O. Sanders (2009). 'Climate change, irrigation and risk management', *ABARE Outlook 09: A changing climate for agriculture.*

Owner: Australian Bureau of Agricultural and Resource Economics.

Authors: T. Goesch, A. Hafi, S. Thorpe, P. Gooday and O. Sanders.

Objectives: To estimate the direct economic impacts of changes in irrigation water availability under the future climate/current development scenario compared with the historical climate/current development scenario.

Scale and Scope: Entire Murray-Darling Basin (22 catchments based on a slight reconfiguration of CSIRO's Sustainable Yields (2008) catchments); 14 commodities; assumes no interregional water trading or external impacts of upstream decisions;

Method and Data: The authors use ABARE's water trade model (one-way, linked hydrologic-economic) which optimises commodity production at a catchment level. Data on rainfall, surface water availability and surface water diversions are from CSIRO (2008).

Results: There is potential for the diversity of irrigated activities to mitigate the impact on incomes of reduced water availability. Intra-regional trade also cushions the impact of reduced water availability by reallocating water to higher value uses.

8. *Reference:* Goesch, T., S. Hone, A. Hafi, S. Thorpe, K. Lawson, S. Page, N. Hughes and P. Gooday (2008). 'Murray-Darling Basin: Economic implications of water scarcity', *Australian Commodities, March quarter 2008, ABARE.*

Owner: Australian Bureau of Agricultural and Resource Economics.

Authors: T. Goesch, S. Hone, A. Hafi, S. Thorpe, K. Lawson, S. Page, N. Hughes and P. Gooday.

Objectives: To examine the direct and indirect economic impacts of a reduction in water availability for irrigated agricultural activities in the basin in the medium term (using median water availability scenario from CSIRO Sustainable Yields (2008)).

Scale and Scope: Entire Murray-Darling Basin (irrigated agriculture only); 18 commodities; assumes no inter-regional water trading or external impacts of upstream decisions; does not incorporate salinity effects of reduced water availability.

Method and Data: The authors use ABARE's water trade model (one-way, linked hydrologic-economic) which optimises commodity production at a catchment level. This information is then fed into ABARE's AusRegion model (general equilibrium) to examine indirect flow-on effects on regional economies.

Results: "The most vulnerable regional economies will tend to be those where the direct effects of reduced water availability are substantial, or where the agricultural and related processing industries comprise a relatively large proportion of economic activity."

9. *Reference:* Connor, J., K. Schwabe, D. King, D. Kaczan and M. Kirby (2009). 'Impacts of climate change on lower Murray irrigation', *Australian Journal of Agricultural and Resource Economics, vol.53, pp437-456*.

Owner: CSIRO Flagship Program: Water for a Healthy Country, and Lower Murray Landscape Futures Program.

Authors: J. Connor, K. Schwabe, D. King, D. Kaczan and M. Kirby (CSIRO Water for a Healthy Country National Research Flagship, University of California, CSIRO Sustainable Ecosystems, CSIRO Land and Water).

Objectives: To evaluate irrigated agriculture sector responses and resultant economic impacts of climate change for a part of the Murray-Darling Basin in Australia.

Scale and Scope: Economic impacts of reduced irrigation water modelled for the Lower Murray Region only (although hydrological impact of climate change is modelled across the entire Murray-Darling Basin); 3 climate scenarios modelled (mild, moderate, severe); economic model accounts for a range of adaptive responses to reduced water availability (deficit irrigation, temporary fallow periods, reducing irrigation area, changing mix of crops).

Method and Data: A basin-wide water balance model is used to estimate changes in inflows to major dams in the entire Murray-Darling Basin under different climate change scenarios. A mathematical programming model is then used to estimate long run and short run adjustments in response to reduced irrigation water availability. Data on rainfall and runoff are from Pittock (2003) and Kirby et al. (2006). Water allocations are then modelled using MDBC's BigMod-MSM. Economic model for adaptive responses use data from, *inter alia*, Jayasuriya (2004) and Qureshi et al. (2007).

Results: "Relatively low-cost adaptation strategies are available for a moderate reduction in water availability and thus costs of such a reduction are likely to be relatively small. In more severe climate scenarios greater costs are estimated".

10. *Reference:* Horridge, M., J. Madden and G. Wittwer (2005). 'The impact of the 2002-2003 drought on Australia', *Journal of Policy Modelling vol.27 pp285-308*.

Owner: Centre of Policy Studies, Monash University

Authors: M. Horridge, J. Madden and G. Wittwer

Objectives: To simulate the short run regional effects of the Australian drought in 2002-2003.

Scale and Scope: Australia wide (57 statistical regions); 144 sectors.

Method and Data: Authors use TERM (The Enormous Regional Model), a computable general equilibrium (CGE) model which treats each region as a separate economy. Data are drawn from various ABS publications.

Results: The effect of the drought varied widely between regions and in some cases was extreme. Despite the relatively small share of agriculture in Australian GDP, the drought reduces GDP by 1.6 per cent, contributes to a decline in unemployment and worsens the balance of trade.

11. *Reference:* Dixon, P., M.T. Rimmer and G. Wittwer (2009). 'Modelling the Australian Government's buyback scheme with a dynamic multi-regional CGE model', *General Paper No.186*, April 2009, *Centre of Policy Studies and the Impact Project, Monash University*.

Owner: Centre of Policy Studies, Monash University

Authors: P. Dixon, M.T. Rimmer and G. Wittwer

Objectives: To model the effects on regional economies of the Australian Government's environmental water acquisitions.

Scale and Scope: Southern Murray-Darling Basin (22 statistical regions); 28 commodities; 35 industries; includes water trading (with constraints) and technological investments.

Method and Data: Authors use TERM-H2O model (TERM adapted to include regional water accounts) to model the effects of government water acquisitions. Data are drawn from ABS publications (including water accounts).

Results: The impact of the buyback on regional economies is quite small. The buyback scheme provides a windfall gain for holders of water rights by raising the price of irrigation water. The scheme may provide a net benefit to irrigation regions while increasing environmental flows.

12. *Reference:* Peterson, D., G. Dwyer, D. Appels and J. Fry (2004). 'Modelling water trade in the southern Murray-Darling Basin', Productivity Commission Staff Working Paper, Melbourne, November.

Owner: Productivity Commission

Authors: D. Peterson, G. Dwyer, D. Appels and J.M. Fry

Objectives: To compare the effects of reductions in water availability of 10, 20 and 30 per cent across three trading scenarios (no trade, intra-regional trade only, both intra- and inter-regional trade).

Scale and Scope: Southern Murray-Darling Basin only (20 statistical regions); 48 sectors.

Method and Data: Authors use TERM-Water model (CGE, each region modelled as separate economy, includes representation of production and water use within irrigation sector, water is tradable, changing input and output mixes allowed) to compare the effects of reduced water availability across trading scenarios. Data are drawn from ABS publications (including water accounts).

Results: "The model estimates that moving from no trade to intra- and inter-regional trade together more than halves the impact of the reductions in water on the gross regional product (GRP) of the southern Murray-Darling Basin. Declines in output are also lower in most industries when intra- and inter-regional trades are allowed. A 20 per cent reduction in water availability has more than double the effect on GRP of a 10 per cent cut, while a 30 per cent cut has an almost fourfold effect".

13. *Reference:* D. Peterson, G. Dwyer, D. Appels and J.M. Fry (2005). 'Water trade in the southern Murray-Darling Basin', *Economic Record vol.81 no.255 pp115-127*.

Owner: Productivity Commission

Authors: D. Peterson, G. Dwyer, D. Appels and J.M. Fry

Objectives: To examine the regional effects of expanding trade of irrigation water in the southern Murray–Darling Basin.

Scale and Scope: Southern Murray-Darling Basin only (20 statistical regions); 48 sectors;

Method and Data: Authors use TERM-Water (see *11) to measure the magnitude and distribution of the effects of expanding water trade, as well as the impact on industries and regions as irrigation activities adjust. Data are drawn from ABS publications (including water accounts).

Results: "Water trading dampens the impact on gross regional product of water allocation cuts. The benefits of introducing trading within irrigation districts are greater than those of a further expansion of trade between regions".

14. *Reference:* Adams, P.D., M. Horridge, J. Madden and G. Wittwer (2002). 'Drought, regions and the Australian economy between 2001-02 and 2004-05', *General Paper G-135, Monash University,* December 2002.

Owner: Centre of Policy Studies, Monash University.

Authors: P.D. Adams, M. Horridge, J. Madden and G. Wittwer

Objectives: To examine the prospects for the Australian economy between 2001-02 and 2004-05.

Scale and Scope: Australia wide (45 statistical regions); 38 industries.

Method and Data: Authors use the MONASH (macro level model) and TERM. Data used for TERM drawn from ABS agricultural output data.

Results: (Detailed simulations of regional effects of the drought are given).

15. *Reference:* Quiggin, J., D. Adamson, P. Schrobback and S. Chambers (2008). '*Garnaut Climate Change Review*: The implications for irrigation in the Murray-Darling Basin', June 2008, *prepared for the Garnaut Climate Change Review* (2008).

Owner: Australian Government

Authors: J. Quiggin, D. Adamson, P. Schrobback and S. Chambers (Risk and Sustainable Management Group, University of Queensland).

Objectives: To provide a consistent framework for analysing the responses of land and water use, and economic returns to agriculture, under a range of climate scenarios.

Scale and Scope: Irrigation in the Murray-Darling Basin (18 regions plus Adelaide); includes variables for severity of climate impacts, stabilisation levels of greenhouse gases, extent of adaptation to climate change.

Method and Data: Authors use a simulation model developed in Adamson et al. (2007), incorporating a state-contingent representation of uncertainty. Data calibrated to ABS agricultural production statistics (2001).

Results: "With the exception of one scenario, the changes in inflows observed as a result of climate change are well within the range of natural variation observed in the historical record. The Basin is already under considerable threat and with adverse climate change could deteriorate further. Care must be taken in interpreting this data due to the issues not included in the model".

16. *Reference:* Hafi, A., S. Thorpe and A. Foster (2009). 'The impact of climate change on the irrigated agricultural industries in the Murray-Darling Basin', ABARE Conference Paper 09.3, February 2009, *Australian Agricultural and Resource Economics Society*.

Owner: Australian Bureau of Agricultural and Resource Economics

Authors: A. Hafi, S. Thorpe and A. Foster

Objectives: To model the effect of reduced water availability on irrigated agriculture in the Murray-Darling Basin.

Scale and Scope: Entire Murray-Darling Basin (22 regions based on CSIRO's (2008) regions); includes salinity externalities.

Method and Data: Authors use a comparative state partial equilibrium model (profit-optimising, one-way, linked hydrologic-economic, incorporates flexible production functions and institutional (trade restriction) configurations). Data are drawn from ABS agricultural censuses (2000-01 and 2005-06) and CSIRO sustainable yield reports, SILOS database.

Results: The results from a hypothetical reduction in water availability are consistent with economic theory and observed responses to changes in water availability. All industries responded to a hypothetical reduction in water availability, a result allowed for by flexible production technologies. It is likely that the crop yield response to irrigation water salinity will be as important to understand as the crop yield response to irrigation water, yet little information on this relationship is available at present.

17. *Reference:* Mallawaarachchi, T., S. Hone, D. Adamson, A. Yainshet, M. Oliver, P. Kokic, J. Quiggin and P. Gooday (2008). 'Reduced water availability: Impact on agricultural activities and regional economies in the Murray-Darling Basin'. ABARE client report prepared for the MDBC.

Owner: MDBC

Authors: T. Mallawaarachchi, S. Hone, D. Adamson, A. Yainshet, M. Oliver, P. Kokic, J. Quiggin and P. Gooday (ABARE, Risk and Sustainable Management Group, University of Queensland).

Objectives: To gain a more comprehensive understanding of the potential economic impacts of six main risks to water resources identified.

Scale and Scope: Entire Murray-Darling Basin. 4 scenarios of reduced water availability; intra-regional (but not inter-regional) trade allowed; salinity impacts, conveyance losses and regional biophysical constraints included.

Methods and Data: Authors use a sequentially-solved set of three models (including direct and indirect economic impacts): RSMG, GRASP and AusRegion.

Results: "The modelling conducted in this report suggests that the economic impact of reduced water availability in the basin could be substantial. If water availability in the basin were to decline-irrigators would source additional water from the environment, subject to extraction policy. Thus, in all simulations, the proportional reduction in irrigation water usage is less than the proportional reduction in overall water availability. Furthermore, as the opportunity cost of water use increases, there are stronger incentives for irrigators to adopt more water efficient technologies or to shift to dryland farming. These adjustments could partially off-set the impact on farm profit.

When irrigation water availability in the basin declines by 30 per cent, farm profit from irrigated agriculture is estimated to fall by 25.6 per cent. The estimated impacts of reduced water availability tend to vary substantially across regions and southern regions are likely to be relatively more vulnerable. The total area of land used for irrigated cotton and rice-wheat production is estimated to fall more sharply than the area of land used for horticulture and dairy production under the reduced water availability scenarios. Actual changes will be influenced by costs and benefits of adaptation that will be determined by individual circumstances, market conditions and future government policy affecting irrigators and dryland farmers."

18. *Reference:* Jayasuriya, R.T. (2004). 'Modelling the regional and farm-level economic impacts of environmental flows for regulated rivers in NSW, Australia', *Agricultural Water Management vol.66 pp77-91*.

Owner: NSW Agriculture

Authors: R.T. Jayasuriya

Objectives: To outline the different approaches taken by NSW Agriculture to quantify economic impacts on irrigators; to provide the results of case studies in two regulated river catchments heavily developed for irrigation.

Scale and Scope: NSW generally with case studies from the Murrumbidgee and Lachlan Catchments.

Method and Data: Author uses a combination of hydrologic and economic simulation modelling (linear programming), where impacts of environmental flows are determined relative to a base case of no environmental flows. Modelling system uses two-stage solution process whereby irrigators make decisions both before an irrigation season (on optimal levels and mixes of crops, pastures and livestock activities) and during it (tactical responses to rainfall scenarios). Hydrologic model is DLWC's Integrated Quality-Quantity Model

Results: "Both regional and farm-level modelling is important is assessing the impacts of water policies in large, regulated valleys. The re-allocation of water from agricultural to environment uses would have a larger net impact on farmers than on the regional economy. There are differences in terms of impacts between production zones (more active irrigation zones indicate higher impacts) as well as among individual representative farms (due to the diverse characteristics including the level of irrigation activity)."

19*. Reference:* Heaney, A., S. Thorpe, N. Klijn, S. Beare and S. Want (2004). 'Water charges and inter-regional trade in the southern Murray-Darling Basin', ABARE Conference Paper 04.14. Presented at the Establishing Australian Water Markets Symposium, Melbourne 9 August.

Owner: ABARE

Authors: A. Heaney, S. Thorpe, N. Klijn, S. Beare and S. Want (ABARE).

Objectives: To indicate the effect of different water delivery charging regimes on the system-wide and regional impacts of trade.

Scale and Scope: Southern Murray-Darling Basin only (8 regions).

Methods and Data: Authors use a simulation analysis (competitive partial equilibrium model) to indicate the effect of different charging regimes on the system-wide and regional impacts of trade in the southern Murray Darling Basin. Land values, water intensities and land use areas from ABARE's SALSA model.

Results: "The findings suggest that the removal of any impediments to trade will result in around 600 gigalitres of additional trade in permanent water entitlements, and an increase in net income of almost $100 million in net present value terms. This reflects, in part, the large sunk investment in on- and off-farm infrastructure. As these assets reach the end of their economic life and environmental demands increase, so too will the value of trade. While changes in regional income as a result of inter-regional trade are small, importantly, the manner in which supply authorities recoup fixed costs from irrigators remaining in the system after trade has distributional effects on regional income and can distort trading patterns."

20. *Reference:* Chambers, A., J. Connor and D. King (2006). 'Modelling the cost of irrigator response to lower Murray River salinity'

Owner:

Authors: A. Chambers, J. Connor and D. King (PIRSA, CSIRO).

Objectives: To report on an analysis of irrigator water demand and profit changes across varying annual water availability, crop water requirements and river salinity conditions.

Scale and Scope: South Australian lower Murray River.

Methods and Data: Authors use a non-linear mathematical program to model short-run irrigator responses to changes in agro-climatic variables (rainfall, salinity); includes temporary water prices

Results: "Results reported here would tend to suggest that the response to increasing salinity is to increase irrigation drainage leaching. Thus, the assumption implicit in the current MDBC net benefits formula used in assessing salinity-offset investments – that irrigators would simply accept yield losses – leads to overstatement of the benefits of actions to decrease salinity."

21. *Reference:* Lee, L., T. Ancev and W. Vervoort (2006). 'Weighing up the cost: Economic impact of water scarcity and environmental targets', Australian Agricultural and Resource Economics Society Conference Paper.

Owner: University of Sydney

Authors: L. Lee, T. Ancev and W. Vervoort

Objectives: To determine the optimal allocation of water, irrigation system, source of water, and crop pattern, subject to various environmental and resource targets.

Scale and Scope: Mooki catchment, NSW, divided into 32 sub-basins; 7 activities (crops); water and deep drainage constraints considered.

Methods and Data: Integrated biophysical-economic model (one-way, profit maximisation at catchment scale) used to determine optimal water allocation. Data from Soil and Water Assessment Tool (SWAT) and agricultural management data (NSW Agriculture).

Results: "When simultaneously setting deep drainage and water extraction rules, so long as basin water is not excessively binding, deep drainage constraints can be a cost-effective means of controlling salinity. However, if the water constraint is too tight then deep drainage targets becomes meaningless; if there is insufficient irrigation water to begin with, imposing deep drainage constraints would have no significant consequence on profit. Considering the value of water in trade, it appears that there is scope for water trading in unregulated systems."

22. *Reference:* Wittwer, G. (2006). 'Modelling future urban and rural water requirements in a CGE framework'. Paper presented at the 50th Annual Conference of the Australian Agricultural and Resource Economics Society, 8-10 February 2006, Sydney.

Owner: Centre of Policy Studies, Monash University

Authors: G. Wittwer

Objectives: To model the impacts of water trading on the national and regional economies of Australia, taking account of estimated structural changes (*inter alia*, demand growth, technological change, water availability, water-efficiency changes) in the next few decades.

Scale and Scope: Regional economies of Australia. Considers structural changes as the first of multiple desirable extensions to TERM.

Method and Data: Author amends TERM model (multi-regional CGE, including water accounts linked to each economic activity) to consider a number of elements of structural adjustment over time

Results: General economic growth is likely to increase the share of water demanded by non-agricultural users at the expense of agriculture. The shadow price of water is estimated to rise with productivity growth in both agricultural and non-agricultural sectors, as well as reduced water availability. Productivity growth in agriculture will favour relatively less water-intensive users at the expense of more water-intensive users. Cotton and rice are therefore likely to be adversely affected, with water diverted to crops and livestock.

23. *Reference:* Goesch, T., A. Hafi, A. Heaney and S. Szakiel (2006). 'Exit fees and inter-regional trade', ABARE Research Report 06.5.

Owner: ABARE

Authors: T. Goesch, A. Hafi, A. Heaney and S. Szakiel

Objectives: To consider the efficiency impacts of an 'ex post' imposition of exit fees on permanent out of scheme water trade.

Scale and Scope: Three irrigation regions; considers one water product (permanent entitlements); 3 scenarios (unrestricted trade, trade with equal exit fees by region, trade with differing exit fees by region).

Methods and Data: Authors use a (illustrative) modelling framework with emphasis on relative (rather than absolute) measures on losses imposed by exit fees.

Results: "The larger the exit fees as a proportion of the traded price of water, the larger would be the loss in economic gains until the point where water trade was no longer profitable. The distortionary effects of exit fees on trade would be greater as other impediments were removed, such as the 2–4 per cent quota on out of scheme trade. Unbundling water access rights from delivery access rights and attaching the access fee (either

annually or capitalised) to the delivery right would be a more efficient means of addressing the third party impacts of trade on delivery system costs. Exit fees would tend to concentrate any purchases of water entitlements for environmental purposes in regions with lower fixed infrastructure costs. This in turn would concentrate the flow-on effects of reduced water availability to specific regions."

24. *Reference:* Hafi, A., N. Brownlowe and W. Walsh (2006). '*Groundwater and surface water use in the Dumaresq River Valley: A hydroeconomic model*', ABARE Research Report 06.17

Owner: ABARE

Authors: A. Hafi, N. Brownlowe and W. Walsh

Objectives: To investigate the impact of an increase in demand for groundwater pumping on stream depletion.

Scale and Scope: Dumaresq River Valley, Border Rivers area of NSW and Queensland; 3 water trading scenarios considered.

Methods and Data: Authors use a hydro-economic model (profit maximising at sub-catchment level) with three linked components (economic, hydro-geological and institutional). Water availability predicted by MODFLOW. Data collected by an original survey of Dumaresq water users; crop data from NSW Agriculture.

Results: "The access to an alternative source of water supply in the form of groundwater would facilitate trade of surface water out of the valley as groundwater substitutes for surface water in irrigation. Consequently, a market for surface water downstream is expected to reduce surface water use and increase groundwater use in the valley. A market for surface water downstream creates new income opportunities for irrigators in the valley even though water trading could result in a reduction in net incomes generated from on-farm agricultural activities. Income earned from selling water is expected to more than offset any reduction in farm profits."

25. *Reference:* Hafi, A. and T. Goesch (2006). 'Groundwater extraction: Economic impacts of stream flow depletion in the Murray-Darling Basin', ABARE Research Report 06.18.

Owner: ABARE

Authors: A. Hafi and T. Goesch

Objectives: To investigate the economic impact of stream flow depletion from groundwater use in physically connected water systems.

Scale and Scope: Two case study areas (Dumaresq River Valley, Murrumbidgee Valley); two scenarios (low and high shared water use by upstream users); two groups of users (upstream: conjunctive, and downstream: surface water only).

Methods and Data: Authors use different nonlinear profit maximisation models for each region considered. Data on demand parameters for water derived from regional agricultural production functions, water demand elasticities drawn from ABARE's Murrumbidgee River Options Model (MROM).

Results: "The results for these two case studies indicate minimal efficiency losses in the absence of institutional arrangements that deal with the double allocation of shared water, although this may not be the case for other connected systems. Moreover, the results of these analyses do not take into account the cost of reduced reliability for surface water users, or the potential for the double allocation of shared water to impose

costs on the environment. More research is needed in connected water systems to correctly identify the shared water component.

Where policy makers have a good understanding of the groundwater system and groundwater/surface water connectivity, the preferred option may be to allocate property rights to the consumptive component of shared water and allow trade in these rights once the overallocation issue has been resolved. The success of any management regime will, however, be highly dependent on being able to monitor groundwater irrigators' use of shared water, and enforcing any restrictions on their access to this water."

26. *Reference:* Eigenraam, M., J. Crean, R. Wimalasuriya and R. Jayasuriya (2003). 'Economic analysis of environmental flow scenarios in the Murray River System'

Owner: MDBC

Authors: M. Eigenraam, J. Crean, R. Wimalasuriya and R. Jayasuriya (Vic DPI and NSW Agriculture).

Objectives: To undertake a preliminary assessment of two mechanisms for water recovery (a Cap reduction and a market-based approach).

Scale and Scope: Major irrigation areas in NSW, Victoria and South Australia; assumes no restrictions on water trading, does not consider structural adjustment costs (ie. investigates short term response only).

Methods and Data: Authors use the Water Policy Model (spatially connected optimisation model incorporating regional irrigation demand functions), and the TERM model to investigate regional impacts.

Results: "There are significant costs to the agricultural sector ($55 million to $155 million depending on the scenario) from a reduction in the Cap. The costs highlight the importance of microeconomic reform in the area of water trade to minimise the economic impact of any proposed changes in water supply for environmental purposes. Undertaking economic analyses on a regional basis tends to hide the distributional aspects of reform. Such distributional information is important in the identification of particular groups which may be more adversely affected by the establishment of environmental flows."

27. *Reference:* [ref.18], Jones, R., J. Crean, P. Aluwihare and R. Letcher (2007). 'Economic costs of environmental flows in an unregulated system', *Australian Journal of Agriculture and Resource Economics, vol. 51 pp305-321.*

Owner: NSW Department of Primary Industries

Authors: R. Jones, J. Crean, P. Aluwihare and R. Letcher

Objectives: To assess the economic costs to irrigated agriculture of environmental flows in an unregulated river system in the Namoi River Valley, NSW.

Scale and Scope: Namoi River Valley, NSW; considers base case scenario and introduction of new Water Sharing Plan (WSP).

Method and Data: Authors develop a stochastic dynamic programming model that interacts with a catchment hydrology model and models of on farm storage dynamics, irrigation scheduling and crop response to soil moisture deficits. Integrated Quantity-Quality Model used to estimate hydrology data.

Results: "Introduction of the WSP would have a negligible impact upon agricultural returns at the catchment level, particularly when compared to other sources of income variability such as crop prices. The economic costs (in percentage terms) are considerably less than the reduction in water availability. There were only small differences in the optimal investment decisions between the base case and the WSP case."

28. *Reference:* Connor, J., M. Kirby, K. Schwabe, A. Lukasiewicz and D. Kaczan (2007). 'Estimating impacts of climate change on Lower Murray irrigation'. Paper presented to the 52th Annual Conference of the Australian Agricultural and Resource Economics Society.

Owner: CSIRO

Authors: J. Connor, M. Kirby, K. Schwabe, A. Lukasiewicz and D. Kaczan

Objectives: To evaluate the irrigated agriculture sector response and resultant economic impacts of climate change using a water balance model.

Scale and Scope: Lower Murray main stem only (below Swan Hill in Victoria and in South Australia); variety of adaptive responses permissible (deficit irrigation, temporary fallowing, permanently reducing irrigation area, changing crop mixes); 4 water availability scenarios.

Methods and Data: Authors use a two-stage mathematical programming model (profit maximising) which estimates short and long-run adjustments. Estimates of the impacts of climate change on water availability provided by MDBC's BIGMOD MSN.

Results: "The results suggest that relatively low cost adaptation strategies are available for moderate reduction in water availability and thus costs of such reduction are likely to be relatively small. In more severe climate change scenarios greater costs are estimated, adaptations predicted include a reduction in total area irrigated, investments in efficient irrigation, and a shift away from perennial to annual crops as the latter can be managed more profitably when water allocations in some years are very low."

29. *Reference:* Adamson, D., J. Quiggin and T. Mallawaarachchi (2005). 'Modelling basin-level allocation of water in the Murray-Darling Basin in a world of uncertainty', *Australian Agricultural and Resource Economics Society*.

Owner: University of Queensland

Authors: D. Adamson, J. Quiggin and T. Mallawaarachchi

Objectives: To use and compare GAMS and Excel-based modelling approaches to ask where water should be allocated, amongst what commodities and how this will affect both the quantity and quality of water along the Murray-Darling River system; to incorporate a state-contingent representation of uncertainty.

Scale and Scope: Murray-Darling Basin; emphasis on incorporating uncertainty.

Method and Data: Authors use an extension and generalisation of the model presented by Quiggin (1988, 1991) with a more detailed representation of the river system and a larger set of commodities. The intention of using this model is provide insights into behavioural responses to changes in policy and climate, rather than forecasting per se.

Results: With simulated reductions in water availability, reductions in water use and regional value added also reduced (the former by more than the latter). With a reduced availability of water, land use switches over to

more water efficient and high value activities. In simulations that include dryland activity, for some regions reduced water supplies could increase the gross value of production. This is due to both increases in the area under dryland activity and the increasing feasibility of low water-use technologies,

30. *Reference:* Aluwihare, P., R. Jones and R. Letcher (2005). 'The farm level impacts of Water Sharing Plans in the Namoi Valley: A stochastic dynamic programming analysis'. Paper presented to the 49th Annual Conference of the Australian Agricultural and Resource Economics Society.

Owner:

Authors: P. Aluwihare, R. Jones and R. Letcher (DPI NSW, Australian National University).

Objectives: To present a bio-economic modelling framework to assess the farm-level impacts of different water sharing plans in a sub-catchment of the Namoi Valley.

Scale and Scope: Mooki sub-catchment, Namoi Valley (northern NSW); 4 water-sharing scenarios (including 3 proposed by Namoi Unregulated River Management Committee).

Methods and Data: Authors use a bio-economic modelling framework based on stochastic dynamic programming linked to hydrological and biophysical models. Data used for representative farm derived from irrigation surveys and advice from local (Mooki) irrigators.

Results: "The opportunity costs of changed water sharing plans are relatively small in the Mooki. The relatively low impact of the water sharing plan rules can be attributed to the assumed availability of groundwater to most farms in the Mooki. However, any reduction to groundwater entitlements as part of the water reform policy agenda would likely have greater economic impacts."

31. *Reference:* Coram, A. (2006). 'The optimal allocation of water along a system of rivers: A continuous model with sequential bidding', *Australian Journal of Agricultural and Resource Economics, vol.50 pp313-326.**

Owner: University of Western Australia

Authors: A. Coram

Objectives: To use a control theory approach to analyse the collectively optimal rate of extraction along a river system.

Scale and Scope: Generalised theoretical discussion of a river system.

Methods and Data: Author considers a sequential bidding mechanism for both a discrete and continuous river system.

Results: "The use of a continuous flow approach to an entire river system also revealed some interesting features of the optimisation problem. Perhaps the most important of these was that this problem may not have a solution if a value is placed on water at more than one terminal point. It was also shown that auctions cannot give the optimal allocation of water.

* The analysis in this paper has been extended in Coram, A. and Noakes, L. (2009), The optimal extraction of water along an arbitrarily configured river system, *Australian Journal of Agricultural and Resource Economics, vol.53 pp251 - 264.*

Abstract: "The fundamental problem for any scheme of water management that tries to maximise welfare across a river system is that of determining the optimal allocation at every point. The problem cannot, in general, be avoided by trading water rights because the price will not account for the effect of extraction at any point on all other points. This article interprets the problem in terms of the indeterminacy that results from missing information on the value of water at internal junctions between rivers. It is then solved in an optimal control theory framework."

32. *Reference:* Dwyer, G., P. Loke, D. Appels, S. Stone and D. Peterson (2005). 'Integrating rural and urban water markets in south east Australia: A preliminary analysis'. Paper presented to the OECD workshop on Agriculture and Water: Sustainability, Markets and Policies, Adelaide 14-18 November.

Owner: Productivity Commission

Authors: G. Dwyer, P. Loke, D. Appels, S. Stone and D. Peterson

Objectives: To undertake a preliminary analysis (using the TERM model) of the effects of expanding the trade of water in south east Australia to include both irrigators and urban users.

Scale and Scope: Focus on urban centres of Adelaide, Canberra and Melbourne, and the major irrigation districts in the southern Murray-Darling Basin; 35 water user groups (including households), 18 regions; 4 water trading scenarios.

Methods and Data: Authors use a regional general equilibrium model of the Australian economy (TERM-Water). Data on industry and regional water use from ABS water accounts.

Results: "Losses from a hypothetical reduction in water availability to gross regional product and household demand are reduced when water trade is allowed. The extent to which these losses are reduced depends on the extent to which trade is allowed and the differing water uses in each trading region. The results of this preliminary modelling show that net gains are greatest, and the costs to industries and regions are generally more dissipated, when trade is unconstrained. When regions with relatively low levels of water consumption (such as Adelaide and Canberra) face shortfalls in water availability and trade with regions that use large volumes of water (such as irrigators in the southern Murray-Darling Basin), they have little effect on traded prices and quantities."

33. *Reference:* Qureshi, M., K. Schwabe, J. Connor and M. Kirby (forthcoming). 'Environmental water incentive policy and return flows', Water Resources Research.

Owner: CSIRO

Authors: M. E. Qureshi, K. Schwabe, J. Connor and M. Kirby

Objectives: To provide an empirical comparison of two incentive policies to acquire water for environmental flows for a part of the Murray-Darling Basin (paying irrigators and water delivery firms to make capital and management investments; buying water from irrigators on the active MDB water market).

Scale and Scope: Murrumbidgee catchment.

Methods and Data: Mathematical programming model (catchment basis, profit-maximising, solved with and without restrictions on water saving activities, five states of nature). Data for on-farm and off-farm drawn from existing data and discussions with irrigation scientists, crop water use and yield response from Bryan and Marvanek (2004).

Results: "The two scenarios are similar in their ability to generate the first 50 GL of water savings, but further savings under the efficiency improvement scheme are limited and quite expensive relative to the market scheme. The first option results in relatively larger reduction in return flows, while the latter option tends to induce significant irrigated land retirement with relatively large reductions in consumptive use and small reductions in return flow."

34. *Reference:* Griffith, M., Codner, G., Weinmann, E. and Schreider, S. (2009). 'Modelling hydroclimatic uncertainty and short-run irrigator decision making', *Australian Journal of Agricultural and Resource Economics, vol.53 pp565-584*.

Owner: Monash University

Authors: Griffith, M., Codner, G., Weinmann, E. and Schreider, S.

Objectives: Explores the impact of seasonal hydroclimatic uncertainty on irrigator decision making and temporary water markets.

Scale and Scope: Goulburn irrigation system comprising the Goulburn, Campaspe and Loddon.

Methods and Data: States of nature are based on hydroclimatic data taken from model runs of PRIDE (Program for Regional Irrigation Demand Estimation) and GSM (Goulburn Simulation Model - a linear programming model of water allocation). A discrete stochastic programming model is used to choose optimal crop areas to irrigate where uncertain variables are characterised into discrete states of nature.

Results: "The estimated costs of hydrocliamtic uncertainty in the Goulburn system are uniformly low for horticulture, but range between 5-7% for dairy, and between 1-9% for mixed farming, equivalent to between $1-4 million per annum.

"The results of this study .. indicate that .. water allocation studies with models that do not account for this uncertainty may produce significantly biased results and conclusions (for example, they may overstate the benefits of a policy change because they assume water will be allocated efficiently)."

35. *Reference:* CRC for Catchment Hydrology (1999-2006). Led by G. Codner (Monash University) 'Sustainable Water Allocation. Project 3.1: Integration of Water Balance, Climate and Economic Model (unpublished/under development) '

Copy not readily available

36. *Reference:* Grffith University and the National Water Commission (led by P. Tan) 'The Water Planning Tool (unpublished/under development) '

Copy not readily available

37. *Reference:* Access Economics (2009). 'Broad interim assessment of the socio-economic impact of water recovery in the Living Murray', report prepared for the Murray-Darling Basin Authority, May 2009.

Owner: Murray-Darling Basin Authority.

Authors: Access Economics in association with Hyder Consulting.

Objectives: To provide a framework for assessing the socio-economic impacts of water recovery in the Living Murray Initiative.

Scale and Scope: Living Murray environmental water purchases only (in Murray Basin); framework includes quantitative assessment of cost effectiveness of the Living Murray program, quantitative and qualitative evaluation of economic impacts of the program, and qualitative social impact assessment of the program.

Method and Data: Desktop studies and development of a framework conducted with reference to some existing publications on economic and social impacts of water trading. Authors also use MSM-BIGMOD (MDBA) for modeling purposes.

Results: "The social impact of the Living Murray varies greatly across the projects. All water recovery measures cause some social impact. The majority of identified social impacts associated with water recovery measures are likely to be short term as communities are constantly adapting to change. The cost effectiveness of water recovery measures declines as the volume of water to be recovered increases."

38. *Reference:* Frontier Economics (2007). 'The economic and social impacts of water trading: Case studies in the Victorian Murray Valley', *report for the RIRDC, NWC and MDBC*

Owner: Rural Industries Research and Development Corporation, National Water Commission and the Murray-Darling Basin Commission.

Authors: Frontier Economics in association with Tim Cummins and Associates, Dr Alistair Watson, and Dr Elaine Barclay and Dr Ian Reeve of the Institute for Rural Futures (University of New England).

Objectives: "To quantify and report on the actual impacts of water trading on individual water entitlement holders, industries and communities in the Murray Valley, in order to test the assumed benefits and perceived concerns arising from the trade."

Scale and Scope: Victorian Murray Valley only; changes that can be attributed to water trading only;

Method and Data: Descriptive.

39. *Reference*: Singh, I., N. Flavel and M. Bari (2009). 'Coopers Creek water sharing plan: Socio-economic impact assessment of changes to the flow rules'. NSW Department of Water and Energy, Sydney

Owner: NSW Department of Water and Energy.

Authors: I. Singh, N. Flavel and M. Bari (NSW Department of Water and Energy).

Objectives: To provide socio-economic impacts of recommended changes to the flow rules for the Coopers Creek Water Sharing Plan.

Scale and Scope: Coopers Creek catchment, NSW.

Method and Data: Authors estimate impacts using the IQQM model, and data from a Survey of Irrigation Licences in Coopers Creek and the ABS.

Results: "Average annual impacts are estimated at $62,000 representing 5.1 per cent of gross value of irrigated production in the region. The major impacts would be borne by the winter pasture growers (11.2 per cent) followed by summer pasture growers (7.9 per cent). These crops are predominantly used for dairy industry in this region. The dairy industry will therefore carry a large portion of these impacts. Based on the multipliers used by ACIL (ACIL Consulting 2002), the potential regional impacts resulting from changing the very low flows are estimated at an average annual loss of $124,000 and one job per year from the Coopers Creek economy.

40. *Reference*: Judith Stubbs and Associates, in conjunction with R. Powell and L. Chalmers (2009). 'Community wellbeing in 'cotton communities': The socio-economic impact of the Australian cotton industry on regional communities in New South Wales and Queensland'.

Owner: Cotton Catchment Communities CRC.

Authors: Judith Stubbs and Associates, in conjunction with R. Powell and L. Chalmers (Centre for Agricultural and Regional Economics).

Objectives: To better understand the contribution of cotton to the social and economic wellbeing of regional communities, and conversely, to understanding what the impact on community wellbeing may be if the relative contribution of cotton were to increase or reduce.

Scale and Scope: Cotton-growing areas in New South Wales and Queensland (5 catchments).

Method and Data: Authors draw on previous work done by R. Powell and L. Chalmers, conduct original surveys and interviews, and draw on ABS publications and NSW state departments for statistics.

Results: "The key predictor of socio-economic impact on the case study regions would appear to be the index of specialisation (degree of economic diversity) rather than the relative contributions of different agricultural output, including cotton, to agricultural GRP. Some evidence of a younger, more vibrant and potentially more educated workforce both in the industry and in economic activities associated with cotton (e.g. services, research, etc) may be evident, and would be of benefit to the local community. Interestingly, the cotton communities also seem to be associated with higher levels of "social capital" by some measures such as positive perceptions of the community and volunteering. Where qualitative trends related to 'cotton' per se were evident, they were as likely to be associated with agriculture in general."

41. *Reference*: Baldwin, C., V. O'Keefe and M. Hamstead (2009). 'Reclaiming the balance: Social and economic assessment – lessons learned after ten years of water reforms in Australia', *Australasian Journal of Environmental Management, vol.16 no.2 pp70-83*

Owner: University of the Sunshine Coast and Hamstead Consulting

Authors: C. Baldwin, V. O'Keefe and M. Hamstead

Objectives: To review the lessons learned about water sharing planning by water planners and stakeholders around Australia.

Scale and Scope: Australia-wide (11 case studies, including 3 within the MDB).

Method and Data: Authors consider the role of social and economic assessments in water planning for the 11 case study areas.

Results: "It is surprising, given the economic origins of the National Water Initiative, that there has been such little use of economics in water planning, such that socio-economic impact assessment is usually done at the last minute as a compliance activity. It may be that water planners do not understand the rationale and utility of [social and ethical] assessments, or if they do, they are not sure how to progress them effectively. This paper provides an overview of the benefits as well as ways to improve current practice."

42. *Reference*: Frontier Economics (2008). 'The diversity of the north: Socio-economic profiles of the river basins in the northern Murray-Darling Basin'.

Owner: Murray-Darling Basin Commission (now Authority)

Authors: Frontier Economics in association with Tim Cummins and Associates, Dr Alistair Watson, and Dr Richard Stayner of the Institute for Rural Futures (University of New England).

Objectives: To construct socio-economic profiles to provide a better understanding of the linkages between water use and socio-economic outcomes.

Scale and Scope: Twelve major river basins in the northern Murray-Darling Basin.

Method and Data: Authors draw on population and agricultural data from the ABS.

Results: (Authors present an account of water use in the northern Basin, including the north's separate water history, water resources and water management, economic profile and community profile).

43. *Reference*: McColl, J. and M. Young (2005). 'Managing change: Australian structural lessons for water'. CSIRO Land and Water Technical report no. 16/05.

Owner: CSIRO

Authors: J. McColl and M. Young

Objectives: To highlight opportunities to facilitate and expedite structural adjustment, including securing water for the environment through the market place.

Scale and Scope: Australia-wide; general discussion.

Methods and Data: Authors draw on existing literature.

Results: "In the long run, economic experience suggests that the nation, regions and communities will be better off if governments: remove impediments to adjustment; facilitate and expedite rather than impede such adjustment; and separately manage the consequences including any adverse effects on third parties and/or the environment, rather than trying to buffer or even counter change. When adjustment is impeded, the most significant adverse impacts are often on the capacity of the most talented in a district or an industry to innovate."

44. *Reference*: Spanswick, S., G. Roth, T. Drew and P. Jones (2007). 'The impact of drought on small business – A pilot study on Wee Waa'.

Owner: Cotton Catchment Communities CRC

Authors: S. Spanswick, G. Roth, T. Drew and P. Jones ().

Objectives: To quantify the impact of the drought on Wee Waa's small businesses and capture additional information on its impact on rural community issues such as health and education.

Scale and Scope: Wee Waa, New South Wales.

Method and Data: Authors undertake business and community surveys and interviews.

Results: The study of the drought on small business in Wee Waa found: gross turnover of the combined businesses surveyed (25 respondents) fell by 52 per cent from 2001 levels of $116 million to $56 million; permanent staff numbers fell 60 per cent between 2004 and 2007 and casual employment fell 40 per cent; he main type of staff positions terminated were Professionals, however positions have been cut across all jobs; of the terminated employees, 2/3 have left the region and the remaining 1/3 are either working locally or are unknown; 95 per cent of businesses had a 60 per cent or greater reliance on a healthy agricultural and cotton industry; reduced access to surface and groundwater for irrigation was the biggest factor other than drought impacting on business; there is less capacity for the community and business to donate time, resources and funding essential to the viability of schools; and there has been a doubling in the number of people accessing health support/counselling due to the drought.

45. *Reference*: RMCG Consultants (2009). 'Socio-economic impacts: Closure of Wakool irrigation districts (or parts thereof)'.

Owner: Wakool Shire.

Authors: RMCG Consultants.

Objectives: To undertake a desktop evaluation of the socio-economic impacts on the community should part or all of the irrigation network be permanently decommissioned.

Scale and Scope: Wakool Shire, NSW; authors consider multiple water loss and climate change scenarios.

Method and Data: Authors draw on existing data and studies and use a simple multiplier to calculate regional effects.

Results: "The impact on the Wakool region will vary with the volume of water that may be lost, how that water will be lost (i.e. in parcels or scattered through out the region) and the speed at which the loss will occur. Farm businesses that sell the water receive an injection of funds to help adjust to the changed circumstances. However, the flow-on impacts of a significant drop in the rural economy due to the loss of water will be pronounced but there is no adjustment support for those remaining in the region. It is estimated that for every 1000 ML of water that is lost from the region will result in: $300,000 loss of agricultural production within the shire; up to $900,000 loss from the regional economy; $3,500 in direct rate revenue loss; loss of one agricultural job; and loss of one regional job. Irrespective of how the water is lost, there will be regional impacts through the loss of agricultural production and flow on losses to the regional economy."

46. *Reference*: NSW Department of Water and Energy (2007). 'Monitoring economic and social changes in NSW water sharing plan areas: Irrigators' survey 2005-06'.

Owner: NSW Department of Water and Energy

Authors: NSW Department of Water and Energy.

Objectives: To collect primary quantitative social and economic data that will enable future monitoring of water sharing plans.

Scale and Scope: New South Wales (following state-wide introduction of water sharing plans).

Methods and Data: Author uses questionnaire to acquire appropriate information.

Results: "59 percent of irrigators believed they could improve the efficiency of water use on their farms and 75 per cent of irrigators also believed that more could be done to improve the efficiency of water use on farms.

Only 3 per cent of irrigators were found to have sold water on the permanent water market and only 4 per cent of irrigators were found to have purchased water on the permanent water market. 20 percent of irrigators had sold water and 20 per cent of irrigators had purchased water on the temporary water market. As with permanent water trading, the highest volume of water traded on the temporary water market occurred in the Lower Murray Darling and Murray CMAs and amongst those irrigators with large (>973MLs) water entitlements.

In an evaluation of irrigators' attitudes towards permanent water trading, 28 per cent of irrigators believed permanent water trading was 'good for their area'; 25 per cent believed it to be 'bad for their area'; while 48 per cent believed it to be 'both good and bad'."

47. Reference: Bari, M., I. Singh and N. Flavey (2008). 'Monitoring economic and social changes within NSW Water Sharing Plan areas: A participatory approach'. Paper presented at the 52nd Annual Conference of the Australian Agricultural and Resource Economics Society.

Owner: NSW Department of Water and Energy

Authors: M. Bari, I. Singh and N. Flavey

Objectives: To present a methodology as applied to monitor the changes in economic and social indicators within the irrigation industry in the Water Sharing Plan (WSP) areas in NSW.

Scale and Scope: New South Wales.

Methods and Data: Authors conduct scoping interviews and undertake literature reviews. Authors also draw on ABS statistics.

Results: "The participatory approach has been successfully used in the first stage of a long term project to monitor economic and social changes in NSW WSP areas and the estimates developed on the basis of the information collected through this monitoring program are expected to be robust and acceptable to the stakeholders."

48. *Reference*: Crean, J., A. Shaw, R.P. Singh and J.D. Mullen (2004). 'An assessment of the economic, environmental and social impacts of NSW Agriculture's advisory programs in water-use efficiency'.

Owner: NSW Department of Primary Industries

Authors: J. Crean, A. Shaw, R.P. Singh and J.D. Mullen

Objectives: To report an assessment of the economic, environmental and social impacts of extension activities by NSW Agriculture related to water use efficiency.

Scale and Scope: Case studies from four industry/regional complexes in New South Wales.

Methods and Data: Authors estimate benefits from water use efficiency extension programs using conventional farm budgets. Data drawn predominantly from interviews.

Results: "In the four evaluations, we have characterised the impact of WaterWise on the Farm (WWF) as bringing forward the adoption of either new technology or best management practices by a certain number of years rather than influencing the maximum level of adoption, except in the case of lucerne. The lucerne industry case study was the only exception, where the lack of industry structures suggested that WWF would actually increase the maximum level of adoption as well as influencing its rate.

A mixture of technologies and best management practices were evaluated across the case studies. In the case of lucerne and cotton, the WWF Initiative promoted better scheduling of irrigation applications involving more frequent but lower volumes of water which had the effect of reducing groundwater accessions and evaporation whilst reducing yield losses associated with both under and over watering. Better irrigation scheduling is principally a management change although normally some relatively minor infrastructure changes (reducing the length of runs, increasing the size of outlets etc) are also required. In the case of viticulture, the principal change promoted by WWF involved the conversion from furrow or spray based systems to drip irrigation systems. Changing to more efficient drip irrigation systems reduced crop water use and groundwater accessions whilst also providing yield and quality gains. More efficient water use in the cherry industry involved increasing the number of drippers per tree to allow faster and more targeted irrigation reducing watertable accessions and increasing fruit size."

49. *Reference*: Khorshed, A., J. Rolfe and P. Donaghy (2006). 'Economic and social impact assessment of water quality improvement', *Australian Journal of Regional Studies, vol.12 no.1*.

Owner:

Authors: A. Khorshed, J. Rolfe and P. Donaghy (University of Southern Queensland, Central Queensland University and QLD Department of Primary Industries and Fisheries).

Objectives: To demonstrate how setting more stringent water quality objectives can enhance and protect environmental assets of water resources.

Scale and Scope: Queensland (including but not limited to the northern Darling Basin).

Methods and Data: Authors use a study area located outside the MDB (Douglas Shire) and model pollutant loads under a range of scenarios. Social and economic impacts calculated using input-output models.

Results: "There are very large and damaging economic and social impacts associated with further declines in water quality in some specific Queensland water systems. Therefore, the case for averting these impacts by at least maintaining current water quality levels is very strong, justifying a range of current government initiatives to minimise further damages. There is also a strong case for undertaking improved water quality objectives above the current standards through best practice management intervention strategies."

50. *Reference*: ABARE/ABS/BRS (2009). 'Socio-economic context for the Murray-Darling Basin'. Technical report under the Basin Plan.

Owner: Murray-Darling Basin Authority.

Authors: ABARE/ABS/BRS.

Objectives: To describe the context within which Basin water resources are used.

Scale and Scope: Entire Murray-Darling Basin.

Methods and Data: Authors draw extensively on various ABS, BRS publications.

Results: (Report provides a description of the socio-economic context within which the Basin's water is used, covering *inter alia* industry profiles (including agriculture), economic wellbeing and community wellbeing).

51. Reference: Price Waterhouse Coopers (2000). 'Socio-economic impact assessment: Condamine-Balonne WAMP'. Report prepared for the Balonne Community Advancement Committee.

Owner: Balonne Community Advancement Committee.

Authors: Price Waterhouse Coopers.

Objectives: To assess the impacts of the Condamine-Balonne water allocation management plan (WAMP).

Scale and Scope: Condamine-Balonne WAMP (NSW, Queensland) only.

Methods and Data: Author uses the IQQM model and undertakes financial valuation modelling. Data drawn from original surveys and available statistics.

Results: "The productive capacity, earnings potential and expenditure patterns of irrigated farms are directly related to the water supplies available to them. A sharp, unplanned reduction in irrigated agriculture would have an immediate and substantial impact on general economic activity within the Balonne region, and on its capacity to maintain associated social and community institutions.

For many irrigated farms and related businesses in the region, expansions have been funded by relatively high levels of debt. For on-farm businesses, this high level of indebtedness has been supported by "bankable" water harvesting licenses, issued over the past decade. A high proportion of debt is tied up in fixed or specific assets – such as large off-stream ring tanks, irrigation channels or laser-leveled fields. Under changes in water availability, as proposed in the draft WAMP, these assets will never be fully utilised (unless additional allocations are purchased).
Lower water harvesting entitlements will substantially reduce the level of irrigated agriculture in the region and result in significant declines in the productive earning capacity of irrigated farms. Small and newly expanded businesses are expected to face more severe impacts.

Achieving a critical mass in size and economic activity has been a significant achievement for the townships of St George and Dirranbandi. Development of irrigated agriculture (particularly in the past five years) has resulted in increases in population, skills, income, infrastructure and services. This has provided substantial qualitative social benefits for the local community. Socio-economic surveys undertaken as part of this assessment identified limited alternative employment opportunities in the region if there was a downturn in irrigated agriculture."

52. *Reference*: Western Research Institute (Charles Sturt University). 'The impact of the current drought on Bourke economy and community'. Report prepared for the Department of State and Regional Department (copied not readily available)'

Copy not readily available

53. *Reference*: Gale, R. and N. Miham (2009). 'The role of monitoring, evaluation, reporting and improvement (MER) as an integrated assessment tool: Improving socio-economic and biophysical outcomes from investment decisions in natural resource management.'

Copy not readily available

54. *Reference*: Gale, R., R. Thomason and N. Miham (2009). 'Catchment Action NSW 2008/09, Mid-Term Project Report, Socio-Economic Monitoring, Evaluation and Reporting: Beyond the Biophysical'.

Copy not readily available

55. *Reference*: Report prepared by the Centre of Agricultural and Regional Economic Pty Ltd (2003). 'A socio-economic analysis of the impact of the reduction in groundwater allocations in the Namoi Valley. The impact of the Namoi Groundwater Sharing Plan'.

Copy not readily available

56. *Reference*: Cordina, D., J. Crean and R. Young (2001). 'Short term impacts of resource re-allocation in the lower Macquarie groundwater management area 2008'.

Copy not readily available

57. *Reference*: Jayasuriya, R. (2000). 'The on-farm impacts of groundwater management scenarios in the lower Murrumbidgee'. Prepared for the Murrumbidgee Groundwater Management Committee.

Copy not readily available

58. *Reference*: Jayasuriya, R., J. Crean and R. Jones (2001). 'Evaluation of environmental flow rules in the Murrumbidgee Valley'. Prepared for the AARES conference 2001.

Copy not readily available

59. *Reference*: Jayasuriya, R., and J. Crean (2001). 'The on-farm impacts of environmental flow rules in the Murrumbidgee Valley'. Prepared for the Murrumbidgee River Management Committee.

Copy not readily available

60. *Reference*: Aluwihare, P. and J. Crean (2002). 'Impact of variable ctp on stream flow extractions in the Coopers Creek Catchment' Prepared for the Northern Rivers Water Management Committee.

Copy not readily available

61. Reference: Hyder Consulting and Access Economics (2008). 'Review of the 2007-08 water entitlement purchases', Final Report, September 2008.

Owner: Department of the Environment, Heritage and the Arts.

Authors: Hyder Consulting in consultation with Access Economics.

Objectives: To review the Australian Government's 2007-08 water entitlement purchases.

Scale and Scope: Review of the first round of the water entitlement purchase strategy (2007-08), including the economic impact of the strategy.

Method and Data: Survey of 20 irrigators who have sold water to the Australian Government as part of the strategy.

Results: The first round of the water entitlement purchase strategy has had only a small effect on the prices and allocations of the overall water market (and therefore levels of agricultural production) due to current low levels of allocations. The economic impacts of the strategy depend on how the proceeds of water sales are used. Most sellers surveyed have used their proceeds to retire debt and re-invest on-farm.

62. Reference: Page, S., T. Goesch, B. Dyack, S. Hone and N. Hughes (2007). 'Purchasing water in the Murray-Darling Basin', ABARE report, October 2007.

Owner: Department of the Environment, Heritage and the Arts.

Authors: S. Page, T. Goesch, B. Dyack, S. Hone and N. Hughes (ABARE).

Objectives: To identify and assess the main mechanisms for buying back water entitlements, including the impact these mechanisms may have on water prices.

Scale and Scope: Examines a range of purchase mechanisms (including open market purchase, auction/tender and others).

Method and Data: Demand elasticities for water taken from a variety of publications.

Results: "In the presence of a market, open market purchases are likely to be the most cost effective mechanism for purchasing water. Where environmental benefits are no independent of where water is purchased, an environmental index will be needed to compare benefits within a physically connected system."

63. Reference: SERP (2004). 'Scoping of the economic issues in the Living Murray, with an emphasis on the irrigation sector'. Report prepared for the Murray Darling Basin Commission.

Owner: Murray Darling Basin Commission (now Authority).

Authors: Social and Economic Reference Panel (MDBC).

Objectives: To outline the economic costs and benefits of the Living Murray program and the scale of key impacts associated with sourcing environmental water.

Scale and Scope: Living Murray program (Murray Basin).

Methods and Data: Authors assess agricultural sector impacts using several models and draw on existing literature on social impacts.

Results: "Based on the water sourcing assumptions underpinning the analysis, the increased scarcity of irrigation water is predicted to lead to some irrigated annual pastures and wheat production in NSW to switch to dryland production, along with a reduction in the area planted to rice. The production that is predicted to be most affected in Victoria is mixed livestock and cropping, with a reduction in irrigated pastures.

For the First Step proposal, the estimated agricultural impacts from the model are based on net income changes, which are likely to indicate higher impacts than would eventuate because some savings in capital costs are likely to arise over time as farm capital adjustments are made, and these have not been included in the indicative assessment. Further, greater water trading through more open markets would act to reallocate water to high value irrigation enterprises, further reducing the opportunity costs to agricultural production overall by as much as a third.

There is an increasing demand in the community for environmental health and amenity. There is increasing (but not unanimous) concern about the health of the River Murray. The Scientific Reference Panel advise that the decline in river health at a system scale is continuing (although this will not be universal for all years or all parts of the river), and that sourcing and actively managing water will be important in improving the health of the River Murray in addition to other measures (including works).

Community engagement and social impact assessment (perhaps at a regional scale) will be important in designing direct adjustment mechanisms to address any significant negative spillovers from water sourcing."

64. Reference: Brennan, D. (2004). 'Review of 'Scoping of the economic issues in the Living Murray, with an emphasis on the irrigation sector''. Report prepared for the Murray-Darling Basin Commission.

Owner: Murray-Darling Basin Commission (now Authority).

Authors: D. Brennan (REAP Research).

Objectives: To provide an independent peer review of the original 'Scoping of economic issues' study.

Scale and Scope: N/A.

Methods and Data: Author discusses economic scoping report and relevant literature.

Results: "It is more likely that the economic scoping report overstates the costs and understates the benefits of changes of the recovery of water from the environment than the alternative.

It is the opinion of the reviewer that there has been too much attention paid to the longer term policy issues in the economic scoping report and supporting policy papers, which has occurred at the expense of more pragmatic advice. Design of policy instruments to acquire water is probably much simpler than design of all-encompassing market-based instruments for ecological outcomes, which may not even be theoretically justified once all the transactions costs are accounted for.

The design of institutional arrangements governing the operation of an environmental flow regime will require consideration of all of the above-mentioned third party impacts, while at the same time considering the potential environmental impacts of alternative flow regimes and their relative social value.

65. Reference: BDA Group (2006). 'Issues and options in applying market based measures in the Living Murray first step'. Report prepared for the Murray-Darling Basin Commission.

Owner: Murray-Darling Basin Commission (now Authority).

Authors: BDA Group.

Objectives: To explore the use of market based measures in achieving water recovery targets.
Scale and Scope: General discussion.

Methods and Data: Authors discuss market-based options for achieving the Living Murray water recovery targets.

Results: "With the cost of purchasing the most common water entitlements currently in the range of $750 to $1,050/ML (Long Term Cap Equivalent), this approach to water recovery would be cost-effective, subject to the payment of any 'exit fees' or price effects on water entitlement markets arising from the scale of purchases.

In relation to price effects, the scale of recoveries will be important. The purchase of 200 GL would represent some 2.3 per cent of the long term diversion Cap for the potential Living Murray water recovery districts in the southern Murray-Darling Basin. This compares with the current level of entitlement trading of 1-2 per cent (some 90 to 180 GL) annually across these districts.

Investigations of likely price impacts from the trading of environmental water on markets for allocations indicates that price effects would generally not exceed 10 per cent, even if trading involved 200 GL annually. From an irrigation perspective, such trading would provide greater volumes of water to irrigators in dry years when it would be of greatest value. In this way, the modest impact of transferring water from irrigation for environmental purposes, estimated at less than 0.5 per cent of agricultural net income, could be even further reduced."

66. Reference: MDBC (2008). 'Brief assessment of the merits of purchasing water entitlements during a time of low water availability', Social and Economic Reference Panel for the MDBC, April

Owner: Murray-Darling Basin Commission.

Authors: Social and Economic Reference Panel (MDBC).

Objectives: To investigate the merits of market-based purchases of water during a time of low-water availability.

Scale and Scope: Living Murray environmental water purchases only (in Murray Basin); examines only those issues that are pertinent or relevant to times of low-water availability, including adverse economic impacts.

Method and Data: Economic analysis of a variety of issues. No primary data used.

Results: "After reviewing the evidence the Social and Economic Reference Panel finds no reason to discontinue or delay the purchase the water entitlements for environmental purposes in periods of low-water availability."

67. Reference: Productivity Commission (2006). 'Rural water use and the environment: The role of market mechanisms'. Productivity Commission Research Report.

Owner: Productivity Commission

Authors: Productivity Commission.

Objectives: To examine the feasibility of establishing market mechanisms to encourage economic efficiency of rural water use, including managing environmental externalities.

Scale and Scope: Australia-wide.

Methods and Data: General discussion of the merits of market-based mechanisms.

Results: "Markets are already making a significant contribution to increasing rural water-use efficiency. But further reform is needed to ensure that water continually moves to its highest value uses (including environmental uses). Market mechanisms to address environmental externalities need to be targeted to location and scale — no 'one size' fits all.

Appropriate arrangements for environmental managers should be established as soon as is practical based on a comprehensive review of different institutional structures. They need to enter markets to source water and to access the full range of water and water-related products on the same terms and conditions as other market participants.

'Saving' water via major infrastructure works is often costly compared with other options and may reduce water available for other uses. Subsidies that seek to improve the uptake of particular technologies or practices solely to increase the productivity of water use are likely to be inefficient."

68. *Reference:* Beare, S., R. Hinde, A. Heaney, N. Che and T. Hillman (2006). 'Meeting environmental water demands under uncertainty', *ABARE Conference Paper 06.09*.

Owner: Australian Bureau of Agricultural and Resource Economics.

Authors: S. Beare, R. Hinde, A. Heaney, N. Che and T. Hillman (ABARE, LaTrobe University).

Objectives: To develop a planning framework, based on a quantitative assessment of river flows and environmental objectives, to examine the costs of creating or augmenting high flow events under a number of scenarios.

Scale and Scope: General planning framework for environmental flow regimes, with Murrumbidgee River case study.

Method and Data: An environmental realisation strategy framework is proposed and formalised as a cost minimisation problem. Both environmental costs/benefits and opportunity costs/benefits are incorporated. Constraints include flow objectives of the release strategy, existing flow conditions and volume of water held by environmental manager. Murrumbidgee Integrated Quantity-Quality Model was used to solve the problem.

Results: "General security entitlements can be used to provide a reliable release strategy at a lower cost than high security entitlements. There are two related reasons for this. One, the cost of holding general security entitlement is lower than high security entitlement. Two, while general security entitlements have a lower yield than high security entitlements, the release rules are generally triggered in seasons of relatively high water availability.

The cost of the release scenarios evaluated here are large when compared with current government commitment to increase environmental flows. This is, in part, a reflection of the strict definition of the success or failure of an overbank flow. The high cost does reflect the need for the environment to have a large volume of water on call to meet release requirements, although average annual use is considerably smaller. This suggests it is possible to reduce the costs of holding water rights for the environment by selling water back to consumptive users in years it is not required for release. There are a number of mechanisms that could be used to facilitate this transfer, including options contracts, leaseback arrangements and the seasonal allocation market."

69. Reference: Young, M., D. Young, A. Hamilton and M. Bright (2002). 'A preliminary assessment of the economic and social implications of environmental flow scenarios for the Murray River Systems'. Report prepared for the Murray-Darling Basin Commission.

Owner: Murray-Darling Basin Commission (now Authority).

Authors: M. Young, D. Young, A. Hamilton and M. Bright (CSIRO and PIRSA Rural Solutions).

Objectives: To provide a preliminary assessment of the economic, financial and social implications of environmental flow enhancement.

Scale and Scope: Murray-Darling Basin; economic (and brief social) impact assessment framework.

Methods and Data: Authors use SALSA model (ABARE) and the Water Policy Model (MDBA).

Results: "Methods for securing water range from the simple reduction of all licences – with no, partial or full compensation – to a variety of market-like processes. If the benefits of securing water for the environment are not to be undone significantly, either the rules and conditions by which water allocations are defined and traded will need to be improved or significant restrictions on both temporary and permanent trades will need to be introduced. Any action that secures large volumes of water for the environment will dramatically increase the value of existing water holdings.

From an irrigation community perspective, the perceived major negative impacts of allocating water to the environment will be related to financial and welfare considerations. Management of this issue will largely depend on how the equity and fairness issues are handled. There is also a need to understand individual and community aspirations, values, and notions of fairness to be able to interpret a social impact."

70. *Reference*: Hafi, A., S. Beare, A. Heaney and S. Page (2005). 'Water options for environmental flows'. ABARE eReport 05.12.

Owner: ABARE

Authors: A. Hafi, S. Beare, A. Heaney and S. Page

Objectives: To explore options contracts as a method for securing water for environmental releases.

Scale and Scope: Murrumbidgee River case study.

Method and Data: Authors use the crop allocation module of the Murrumbidgee River Options Model (ABARE) simulation tool to estimate the expected yield and the opportunity cost of writing the option for a range of thresholds.

Results: "Trade results in the provision of environmental services at lower costs, and to irrigators through the option premium. The gains to both irrigators and the environment from trade is the economic surplus or value of holding an options contract over the alternative of holding a permanent water entitlement, on a per megalitre basis. For each combination of option exercise price and permanent water price, ten year contracts are more valuable than five year contracts because of the longer stream of benefits. However, from an irrigator's perspective, there are risks involved in committing to a longer term contract. For a given contract, the value of the option decreases with the exercise price, while it increases with the price of permanent water. The option value will also be sensitive to changes in the interest rate and the rate at which permanent water entitlements appreciate." (further quantitative results presented).

71. *Reference*: Siebert, E., D. Young and M. Young (2000). 'Market-based opportunities to improve environmental flows: A scoping paper'. Report prepared for Environment Australia

Owner: Environment Australia.

Authors: E. Siebert, D. Young and M. Young (CSIRO).

Objectives: To promote discussion relating to the trading and banking of environmental water allocations.

Scale and Scope: General discussion.

Method and Data: General discussion.

Results: "Ultimately, there is an opportunity emerging to enhance the management of environmental flows using the principles of market based mechanisms such as trading and banking to achieve more active and adaptive management. Any system developed to enable trade in and banking of environmental flows would need to demonstrate the following characteristics: flexibility, transferability, integration."

72. *Reference*: Dyack, B., J. Connor and D. MacDonald (2005). 'Screening options and setting priorities for River Murray floodplains'. Paper prepared for the 49th Annual Conference of the Australian Agricultural and Resource Economics Society, Coffs Harbour, 9-11 February

Owner: CSIRO

Authors: B. Dyack, J. Connor and D. MacDonald

Objectives: To describe how economic analysis can contribute to a screening process for seeking a balance for the overall environmental integrity of the Murray River basin, incorporating biophysical information as well as market and non-market benefits for a range of possible investments in floodplain health.

Scale and Scope: Murray River basin (focus on Living Murray icon sites).

Method and Data: General discussion.

Results: "The recommended approach for assessing floodplain options includes the following sequential steps as part of a screening process: Biophysical screening (identify the options that are feasible, have the greatest possibilities of success and achieve the most desirable outcomes from a biophysical perspective); Economic screening (including financial screening, threshold gap analysis, full cost-benefit analysis with non-market valuations); and Social Screening for Consensus (assess options as socially acceptable). The resulting recommendations are distinctly different than the standard cost-benefit approach that economists might have been inclined to offer without an understanding of the complexity of setting priorities in the floodplain context."

73. *Reference*: Scoccimarro, M. and D. Collins (2006). 'Natural resource 'buybacks' and their use to secure environmental flows'.

Owner: Land and Water Australia.

Authors: M. Scoccimarro and D. Collins (BDA Group).

Objectives: To demonstrate the range of available buyback instruments, including irrigators' attitudes to them, in order to stimulate policy debate surrounding their potential use.

Scale and Scope: General discussion. Gunbower-Koondrook-Perricoota Forests used as a case study, with six buyback scenarios considered. Includes discussion of irrigators' attitudes to buyback instruments.

Method and Data: Use an empirical model that represents the spatial-temporal pattern of irrigation water demand in the Murray River basin and decisions regarding diversions for environmental watering.

Results: "No single instrument is likely to be effective in meeting the diversity of environmental watering demands faced under the Living Murray and more broadly across Australia. A key factor underlying this conclusion is the significant variability in watering demands over time within and between different sites. In many instances the purchase of existing irrigation entitlements will be inefficient in meeting variable watering demands. In some instances environmental watering needs and irrigation water demands will exhibit a counter-cyclical pattern, offering opportunities for mutually advantageous trading.

Further challenges will be faced where environmental watering demands are both variable and 'peaky', such as those explored in our case study, where new environmental water is required to top-up natural flooding events to breach levees and supply water to riparian wetlands and forest communities. The potential volumes of water to achieve this can be many times nominal entitlement holdings, raising difficulties in sourcing large volumes of water, quickly and often early in irrigation seasons when announced allocations are typically low.

The research has demonstrated the importance of tailoring market instruments to suit the characteristics of individual environmental demands and prevailing water markets. The challenges will be compounded where environmental managers will have to build water portfolios to meet a suite of environmental watering demands with varying levels of complementarity and connectivity."

74. *Reference*: Heaney, A., G. Dwyer, S. Beare, D. Peterson and L. Pechey (2006). 'Third-party effects of water trading and potential policy responses'. Australian Journal of Agricultural and Resource Economics, 50 (3) pp 277- 293.

Owner: Commonwealth of Australia

Authors: A. Heaney, G. Dwyer, S. Beare, D. Peterson and L. Pechey (ABARE. Productivity Commission).

Objectives: To identify key potential third-party effects of water trade under existing property rights structures in Australia, and to examine policy responses to address these effects.

Scale and Scope: Examines issues relevant to third party effects of water trading (reliability of supply, reliability of delivery, storage and delivery charges, water quality).

Methods and Data: General discussion.

Results: "The separation of water entitlements from land failed to account for the spatial characteristics of water supply, demand and use that were implicit in the joint right. Trade in water entitlements and allocations have therefore given rise to third-party effects. Third-party effects on delivery reliability are likely to be relatively localised and small in terms of scale and cost, but nonetheless amenable to property right solutions. Other effects have the potential to be more substantial, such as some of the effects on the security of supply.

While for the most part, these third-party effects can be addressed through the introduction of more completely specified water rights, the creation, implementation and enforcement of property rights regimes is not costless. In some instances, the costs of property right solutions may be higher than the benefits they generate. It is likely that many of the third-party effects of trade discussed in this paper do not warrant policy intervention at the national or state level. In some instances, effects are likely to be relatively minor although some may be significant at the local level.

Where there are significant gains from trade, the existence of these third-party effects should not been seen as a reason to impede trade. There are first-best policy instruments to address these effects at an appropriate scale."

75. *Reference:* Access Economics (2008). 'Economic impacts of the 4 per cent interim threshold limit'. Report prepared for the Department of the Environment, Water, Heritage and the Arts.

Owner: Department of the Environment, Water, Heritage and the Arts.

Authors: Access Economics.

Objectives: To determine the economic impacts of the 4 per cent interim threshold limit on water trade. *Scale and Scope:* Victoria only.

Method and Data: Authors analyse unit trade data and develop a regional matrix of entitlement applications that were explicitly refused because of the limit. From this, changes in water use by region were inferred, with resulting impacts upon the mix and value of agricultural production across Victoria. These impacts are then used as inputs into a CGE model, with resulting flow on economic impacts. Data provided by the Department of Sustainability and Environment for the 2007-08 irrigation season.

Results: The total volume of trades refused in 2007-08 (7,378 ML) because of the limit is approximately 5.1 per cent of all annual trade in Victorian water entitlements. The figure becomes 8 per cent if we also include those applications for a disassociation from the land that were also refused as a trade. At a regional level, the ITL largely acted to prevent an overall trade of water entitlements from the Goulburn and Loddon Valleys to the Sunraysia region of the lower Murray. Overall agricultural production would be $5.1 million higher without the limit. Based on CGE modelling, it is estimated that the net incremental output associated with the trades would have generated an additional $5.92 million in Gross State Product for the irrigation year 2007-08."

76. *Reference*: Brennan, D. (2008). 'Missing markets for storage and the potential economic cost of expanding the spatial scope of water trade', Australian Journal of Agricultural and Resource Economics, vol. 52 pp471-485

Owner:

Authors: D. Brennan (University of Western Australia).

Objectives: To evaluate the economic costs of missing markets for water storage in the context of broadening trade.

Scale and Scope: Victoria.

Methods and Data: Author uses an empirical model that represents the spatial-temporal pattern of irrigation water demand in the Goulburn Valley and decisions regarding inter-year storage of water in Lake Eildon.

Results: "Because irrigators have no incentive to trade-off the benefit of current use (or sale) with the value of water storage, there is an erosion of reliability when opportunities for trade are broadened. The empirical results demonstrate that the loss in economic value associated with reduced reliability are as large as the gains from trade, so there is no net benefit from trade."

77. *Reference:* Frontier Economics (2009). 'Volumetric restrictions on water entitlement trade'. Report prepared for the ACCC

Owner: Australian Competition and Consumer Commission (ACCC).

Authors: Frontier Economics.

Objectives: To undertake an economic assessment of the effect of volumetric restrictions on water trade.

Scale and Scope: Murray-Darling Basin; authors consider impacts on economic efficiency, transactions costs and social and distributional impacts.

Methods and Data: Authors propose a conceptual framework and provide an empirical assessment of volumetric restrictions, drawing on data from state water registers.

Results: "We find that restricting water entitlement trade reduces economic efficiency, and the related costs are both short-run and long-run. To the degree that water entitlement trade facilitates flexibility in the short-run, restrictions to water entitlement trade can affect allocative and productive efficiency and the welfare losses can be observed as foregone high-value agricultural crop production. Restrictions to water entitlement trade also affect dynamic efficiency by distorting long-run decisions. This is because water entitlements confer perpetual rights to access water and are the foundation of water-related investment decisions and water-related risk management.

Restrictions on trade can constrain farm business decision-making such as cash-flow management and ultimately decisions to sell assets and exit from irrigated production. This is because water entitlements are a significant proportion of the value of assets of many farming businesses.

In assessing the efficiency impacts of these restrictions, it is important to take account of interactions between the entitlements market and the allocations market. This may mean that efficiency losses are not so much to do with the inability to move water to higher-valued uses in response to seasonal conditions (as this can still be done via allocations trading), but may relate more to longer-term considerations.

In addition to efficiency costs, implementation of volumetric constraints imposes transactions costs for government administrators and to water users, including in relation to conducting ballots for trading applications and in strategies made to avoid the effects of the volumetric constraint.
While ostensibly designed to manage the distributional impacts of adjustment processes, volumetric constraints can also result in a number of other unintended and detrimental distributional or equity impacts."

78. *Reference:* Hyder Consulting (unpublished). 'Review of interim threshold limit on permanent water trade'. Report prepared for the Department of the Environment, Water, Heritage and the Arts, September 2008.

Owner: Department of the Environment, Water, Heritage and the Arts.

Authors: Hyder Consulting.

Objectives: To assess the application, operation and impacts (economic, environmental, social) of the (4 %) interim threshold limit on permanent water trade.

Scale and Scope: Water trades in Victoria, NSW and SA.

Methods and Data: Authors draw on CGE modelling conducted by Access Economics to determine economic impacts of the limit. Authors draw on existing literature for social and environmental impacts of the limit. Water trade data drawn from state water registers.

Results: "The study has found that during the 2007-08 irrigation season, the limit has operated and has been applied differently across the three jurisdictions. There were also differences between individual water service providers in New South Wales and South Australia.

The economic, environmental, and social impacts of the interim threshold limit were investigated. This review has found that: overall agricultural production in Victoria would be $5.1 million higher without the limit; the net incremental output associated with the trades would have generated an additional $5.92 million in Gross State Product for the irrigation year 2007-08; an additional 40 full time equivalent jobs would have been associated with the water trades across Victoria in the same year.

This review has also found that some environmental purchases have been affected by the limit in the past and future purchasing for the environment could be severely constrained by the limit. Previous studies have noted both potential negative and positive impacts associated with entitlement trade. The limit would be dampening any positive and negative social impacts."

79. *Reference*: Bjornlund, H. (2002). 'The socio-economic structure of irrigation communities: Water markets and the structural adjustment process', Rural Society vol.12 no.2 pp123-147.

Owner: University of South Australia

Authors: H. Bjornlund

Objectives: To investigate the structural adjustment impact of temporary water markets.

Scale and Scope: Pyramid-Boort and Torrumbarry districts, northern Victoria.

Methods and Data: Author uses descriptive statistics, factor analysis and cluster analysis. Data drawn from interviews with buyers and sellers in the temporary market during 1998-99.

Results: "These analyses suggest that all sectors of the farming community use water markets to cope with the adjustment pressures. One group uses the markets to retain their farming lifestyle, another group uses it as part of the adjustment process to become larges and more viable, while a third group uses it opportunistically. The irrigators who are not using markets are significantly smaller and use all their water. The research outcome strongly supports that structural adjustment schemes should concentrate on assisting adjusting farmers to become economically viable and to adopt best practice natural resource management."

80. *Reference*: Bjornlund, H. (2008). 'water markets and their environmental, social and economic impacts in Australia', ...

Owner: University of South Australia

Authors: H. Bjornlund

Objectives: To analyse water markets and their environmental, social and economic impacts in Australia.

Scale and Scope: Goulburn-Murray Irrigation District (and general Murray-Darling Basin).

Methods and Data: Review of relevant literature, including economic and social impact analyses.

Results: "There is evidence that both entitlement and allocation markets have facilitated the anticipated reallocation of water with associated socio-economic benefits. There is however also evidence of declining rural communities as a result of drought and policy induced scarcity or, as some argue, as a result of the operations of water markets. There is however no real evidence whether this decline has been caused by scarcity or markets; or whether, in fact, markets have reduced the socio-economic and community impact of scarcity.

Social and community impacts have, together with environmental impacts, been the most important factors causing community concerns over the impact of water markets and especially the markets in water entitlements. These concerns were associated with the impact on the individual farmer's welfare and on the welfare of the wider rural community depending on irrigation as the engine of economic activity."

81. *Reference*: Mallawaarachchi, T. and A. Foster (2009). 'Dealing with irrigation drought: The role of water trading in adapting to water shortages in 2007-08 in the southern Murray-Darling Basin'.

Owner: Department of the Environment, Water, Heritage and the Arts.

Authors: T. Mallawaarachchi and A. Foster (ABARE).

Objectives: To capture insights on the nature of water transactions, including the volume and price of trades and the direction of these trades in the 2007-08 irrigation season.

Scale and Scope: New South Wales, Victoria and South Australia, with case studies in latter two states; authors consider volume, price and direction of trades.

Methods and Data: Authors review existing literature and draw on water trade data from ABARE's farm survey.

Results: "The study concludes that irrigators have demonstrated an ability and willingness to engage in trade as a means of achieving greater benefits from limited water supplies. In particular, the active market for water allocations provides irrigators with increased flexibility for coping with water scarcity. The analysis shows the bulk of water movements occur via the sale of temporary water allocations. The number of permanent water trades remains relatively low. Water markets, based on voluntary exchange, have allowed buyers to reduce the impact of drought on farm production through the purchase of additional water. South Australia was the major importing state, while New South Wales was the largest exporter of water in 2007-08. The price of temporary water was highly variable in 2007-08, both within and between trading zones, ranging from around $200 to $1200 per megalitre."

82. *Reference*: Oliver, M., B. Dyack and D. Ashton (2009). 'Irrigation in the Murray-Darling Basin: Farms trading temporary water in 2006-07'.

Owner: Department of Forestry, Fisheries and Agriculture.

Authors: M. Oliver, B. Dyack and D. Ashton (ABARE).

Objectives: To undertake a detailed analysis of irrigation farms involved in temporary water trading in 2006-07.

Scale and Scope: Murray-Darling Basin (10 regions).

Methods and Data: Authors undertake widespread surveys.

Results: "Water trading is one of the ways irrigators have responded to increased water scarcity. Results suggest water trading was effective in reallocating water among users in 2006-07. The ability to trade water appears to have assisted some irrigators in avoiding substantial financial losses in 2006-07, either by obtaining income from water sales or by purchasing water to maintain production.

An estimated 31 per cent of dairy farms, 20 per cent of broadacre farms and 23 per cent of horticulture farms participated in temporary water trading in 2006-07. By region, the proportion of farms participating in trading was between 40 and 50 per cent in the Murrumbidgee, Murray, Goulburn-Broken and Loddon-Avoca regions. The main buyers and sellers varied by industry. Overall, dairy farmers were prominent buyers of temporary water in 2006-07, as they sought to offset relatively low seasonal allocations. Conversely, horticulture farms, with generally more reliable irrigation water entitlements, tended to be prominent sellers in most regions."

83. *Reference*: Singh,I., M. Bari and N. Flavel (2008). 'Water trading within NSW irrigation industry: An empirical evaluation of scale, reasons and attitudes'.

Owner: NSW Department of Water and Energy.

Authors: I. Singh, M. Bari and N. Flavel.

Objectives: To discuss the level of water trading within the NSW Irrigation Industry along with water prices, reasons, attitudes and knowledge of both permanent and temporary water trading.

Scale and Scope: NSW.

Methods and Data: Authors undertake an original survey of over 1000 irrigation water users in NSW and draw on relevant secondary sources.

Results: "Nearly 7 per cent and 40 per cent of the irrigators surveyed participated in the permanent and temporary water markets respectively. Fifty six per cent of the irrigators believed that temporary trading was good for their area, whereas only 28 per cent had similar views regarding permanent trading."

84. *Reference*: Edwards, J., H. Bjornlund and B. Cheers (2007). 'Revisiting the Goldshmidt hypothesis: Community members' beliefs about water trading and the future of rural communities'. Conference paper prepared for The Australian Sociological Association, 4-7 December, Auckland.

Owner:

Authors: J. Edwards, H. Bjornlund and B. Cheers (University of South Australia).

Objectives: To report on the attitudes and beliefs of the residents of community concerning the impact of water trading on the long-term viability of their community.

Scale and Scope: Undisclosed town of 4000 inhabitants.

Method and Data: Authors conduct interviews in an undisclosed town within the Murray-Darling Basin.

Results: Authors find that rural communities "contend that water trading will lead to fewer farms in their district. This will, they suggest, accelerate population decline, which will, in turn, lead to fewer local employment opportunities and a contracting local economy, through reduced spending. Interviewees also suggest that water trading is redirecting water from family-owned farms to corporately-owned enterprises. This change, too, will also have detrimental effects on the sustainability of rural communities."

85. *Reference*: Young, M., D. MacDonald, R. Stringer and H. Bjornlund (2000). 'Inter-state water trading: A two year review'.

Owner: CSIRO Land and Water

Authors: M. Young, D. MacDonald, R. Stringer and H. Bjornlund (CSIRO and University of South Australia).

Objectives: To investigate the economic, social and environmental impacts of inter-state water trading.

Scale and Scope: Murray-Darling Basin.

Method and Data: Authors review the pilot water trading project within NSW, Victoria and SA. Authors draw on water trade data from various sources.

Results: "Inter-state trading is increasing the value of water use within the Murray-Darling Basin. Virtually all (99 per cent) of the water sold was not being used by the sellers. During the first two years, virtually all water sold has gone to high value uses. From a social impact perspective, inter-state trading during the first two years has had no measurable adverse social implications for the districts that have sold water inter-state

(predominantly because the water was not being used by the sellers). From a salinity perspective and in the long-run, inter-state trading can be expected to have a negative impact on river salinity. Most water is being transferred to South Australian land that has not previously been irrigated

86. Reference: Brennan, D. (2004). 'Price formation on the Northern Victoria water exchange'. Paper presented at the Conference of the Australian Agricultural and Resource Economics Society, 11-13 Feb.

Owner:

Authors: D. Brennan (REAP Research).

Objectives: To present a preliminary analysis of market data on the last 5 years of trade on the Victorian water exchange, including the impacts of water allocations and seasonal conditions.

Scale and Scope: Northern Victoria (Goulburn Murray).

Methods and Data: Econometric analysis is undertaken of the impact of seasonal conditions on water. Data drawn from Northern Victoria water exchange (five years).

Results: "The data highlight the importance of physical bottlenecks on spatial price relationships, and indicate that analyses of the benefits of "free trade" should account for these constraints; otherwise benefits from trade will be overstated. The data show a persistent pricing premium in the Goulburn valley over the entire 5 year period, indicating that sourcing more water from this region for environmental flows will be a costly policy. Regression analysis of average seasonal prices from the water exchange has indicated that allocations and rainfall explain most of the variation in the price of water traded on the seasonal market. It is essential that future analyses of environmental flows consider the impact of flow regimes on the reliability of allocations."

87. *Reference:* Bjornlund, H. and P. Rossini (2005). 'Fundamentals determining prices and activities in the market for water allocations', *International Journal of Water Resources Development, vol.21 no.2 pp355-369*.

Owner: University of South Australia

Authors: H. Bjornlund and P. Rossini

Objectives: To analyse prices paid and volumes traded in the market for water allocations to provide insight into which factors drive activities in that market.

Scale and Scope: Goulburn-Murray Irrigation District, Victoria.

Methods and Data: Authors undertake correlation analysis, regression analysis and time series decomposition. Data drawn from Goulburn-Murray Water for years 1993-94 to 2002-03.

Results: "While factors such as commodity prices, supply and demand as well as macroeconomic indicators have had an influence on price and volume traded, the main determinants during the study period have been the level of seasonal allocation, rainfall and evaporation. During this period of relative water scarcity, irrigators with water-dependent capital assets such as dairy and horticultural farmers have been willing to pay increasing water prices relative to commodity prices in order to protect these long-term investments and stay in business."

88. *Reference:* Wheeler, S., H. Bjornlund, M. Shanahan and A. Zuo (2008). 'Price elasticity of water allocations demand in the Goulburn-Murray Irrigation District', *Australian Journal of Agricultural and Resource Economics, vol.52 no.1 pp37-55*.

Owner: University of South Australia

Authors: S. Wheeler, H. Bjornlund, M. Shanahan and A. Zuo

Objectives: To estimate price elasticities for demand and supply of water in Goulburn-Murray Irrigation District.

Scale and Scope: Goulburn-Murray Irrigation District.

Methods and Data: Bid price data drawn from Goulburn-Murray Water for years 2001 to 2007; average monthly prices drawn for years 1997-2007.

Results: "Based on bid prices, the price elasticity of demand for water allocations appears highly elastic, with elasticities strongly influenced by the season and drought. The price elasticity of supply for water allocations is also elastic, albeit less elastic than demand. Using actual prices paid, water demand is negatively related to price and is inelastic, and appears to be most influenced by demand the previous month, drought and seasonality factors."

89. *Reference:* Bell, R., J. Gali, P. Gretton and I. Redmond (2007). 'The responsiveness of Australian farm performance to changes in irrigation water use and trade'. Paper presented to the 51st Annual Conference of the Australian Agricultural and Resource Economics Society, 14th -16th February.

Owner: Productivity Commission

Authors: R. Bell, J. Gali, P. Gretton and I. Redmond

Objectives: To assess the links between farm performance and water use practices, involvement in water trading and other farm characteristics.

Scale and Scope: Murray-Darling Basin.

Methods and Data: Authors use a comprehensive farm–level panel data set (Agricultural Statistics Unit Record Data File – joint ABS-Productivity Commission project) and a profit maximising model to estimate elasticities.

Results: "The use of irrigation water by farms is more responsive to a change in water prices, after controlling for all other factors, in the broadacre cropping industry groups (grains, sugar and cotton) than in the fruit, vegetables or nurseries industry groups. The more elastic estimates indicate the ability of some irrigated production activities to flexibly adjust their input use with a change in the price of water. Therefore, despite the significance of irrigation water use in many industries and regions, increases in water prices would lead to lower on-farm irrigation water use in some irrigated activities, all other things being equal. A greater likelihood of temporary water trade is, on average, associated with higher farm profits in each industry group."

90. *Reference:* Appels, D., R. Douglas and G. Dwyer (2004). 'Responsiveness of demand for irrigation water: A focus on the southern Murray-Darling Basin'. Productivity Commission Staff Working Paper.

Owner: Productivity Commission

Authors: D. Appels, R. Douglas and G. Dwyer

Objectives: To explore the determinants of the elasticity of demand for irrigation water (in rice, dairy and horticulture).

Scale and Scope: Southern Murray-Darling Basin; authors consider both short-run and long-run responses.

Methods and Data: Authors present a conceptual framework drawing on economic theory, before turning to an analysis of demand elasticity for each of the above crops.

Results: "Demand for irrigation water is relatively unresponsive to changes in the price of water at relatively lower prices in the short run, but becomes more responsive at higher prices, and in the long run. Irrigator responsiveness depends on the total water needs of an irrigator's crop. These needs are first satisfied from rainfall, then from seasonal allocations, and finally by purchases of traded water. Irrigators' responses to changing water prices will vary because of past investment decisions and available substitution choices."

91. *Reference*: Brennan, D. (2006). 'Water policy reform in Australia: Lessons from the Victorian seasonal water market', *Australian Journal of Agricultural and Resource Economics, vol.50 no.3 pp403-423*.

Owner: CSIRO

Authors: D. Brennan

Objectives: To present a discussion on the nature of temporary water markets from a conceptual viewpoint and by examining evidence from the market.

Scale and Scope: Goulburn-Murray region, Victoria.

Methods and Data: Author presents a conceptual framework that highlights the relationship between the short-run opportunity cost of water and longer-term investment decisions. Data drawn from the public water exchange in the Goulburn-Murray region.

Results: "Evidence from the market suggests that transactions costs are low and most of the existing constraints to trade in seasonal allocations are the result of hydrological conditions. Analysis of market data suggests that the price response of the market to water availability is much more pronounced in years of low rainfall. The implications of the paper for wider policy reform are that attention should be paid to improving property rights for the management of inter-temporal risk before other reforms, such as broadening of permanent water markets and institutionalising environmental flows, are implemented. This is because these other reforms will change the spatial and temporal pattern of water use and thus affect reliability, which underpins the value of water in irrigated agriculture."

92. *Reference:* Bjornland, H. and P. Rossini (2006). 'An empirical analysis of factors driving outcomes in markets for permanent water – An Australian case study'. Paper presented to the

Owner: University of South Australia

Authors: H. Bjornlund and P. Rossini

Objectives: To explore the existence of empirical evidence of factors influencing farmers' willingness to pay for water entitlements and the factors driving the level of activity in the market.

Scale and Scope: Goulburn-Murray region, Victoria.

Methods and Data: Authors undertake correlation analysis, regression analysis and time series decomposition. Data drawn from Goulburn-Murray Water for years 1993-94 to 2002-03.

Results: "It was found that commodity prices have had very little influence on the price of water in the permanent market (as was found with the prices in the temporary market) during the ten-year period, with the exception of wine grape prices. The other main factors influencing price are interest rate, the level of seasonal allocation, and the price of temporary water.

Comparing the cycle ratios of the prices in the two markets suggests that prices of temporary water fluctuate much more widely than prices of permanent water. While it seems that generally increases in the price level of temporary water is capitalized into the price of permanent water, this is not the case during seasons where the price of temporary water is unusually low due to high levels of supply, or when it is unusually high due to extremely low supply.

Analysis of the volume of water traded in the market for permanent water shows that the volume of water traded has been steady over the seven-year period studied. It was found that demand in the market for permanent water seems to stagnate when supply is very low and irrigators therefore struggle to cover their short term needs."

93. *Reference:* Bjornlund, H. and M. Shanahan (2007). 'Comparing implicit and explicit water prices in three Australian states'. Paper presented at the PRRES Conference.

Owner: University of South Australia

Authors: H. Bjornlund and M. Shanahan

Objectives: To examine changes to water prices following the introduction of water markets along the River Murray, by tracing prices through the transition from an 'immature water market' to an early maturing stage.

Scale and Scope: Water prices in Central Goulburn (Victoria), Murray Irrigation (NSW) and Riverland (SA) regions.

Methods and Data: Authors use hedonic pricing functions to determine the implicit price of water, and compare with price data drawn from state water registers.

Results: "There is evidence that in the early years of water markets along the River Murray, the price for water entitlement and the implicit price of water estimated from land sales were tending to converge. The evidence also suggests that in line with expectations, prices for entitlement and implicit water differ between states. On the entitlement market prices were generally highest in South Australia and lowest in New South Wales, while a similar although more complex trend by state is observable in the implicit water markets."

94. *Reference:* Ho, C., D. Armstrong, P. Doyle and B. Malcolm (2004). 'Impacts of changing water price and availability on irrigated dairy farms in northern Victoria'. Paper presented at the 51st Annual Conference of the Australian Agricultural and Resource Economics Society.

Owner:

Authors: C. Ho, D. Armstrong, P. Doyle and B. Malcolm (DPI Vic, University of Melbourne).

Objectives: To evaluate how changes in irrigation water price, availability and policy will impact on the viability of dairy farming in the region.

Scale and Scope: Northern Victoria; dairy industry only. Authors consider multiple water price, availability and reliability scenarios.

Methods and Data: Authors use two case study farms (one 'water reliant' and the other 'fodder reliant') and a spreadsheet modelling approach.

Results: "Small increases in irrigation water price and small reductions in the long-term irrigation water allocation will not have a substantial impact on the viability of well-managed, efficient dairy farms. However, large increases in water price and/or reductions in long-term allocation will have a substantial impact, in particular on the water reliant and less efficient farms. Some farms may have the potential to improve pasture and feeding management, which could counteract the impact of increasing water price or decreasing water availability."

95. *Reference*: ACIL Consulting (2002). 'Economic impacts of the draft water sharing plans: An independent assessment'. Report prepared for the NSW Department of Land and Water Conservation.

Owner: NSW Department of Land and Water Conservation.

Authors: ACIL Consulting.

Objectives: To assess the state-wide economic impacts of the draft NSW water sharing plans (DWSPs).

Scale and Scope: Eight surface water and five groundwater sources in NSW.

Methods and Data: Authors use the IQQM to examine the effects of the DWSPs on water availability in low-flow years. A simple multiplier is used to infer regional economic losses. Data drawn from a range of sources.

Results: "Relative to an current (or average recent) use baseline, none of the five DWSPs for groundwater sources imply a reduction in extraction availability. In all cases, under DWSP rules, irrigators would have access to more water than they have used in recent years. Of the eight DWSPs for surface water, four (Hunter, Macquarie, Murray-Darling) imply no reduction on average in allowed diversions relative to current levels. The other four (Gwydir, Lachlan, Namoi, Murrumbidgee) do imply reductions on average, and to varying degrees.

In terms of economic impact, in a 'normal' year the economic consequences of adoption of the DWSP proposals would be small in regional and state-wide economic terms. Adoption of the surface water DWSPs would result in aggregate economic losses for valleys proportionate to the reduced access to water in those cases. In a normal year, they would not be great – some $5 million in annual gross agricultural income, or half

the value added terms across the eight valleys examined. On a state-wide basis, these are very small numbers. Locally, however, the losses would not be insignificant."

96. *Reference*: Nelson, R. and P. Kokic (2004). 'Forecasting the regional impact of climate variability on Australian crop farm incomes', ABARE eReport 04.23.

Owner: ABARE

Authors: R. Nelson and P. Kokic

Objectives: To simulate the regional impact of climate variability on farm incomes.

Scale and Scope: Australia-wide.

Methods and Data: Authors use AgFIRM (Agricultural Farm Income Risk Model; a simulation model) which combines biophysical models of crop and pasture yield with ABARE's econometric model of farm incomes. Data drawn from ABARE's farm survey database.

Results: "The sensitivity of farm incomes to climate variability across Australia's cropping regions is strongly related to the diversity of both on-farm and off-farm income sources. With Australian drought policy focused on self reliance, enhancing the diversity of farm income sources could be one of the most effective policy strategies for reducing the sensitivity of farm incomes in regions with high sensitivity to climate variability.

Average crop farm incomes are much more sensitive to climate variability in years with negative or falling SOI (Southern Oscillation Index) phases at the end of May and June, than in years when the SOI is positive or rising. Crop farm incomes are highly sensitive to climate variability across the central western slopes and plains of New South Wales, and in the Mallee region.

Using seasonal climate forecasts to forecast income variability could enhance the development and implementation of drought resilience policy in Australian agriculture. Seasonal forecasting of income variability could improve the timing of, and better target the duration of, assistance."

97. *Reference*: Flavel, N. and M. Bari (2009). 'Economic assessment relating to the draft water sharing plan for the Peel Valley: Changes to the alluvial groundwater access rules for Cockburn River and Goonoo Goonoo Creek'.

Owner: NSW Office of Water, Sydney.

Authors: N. Flavel and M. Bari (NSW Office of Water).

Objectives: To estimate the economic impact of lost pumping opportunities in the Cockburn River and Goonoo Goonoo Creek alluvial management zones of the Peel Alluvium water source.

Scale and Scope: Cockburn River and Goonoo Goonoo Creek in the Peel Valley, northern NSW; modelling includes sensitivity analsyis.

Methods and Data: Authors use estimates of the effects of reduced water use in the study area, and calculate regional effects using a simple multiplier. Data drawn primarily from the ABS.

Results: "Estimated modelled economic impacts [from changes to cease to pump limits] detailed in this report include: a 3.0 per cent ($8,100) annual increase the gross value of irrigated agriculture around Cockburn River; a 6.6 per cent ($9,100) annual decrease in the gross value of irrigated agriculture around Goonoo

Goonoo Creek. These impacts are likely to be borne by irrigated pasture and irrigated fodder crop producers, who mostly use these crops for hay production and grazing of beef and dairy cattle. Based on these estimates it is unlikely that there will be a significant net impact of the proposed rule changes on the Peel Valley."

98. *Reference*: Dwyer, G., R. Douglas, D. Peterson, J. Chong and K. Madden (2006). 'Irrigation externalities: Pricing and charges'. Productivity Commission Staff Working Paper

Owner: Productivity Commission

Authors: G. Dwyer, R. Douglas, D. Peterson, J. Chong and K. Madden

Objectives: To examine the extent to which charges imposed by irrigation water utilities can address externalities from irrigation water supply and use.

Scale and Scope: Authors consider multiple aspects of externalities in irrigation (environmental change, potential responses, externality charges).

Methods and Data: General discussion drawing on economic theory.

Results: "Many of the externalities associated with irrigation water supply and use are complex and the links between sources and effects of environmental change are not always well understood. At times, it is difficult to identify, observe and measure effects from individual sources, and resulting changes in environmental conditions. Further, the effects can be geographically dispersed or located far from the source. In some situations, a time lag may exist between an activity and its effects.

There is no justification on efficiency grounds for imposing the full external costs of an externality on the party designated as the polluter. If private action through the market fails to address the externality, there may be a role for government intervention. The presence of an externality does not necessarily imply market failure, however, and government intervention may not improve the allocation and use of resources. Further, the benefits of any proposed government intervention may be less than the costs.

A tax could be an appropriate policy tool for some, but not all, externalities. In general, such a tax will be most appropriate where the marginal cost of an externality is directly related to the use of irrigation water, and nothing else. An externalities tax will be less appropriate where there is little link between the externality and the use of irrigation water."

99. *Reference*: Roper, H., C. Sayers and A. Smith (2006). 'Stranded Irrigation Assets'. Productivity Commission Staff Working Paper.

Owner: Productivity Commission

Authors: H. Roper, C. Sayers and A. Smith

Objectives: To present options to address the perceived adverse financial consequences of stranded irrigation assets.

Scale and Scope: General discussion.

Methods and Data: General discussion. Authors consider stranded assets and trade, pricing and exit fees.

Results: "Despite significant concern, it is not certain that proposals under the National Water Initiative (NWI) to relax restrictions on permanent water trading will necessarily result in widespread stranded (under-utilised)

irrigation assets. Prior to the NWI, sales did not always reach restriction levels, suggesting that there are other factors influencing the volume of permanent trade. Stranded assets do not necessarily represent an impediment to the efficient use of infrastructure, the allocation of entitlements, or the use of water. Current proposals to manage the adverse financial impact of stranded assets — such as the ongoing payment of annual access fees, 'tagging' and 'exit' fees — will reduce the economic gains potentially available from entitlement trading. A more efficient approach would be the introduction of full cost recovery infrastructure pricing."

100. *Reference*: Nordblom, T., I. Hume, A. Bathgate and M. Reynolds (2006). 'Mathematical optimisation of drainage and economic land use for target water and salt yields', *Australian Journal of Agricultural and Resource Economics, vol.50 pp381-402*.

Owner: DPI NSW

Authors: T. Nordblom, I. Hume, A. Bathgate and M. Reynolds

Objectives: To present a method for calculating technically feasible options for changes from current to future mean water yields and salt loads from upstream catchments, and the land-use changes to attain each of these options at minimum cost.

Scale and Scope: Study area is Little River sub-catchment, Macquarie River, NSW.

Methods and Data: Authors integrate farm-level and catchment-level economic optimisation models.

Results: "The framework presented here will hold for upstream catchments with local, responsive groundwater flow systems, but not for slower-responding intermediate or regional groundwater flow systems. It presents decision-makers with a full set of trade-offs on the supply side with respect to land-use change options."

101. *Reference*: Murray Darling Basin Commission (2000). 'Economic and Environmental Impacts of Development on the Condamine, Moonie and Border Rivers in Queensland on the Murray and Lower Darling Rivers.

Owner: Murray Darling Basin Authority

Authors: A. Prasad and A. Close

Objectives: To evaluate the effects of additional developments on the Condamine, Moonie and Border rivers in Queensland on water availability and its economic and environmental interests downstream in the River Murray and the Lower Darling.

Scale and Scope: Condamine, Moonie, Border Rivers in Queensland and Murray and Darling Rivers.

Methods and Data: Uses existing models including Integrated Quantity Quality Models (IQQM) for Queensland and NSW catchments to simulate daily flows which were then used in the MDBC BIGMOD and MURKEY models to determine economic and environmental impacts in the Lower Darling and Murray Rivers.

Results: Seven scenarios were considered with different levels of development in the Condamine-Balonne and Moonie catchments and implications for flows, diversions, losses, economic impacts on irrigators in NSW and Victoria and key environmental indicators along the River Murray were reported.

102. *Reference*: Crean, J., F. Scott, and A. Carter (2000). 'Economic assessment of water charges in the Peel Valley'. DLWC.

Copy not readily available

103. *Reference:* Howard, J.L. (2008). 'The future of the Murray River: Amenity reconsidered?', *Geographical Research vol.46 no.3 pp291-302*.

Owner: Charles Sturt University

Authors: J. L. Howard

Objectives: To review studies showing the importance of amenity (tourism, recreation and lifestyle) values of the Murray River.

Scale and Scope: Amenity values only; Murray River only.

Methods and Data: Draws on existing literature.

Results: "The debate about water use in the Murray is not simply one between environment and production but also one involving lifestyles. The importance of amenity (tourism, recreation and lifestyle) is of similar scale (has significant economic value and community support) to productive values. Community concerns about loss of amenity values have impeded restoration programs despite evidence that existing practices are causing environmental damage."

104. *Reference:* Bennett, J. (2005). 'Realising environmental demands in water markets', in *The Evolution of Markets for Water: Theory and Practice*, edited by J. Bennett. Edward Elgar: Cheltenham, UK.

Owner: Australian National University

Authors: J. Bennett

Objectives: To address whether governments are setting environmental flows at economically efficient levels and the role of markets in determining environmental allocations of water.

Scale and Scope: General discussion.

Methods and Data: General discussion.

Results: A staged process could be pursued to secure environmental flows, with governments ensuring minimum standards and allowing any additional water for environmental flows to be purchased through water markets.

105. *Reference:* Bennett, J., R. Dumsday, C. Lloyd and M. Kragt (2007). 'Non-use values of Victorian public land: Case studies of river red gums and East Gippsland forests'. Report prepared in conjunction with URS Australia for the Victorian Environmental Assessment Council.

Owner: Victorian Environmental Assessment Council.

Authors: J. Bennett, R. Dumsday, C. Lloyd, M. Kragt, in conjunction with URS Australia.

Objectives: To apply choice modelling to river red gum forests (and East Gippsland forests).

Scale and Scope: River red gum forests and East Gippsland forests.

Methods and Data: Original choice modelling surveys undertaken both inside and outside regions under investigation, regressions run on results.

Results: "The flexibility characteristic of choice modelling affords makes it especially suited to the VEAC application outlined in this paper. Choice modelling results of the type presented here allow decision makers to explore the benefits of multiple alternatives through a single study."

106. *Reference:* Bennett, J., M. van Bueren and S. Whitten (2004). 'Estimating society's willingness to pay to maintain viable rural communities', *Australian Journal of Agricultural and Resource Economics vol.48 no.3 pp487-512*.

Owner: ANU, Centre for International Economics, CSIRO?

Authors: J. Bennett, M. van Bueren and S. Whitten

Objectives: To use choice modelling to estimate society's willingness to pay to maintain viable rural communities.

Scale and Scope: Community and environmental values for Murrumbidgee River floodplain, NSW.

Methods and Data: Choice modelling surveys developed, regressions run on results.

Results: "Even given the caveats associated with sampling in both studies, the evidence shows that a significant proportion of Australian households are willing to pay to see rural population levels maintained. A caveat to this conclusion is that the results do not necessarily justify the provision of support to rural areas in the absence of any environmental stewardship obligations."

107. *Reference:* Gillespie Economics, DCA Economics and Environmental & Resource Economics (2008). 'River red gum forests investigation – Socio-economic assessment'. Report prepared for the Victorian Environmental Assessment Council

Owner: Victorian Environmental Assessment Council.

Authors: Gillespie Economics, DCA Economics and Environmental & Resource Economics.

Objectives: To outline a social and economic assessment of VEAC's recommendations for the river red gums investigation.

Scale and Scope: Victoria (study area does not align exactly with VEAC's river red gums investigation area). Includes cost benefit analysis (market and non-market valuation) and regional impact analysis with a focus on Victoria's timber industry. Does not include costs of procuring water for environmental purposes.

Methods and Data: Authors draw on existing literature for non-market values of forests.

Results: "The BCA reveals an estimated net benefit to the Victorian economy [from preserving river red gum forests] of approximately $107 million per year on average for 20 years, excluding the cost of the environmental water which is essential to realising this net benefit. The costs of allocating 'adequate' environmental water are likely to be substantial."

108. *Reference:* Morrison, M. and J. Bennett (2004). 'Valuing NSW rivers for use in benefits transfer', *Australian Journal of Agricultural and Resource Economics vol.48 no.4 pp592-611*.

Owner: NSW Department of Environment, Climate Change and Water

Authors: M. Morrison and J. Bennett (Charles Sturt University, ANU).

Objectives: To use choice modelling techniques to value improved river health in NSW.

Scale and Scope: Five NSW catchments (Gwydir, Georges, Murrumbidgee, Clarence, Bega); four environmental attributes (recreational uses, fish species, health vegetation and wetlands, and waterbirds and other fauna).

Methods and Data: Choice modelling surveys developed, nested logit model regressions run on results.

Results: "Both use and non-use values were found to exist for all catchments. In addition, value estimates were found to differ across catchments when populations resident within catchments were sampled, showing the importance of valuing improved river health by sampling populations within catchments."

109. *Reference:* van Burean, M. and J. Bennett (2000). 'Estimating community values for land and water degradation impacts'. Report prepared for the NLWRA.

Owner: National Land and Water Resources Audit.

Authors: M. van Bueren and J. Bennett (ANU).

Objectives: To use choice modelling to estimate the non-market environmental and social impacts of land and water degradation.

Scale and Scope: Australia-wide.

Methods and Data: Choice modelling surveys conducted.

Results: "Across both regional and national samples, respondents hold positive values for environmental attributes, whilst negative implicit prices are estimated for losses of people from country communities. This result implies that respondents perceive depopulation as a cost and are willing to trade-off income to prevent a loss in community viability."

110. *Reference:* Whitten, S. and J. Bennett (2001). 'A travel cost study of duck hunting in the upper southeast of South Australia', Research Report no.7, Private and Social Values of Wetlands Research Reports.

Owner: Australian National University

Authors: S. Whitten and J. Bennett (UNSW, ANU).

Objectives: To estimate the consumer benefits of duck hunting as one component of wetland values.

Scale and Scope: Duck hunting event in upper southeast South Australia.

Methods and Data: Travel cost surveys undertaken.

Results: The total surpluses generated by hunting in upper southeast South Australian wetlands are likely to exceed one million dollars. However, a benefit-cost analysis of duck hunting in the USE is far from

straightforward because it involves a three-way trade-off (community distress over duck hunting, costs of maintaining wetlands, additional socio-economic benefits from healthy wetlands).

111. *Reference*: Bennett J. and Morrison M. (2001). 'Valuing the environmental attributes of NSW rivers'. Report prepared for the NSW Environmental Protection Agency.

Owner: NSW Environmental Protection Agency.

Authors: J. Bennett and M. Morrison (Environment and Resource Economics).

Objectives: To use choice modelling techniques to provide information on the values of NSW rivers.

Scale and Scope: Five NSW rivers (Gwydir, Georges, Clarence, Bega, Murrumbidgee).
Methods and Data: Choice modelling surveys undertaken with options described in terms of a number of environmental attributes (water quality, riverside vegetation and wetland health, number of bird, fish and fauna species present).

Results: "Value estimate differences were found across rivers and between "within" and "outside" catchment respondents. For an improvement in water quality that would allow fishing (rather than just boating), respondents were willing to pay $50 on average, and for additional improvements that would allow swimming respondents were willing to pay an additional $35 on average."

112. *Reference:* Bennett, J., R. Dumsday, G. Howell, C. Lloyd, N. Sturgess and L. van Raalte (2008). 'The economic value of improved environmental health in Victorian rivers', *Australasian Journal of Environmental Management, vol.15*.

Owner:

Authors: J. Bennett, R. Dumsday, G. Howell, C. Lloyd, N. Sturgess and L. van Raalte (ANU, DCA, DSE, University of Melbourne, URS Australia).

Objectives: To use choice modelling techniques to generate benefit estimates for a selection of Victorian rivers.

Scale and Scope: Three Victorian rivers (Goulburn, Moorabool, Gellibrand); four environmental attributes (native fish, healthy riverside vegetation, native waterbird and animals species, water quality/recreation).

Methods and Data: Choice modelling surveys undertaken across six sub-samples (Melbourne, Gellibrand, Moorabool).

Results: "In all cases, the cost, fish, vegetation, and bird attributes are significant in explaining respondents' choice behaviour and have the a priori expected signs. The water quality attribute was significant only for the Goulburn River in-catchment and Melbourne subsamples. In three of the six models, respondent income is a significant variable and is positively signed. In other words, for these samples, river health is confirmed as a 'normal good' in so far as income and value are positively correlated."

113. *Reference:* Midas Consulting (2001). 'Potential social and economic effects of recommendations for Victoria's box-ironbark forests and woodlands area'. Report prepared for the Environmental Conservation Council.

Owner: Environmental Conservation Council (now the Victorian Environmental Assessment Council).

Authors: Midas Consulting.

Objectives: To identify and assess the potential social and economic effects of the ECC's final recommendations on Victoria's box-ironbark forests and woodlands area.

Scale and Scope: Victorian box-ironbark forests and woodlands area only; cost benefit analysis and regional impact analysis (includes socio-economic survey and employment survey).

Methods and Data: Authors aggregate market and non-market (biodiversity, recreation, tourism) values for box-ironwood forests, drawing on existing literature.

Results: "The bulk of the net benefits identified in the cost benefits analysis arise from the benefits attributed to conservation of biodiversity. As these benefits are population-related, approximately 93 per cent of the benefits accrue to Victorians living outside the study area. The regional effects become more serious when the impact of the ECC's recommendations on employment are considered.

114. *Reference:* Morrison, M., Bennett J. and Blamey R. (1999). 'Valuing improved wetland quality using choice modelling', *Water Resources Research vol.35, no.9, pp2805-2814*.

Owner:

Authors: M. Morrison, J. Bennett and R. Blamey (Charles Sturt University, UNSW).

Objectives: To investigate the non-use environmental values of the Macquarie Marshes, NSW.

Scale and Scope: Macquarie Marshes, NSW; includes environmental values and community values on preventing job losses.

Methods and Data: Choice modelling surveys undertaken in Sydney.

Results: "The importance of including employment effects when calculating willingness to pay for an environmental improvement is evident. While the existence values for improved environmental quality outweigh the existence values for rural employment, the inclusion of employment effects has reduced willingness to pay by 20-30 per cent."

115. *Reference:* Morrison, M. (2002). 'Understanding local community preferences for wetland quality', *Ecological Management and Restoration vol.3 no.3*.

Owner: Charles Sturt University

Authors: M. Morrison

Objectives: To investigate the nonuse environmental values of the Macquarie Marshes, NSW.

Scale and Scope: Macquarie Marshes, NSW; includes environmental values and community values on preventing job losses.

Methods and Data: Choice modelling surveys undertaken in the Macquarie Valley, closely modelled on Morrison et al (1999).

Results: "While the community has different priorities for wetland improvement, overall per household willingness to pay was greater in the Macquarie Marshes than for households in Sydney. Households in the Macquarie Valley were willing to pay more for the protection of endangered and protected waterbird species,

more to preserve irrigation-related employment, about the same for increased wetland area, but less for frequency of waterbird breeding events."

116. *Reference:* Whitten, S. and J. Bennett (2001). 'Non-market values of wetlands: A choice modelling study of wetlands in the upper southeast of South Australia and the Murrumbidgee floodplain in New South Wales', Research Report No.8, Private and Social Values of Wetlands Research Reports

Owner: CSIRO

Authors: S. Whitten and J. Bennett (UNSW, ANU).

Objectives: To estimate the non-monetary values of wetlands in two case study areas: Upper southeast South Australia and the Murrumbidgee floodplain, NSW.

Scale and Scope: Upper southeast SA, Murrumbidgee floodplain, NSW.

Methods and Data: Choice modelling surveys undertaken.

Results: "In both areas, respondents held significant values for non-monetary benefits of wetlands outputs. The size of the values was affected by income, age, intention to visit the wetlands and to a lesser extent location."

117. *Reference*: Dyack, B., Rolfe, J., Harvey, J., O'Connell, D., Abel N. and Ryan S. (2007). 'Valuing recreation in the Murray: An assessment of the non-market recreational values at Barmah Forest and the Coorong'. CSIRO.

Owner: CSIRO Flagships Program: Water for a Healthy Country.

Authors: B. Dyack, J. Rolfe, J. Harvey, D. O'Connell, N. Abel and S. Ryan

Objectives: To estimate the value of recreation and identify how recreational values might vary with changes in management.

Scale and Scope: Barmah Forest and the Coorong (Murray River).

Methods and Data: Authors undertake surveys in case study areas, incorporating questions to determine revealed and stated preference values.

Results: "Using the travel cost method results, the total non-market recreational trip value of $529 per adult visitor for Barmah Forest implies an estimate of the total value of recreation at Barmah

Forest of $13 million. The corresponding estimate for the Coorong is $57 million. The estimated non-market recreational trip values per adult visitor are $593 at Barmah and $740 at the Coorong."

118. *Reference*: Atech Group (2000). 'Cost of algal blooms'. Report prepared for the Land and Water Resources Research and Development Corporation and the Murray-Darling Basin Commission.

Owner: Land and Water Resources Research and Development Corporation and the Murray-Darling Basin Commission.

Authors: Atech Group.

Objectives: To identify the principal water groups affected by freshwater algal blooms and quantify the direct and indirect costs of these algal blooms.

Scale and Scope: Australia-wide (excluding Northern Territory and Tasmania).

Methods and Data: Author collects data from State of the Environment reports and conversations with relevant state agencies. Author estimates total costs by amalgamating information on the amount that is due to be spent in preventative measures.

Results: "If the Australian community is eventually to spend approximately $120 million per year on environment protection activities that can be attributed to algal blooms, the current cost of algal blooms must be at least $120 million. In fact the current cost will be considerably larger than

$120 million per year, for two reasons. First, the anticipated investments in environment protection will generate net benefits in the form of reduced incidence and cost of algal blooms. Those future gains are the partial reversal of costs currently incurred, such as: increased cost of water treatment; reduced agricultural productivity; and loss of non-use values. Second, whatever environment protection activities are actually undertaken, they will not totally eliminate algal blooms. Both extractive and non-extractive users will continue to bear costs that cannot be fully reversed."

119. *Reference*: Brouwer R. (2009). 'Multi-attribute choice modelling of Australia's rivers and wetlands: A meta-analysis of ten years of research. CSIRO Working Paper Series 2009-05

Owner: CSIRO.

Authors: R. Brouwer

Objectives: To investigate the suitability of using existing willingness to pay values derived from estimated choice models for the purpose of benefits transfer.

Scale and Scope: Australia-wide (including MDB).

Methods and Data: A meta-analysis of the empirical findings of 10 years of choice experiment applications to water and wetland management issues in Australia. A random effects Tobit model and fixed effects model are employed.

Results: ""The use of different attributes, measurement units and levels of choice experiments makes it hard to compare willingness to pay (WTP) values for environmental attributes from different studies. Nevertheless WTP values were found 'more or less' transferable across catchments.

"The random effects model model outperforms the fixed effects model in terms of predictive power. Nevertheless the prediction error of the estimated model is never lower than 40%. The question whether or not this is considered an acceptable transfer erro is subjective and depends on policy and decision-maker demand for accurate and reliable non-market valuation estimates in water and wetlands policy appraisal."

120. *Reference*: Morrison, M., D. Hatton MacDonald, J. Rose and K. Boyle. (2010). Ecological Values for a major River System at Risk: Australia's Murray-Darling Basin River System

Owner: CSIRO.

Authors: M. Morrison et al.

Objectives: The focus of the study is key environmental quality indicators along the length of the River Murray. Sub-samples were collected in the Murray-Darling Basin and across the rest of Australia, and the data were analysed using random parameter error components logit models.

Scale and Scope: River Murray.

Methods and Data: To support decision making, a sample of 6000 Australians was asked to evaluate a set of choice experiments regarding the value of improvements in environmental quality.

Results: Willingness to pay to improve the quality o the Coorong from poor to good quality alone is about $1.2 billion per year for ten years. Total willingness to pay to improve the quality of the Coorong, to increase the frequency of waterbird breeding from every 10 years to every 7 years, to increase native fish populations from 30% to 40% of original levels and increase the area of healthy native vegetation from 50% to 60% is equal to $1.6 billion per year for 10 years.

121. *Reference*: Hassall and Associates (2004). 'Quantifying the economic value of river dependent industries in the southern Murray-Darling Basin'

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122. *Reference*: Bennett, J. (2002). 'Non-market valuation scoping study' Report prepared for the Murray-Darling Basin Commission.

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123. *Reference*: Crase, Lin and Gillespie, Rob (2008). 'The impact of water quality and water level on the recreational values of Lake Hume'. *Australian Journal of Environmental Management* 15: 21-29.

Copy not readily available

124. *Reference*: Hatton MacDonald et al., (2009). Review of the Social-Economic Values associated with the River Murray, floodplains and wetlands. Milestone Report. CSIRO: Water for a Healthy Country National Research Flagship

Owner: CSIRO.

Authors: D. Hatton MacDonald, S. Tapsuwan, S. Albouy and A. Rimbaud

Objectives: To review the techniques used and values derived for environmental, recreational and cultural benefits associated with the River Murray.

Scale and Scope: River Murray.

Methods and Data: Authors review 24 studies either completed or in progress.

Results: "There are gaps in the research with respect to understanding the nature of the trade-offs between the major environmental quality indicators such as a healthy Coorong and upstream amenity and recreational activities. An Appendix provides tables summarising identified studies and values reported.

A research project by Hatton MacDonald at al (in prep) is cited which indicates that Australians are willing to pay substantial amounts to improve the quality of the River Murray and Coorong, much more than had been found in previous studies.

125. *Reference*: Mazur K. and Bennett J. (2009). Choice modelling in the development of natural resource management strategies in NSW, Environmental Economics Research Hub Research Report No 1

Owner: ANU

Authors: Kasia Mazur and Jeff Bennett

Objectives: The objective of this study is to explore the application of choice modelling (a non-market valuation technique) to estimate population wide values including use and non-use values for increased provision of environmental benefits in NSW.

Scale and Scope: NSW.

Methods and Data: Theoretical review.

Results: "CM is increasingly being used in environmental valuation studies around the world. It has the capacity to avoid many of the biases faced by other SP techniques such as the CVM and the ability to assess a number of policy options in one exercise. In addition, it has advantages for benefit transfer application.

'The integration of CM-derived value estimates into policy decision support tools used by NSW CMAs would provide more accurate information and improved resource allocation. NRM actions could be better targeted to generate greater net social well-being This would also help to reduce the uncertainty associated with different policy actions and increase the likelihood of the success of these policies.'

126. *Reference*: Environment and Behaviour Consultants (2003). 'Development of a framework for social impact assessment in the Living Murray: Water recovery in the Murray Irrigation Area of NSW'. Report prepared for the Murray-Darling Basin Commission

Owner: Murray-Darling Basin Commission.

Authors: Environment and Behaviour Consultants (M. Fenton).

Objectives: To develop a conceptual framework for undertaking social impact assessment of water recovery in the context of the Living Murray program.

Scale and Scope: Murray Irrigation Area, NSW.

Methods and Data: Authors draw on data from interviews in the MIA and appropriate secondary sources.

Results: "Even with uncertainty in relation to the type of water recovery mechanisms that may be implemented, the community within the MIL area was found to be concerned about potential social impacts. The uncertainty itself is an important issue in the identification and prediction of impacts as it was clear that several of the key

informants, given the uncertainty that existed, expected the worst in relation to both the type and magnitude of impacts.

Precursor impacts (which are identified through community experience with past events such as the withdrawal of government services and the recent drought), create a "risk shadow" and are used by the community as a basis for identifying potential social impacts that may occur as a consequence of the introduction of different water recovery mechanisms.

It was also apparent from the key informant interviews that procedural issues play a significant role in community assessment of potential social impacts. In contrast to the 'risk shadow' associated with identification of potential impacts, procedural issues created a similar 'process shadow'."

127. *Reference*: Hassall and Associates (2003). 'Scoping study: social impact assessment of possible increased environmental flow allocations to the River Murray'. Report prepared for the Murray-Darling Basin Commission.

Owner: Murray-Darling Basin Commission.

Authors: Hassall and Associates, Professor Helen Ross and Mary Maher and Associates (University of Queensland).

Objectives: To profile the social and economic context of communities that may be affected by possible increased environmental flows, and scope the possible impacts from changed flow regimes.

Scale and Scope: River Murray and lower Darling (8 catchments).

Methods and Data: Desktop study and literature review. Authors draw on relevant statistics from the ABS.

Results: "The issues highlighted as most relevant for further study are: employment levels (for those engaged in primary and secondary industries in which water is an input, and in towns whose economies are highly dependent on irrigated produce); farm and business viability; maintaining adequate population in small, declining towns (since this affects the viability of small businesses, services and organised recreation opportunities); cultural impacts for Indigenous people and possibly other ethnic and social groups; psychological impacts and impacts of further change on individual and community coping abilities; and other quality of life issues (for instance in lifestyle opportunities, scenic amenity and environmental improvements).

128. *Reference*: Hassall and Associates (2003). 'Profiling social and economic context: Social impact assessment of possible increased environmental flow allocations to the Murray River System'. Report prepared for the Murray-Darling Basin Commission.

Owner: Murray-Darling Basin Commission.

Authors: Hassall and Associates, Professor Helen Ross and Mary Maher and Associates (University of Queensland).

Objectives: To present a social and economic profile of each of the catchments within the study area.

Scale and Scope: River Murray and lower Darling (8 catchments).

Methods and Data: Authors draw on published and unpublished products from the ABS.

Results: (Detailed social and economic profile presented for each catchment).

129. *Reference*: National Academies Forum (2005). 'Social impact of changing water regimes: Framework and Echuca case study'.

Owner:

Authors: National Academies Forum.

Objectives: To examine the impact of changed water management regimes on a community highly dependent on irrigation.

Scale and Scope: Echuca (Murray River).

Methods and Data: Author presents a conceptual framework to examine the social impacts on community in the region

Results: "The practitioners who live on and make their livelihoods from the land and depend on water will have different perspectives on water allocation and usage from those of the professional specialists and experts who provide advice and make policy about water allocation and regimes. The different perspectives in turn have an impact on the morale, optimism, acceptance of new water regimes by practitioners and perhaps even the willingness to participate in or resign from community debate and consensus on the issues."

130. *Reference*: Rea, N. and the Anmatyerr project team (2008). 'Provision for cultural values in water management: The Anmatyerr story'. Land and Water Australia research project.

Owner: Land and Water Australia.

Authors: N. Rea and the Anmatyerr project team (Land and Water Australia).

Objectives: To demonstrate a methodology for the documentation and recognition of cultural values of water and their translation into meaningful outcomes through cultural water provisions.

Scale and Scope: Northern Territory (but with general application).

Methods and Data: Authors canvass cultural water values for the Anmatyerr indigenous people, including volumetric and non-volumetric values, and discuss threats to these values.

Results: (Authors make recommendations to various territory organisations).

131. *Reference*: Cast, A. et al. (2008), South Australian Murray-Darling Basin Environmental Values Report, CSIRO: Water for a Healthy Country National Research Flagship

Owner: CSIRO.

Authors: A. Cast, D. Hatton MacDonald, A. Grandgirard, T. Kalivas, S. Strathearn, M. Sanderson, B. Bryan and D. Frahm.

Objectives: To elicit environmental, economic and social values held by regional community policy advisors for inclusion in determining NRM investment priorities.

Scale and Scope: South Australian Murray-Darling Basin.

Methods and Data: Findings from 56 two hour semi-structured interviews.

Results: "People have anthropocentric values. Some small scale trade-offs are acceptable within the context of economic activity and recreation.

"There is a dichotomy of views surrounding the economy and the environment. One group of people would not contemplate the prospect of economic activity being curtailed significantly to achieve environmental benefits. Another group suggested precisely the opposite that economic activities need to be curtailed to achieve sustainability.

132. *Reference*: Forward NRM and Arilla-Aboriginal Training and Development (2003). 'Scoping study on indigenous involvement in natural resource management decision making and the integration of indigenous cultural heritage considerations into relevant MDBC programs'.

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133. *Reference*: Land and Water Australia (2006). 'Water perspectives: Outcomes of an expert workshop scoping social and institutional research questions in support of the National Water Initiative.

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134. *Reference*: Consortium of Hawke Research Institute for Sustainable Communities, et al. 'People, pumps and pipes: A social study of change in the collaborative supply of irrigation services'. Funded by the Australian Research Council.

Copy not readily available

135. *Reference*: Productivity Commission (2009). Market Mechanisms for Recovering Water in the Murray-Darling Basin. *Agricultural Water Management* 96: 1641-1651.

Final report not available

136. *Reference*: M.E. Qureshi, T. Shi, S.E. Qureshi and W. Proctor. 'Removing barriers to facilitate efficient water markets in the Murray-Darling Basin of Australia' *Agricultural Water Management* 96: 1641-1651.

Owner: CSIRO.

Authors: E. Qureshi, T. Shi, S.E. Quershi and W. Proctor.

Objectives: To evaluate the costs of water market restrictions in the Murray-Darling Basin.

Scale and Scope: Southern Murray-Darling Basin.

Methods and Data: Mathematical model of the benefits of water trade to irrigated agriculture.

Results: Expanding water trade leads to an increase in mean annual net returns of $ 88 million.