Murray Darling Program

TITLE:

Property Rights and Water Buy Back in Australia's Murray-Darling Basin

Authors:

David Adamson, Max Oss-Emer and John Quiggin

Working Paper: M11_1

2011

RSMG Working Paper Series

Schools of Economics and Political Science

The University of Queensland

St Lucia

Brisbane

Australia 4072

Web: www.uq.edu.au

Property Rights & Water Buy Back in Australia's Murray-Darling Basin

To mitigate environmental damage from the over allocation of water property rights to irrigation in Australia's Murray-Darling Basin, the Federal Government has introduced a Buy-Back policy. However, the conjunctive nature of water resources in the Murray-Darling Basin is highly variable. Consequently alternative water property rights describing their reliability to supply water have been developed. Thus three critical questions concerning both the policy design and its outcome have been raised. Firstly, how much water will be transferred to the environment on an annual basis? Secondly, how will the environment benefit from this water? Thirdly, what are the economic consequences of restoring environmental flows? This article presents a state-contingent model of risk and uncertainty that allows for the specification of water resources and water property rights by water supply states of nature. This specification then allows for the optimal mix of water entitlements to be determined under a range of policy options and budgetary constraints that encapsulates the ability to supply water to environmental targets under alternative states of nature.

Key Words: property rights, optimisation, state contingent analysis, environmental targets

JEL Codes: C6, Q15, Q25

For most of the 20th century, the Basin displayed the characteristics of what Randall (1981) calls the ‘expansionary’ phase of irrigation policy. The primary aim was to increase the volume of agricultural output and the number of farmers sustained by that output. Little attention was paid to the economic viability of either irrigation projects or small scale agriculture, and almost no attention was paid to problems of environmental sustainability, including salinity, and the need for flows to maintain vulnerable ecosystems.

Randall (1981) proposed that the water market in Australia’s Murray-Darling Basin (Basin) was entering a mature phase when transferable water entitlements were being developed. Randall proposed that free market trade, involving all water users, would allow the true price of water use to be determined. This price discovery would have two benefits. Firstly, it provides the most efficient means of allocating water between all water users (irrigators, urban communities and the environment). Secondly, the price discovered would encapsulate the full costs associated with that water use, including externalities.

Unfortunately, the arrival of the mature phase has not yielded the hoped-for benefits, and in some respects has exacerbated the problems of the Basin. In the early 1990s, revocable water licenses attached to particular parcels of land were converted into tradeable entitlements. Unfortunately, the total volume of licenses already exceeded the level consistent with sustainable diversions from the natural environment in the long term. Moreover, some licenses that had never or rarely been used (‘sleepers’ and ‘dozers’) became available to purchasers with a demand for additional water. Thus, the effect of tradability was to lock the existing over allocation into place.

On the other hand there were critical limits on tradability The Productivity Commission (2010) review of the Basin's water markets found that irrigators were impeded by complex set management rules preventing water from permanently moving between catchments in the Basin or away from irrigation. The report suggested that these impediments have constrained economic rents for irrigators and ingrained the externality costs of over allocating water resources to the public purse.

The severe drought conditions that prevailed from 2006 to 2010 revealed that, far from achieving maturity the Basin had entered a 'crisis' phase, with severe conflict between and within different user groups. In 2007 the *Water Act* was introduced in an attempt to 'restore the balance' between all water users, through a proposed 'Basin Plan' which was to determine the sustainable allocation of water between all users, based on the best available science.

Although the Act was primarily concerned with promoting capital expenditure on water saving infrastructure, it included an option for purchasing water allocations. In 2008, the Water for the Future program was introduced with the aim of purchasing water rights from 'willing sellers'. The program has been operated by the Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC), while the water for the environment will be managed by the Commonwealth Environment Water Holder (CEWH).

Because of the variability of flows in the Basin, water entitlements have been constructed to reflect the inherent variability in water supply. For simplicity, irrigation entitlements can be classified into three groups: high security, general security and supplementary. High security licences are generally allocated first and are expected to receive their full face value 95 years out of 100. As water supply increases within the system, general security licences receive a proportion of the face value of the asset supply. Only under times of high flow is water provided to supplementary licences (labelled low security in tables and charts).

In the initial phase of *Water for the Future*, the primary objective was to purchase rights to substantial volumes of water, without much concern for the type of water rights that were acquired, although the price paid depended on the reliability of supply.

In 2010 the Murray-Darling Basin Authority (MDBA) released the Guide to the draft Basin Plan provided an upper and lower bound of the new sustainable extraction levels and the amount of water that needs to be transferred to the CEWH to negate externalities of irrigation activity (MDBA 2010a). Although the Guide received a hostile public reception and is likely to be revised substantially, it provides a basis for assessing the extent to which options for water management are consistent with a scientifically-based understanding of the sustainable capacity of the Basin to supply water for extractive uses such as irrigation.

It is the aim of this article to therefore examine if the existing Buy-Back could achieve the desired outcomes of the 2010 Basin Plan. To achieve these goals, this article compares six alternative policy approaches on buying-back water, as described in the second section.

The article is organized as follows. Firstly the problems of over utilizing an inherent variable conjunctive water supply within the Murray Darling Basin are discussed. Secondly information about the Buy-Back process and the nature of water entitlements is outlined. Then the model used to test the six 'Buy-Back' policy options is presented. These results are then presented in light of examining the how successfully the reallocation program might be in rectifying natural resource externalities. Finally concluding comments are presented.

The Murray-Darling Basin & its Water Resources

The Basin is of national significance in Australia, due to its size, social importance, economic output and iconic environmental assets. Located on the eastern seaboard of Australia, it stretches over 14% of the nation and its waters flow through the political boundaries of Queensland, New South Wales, the Australian Capital Territory, Victoria and South Australia before entering the sea. The Australian Bureau of Statistics (ABS) (2008b) estimates that approximately 10% of Australia's population resides within the Basin and a further 5% living in the City of Adelaide are dependent upon the Basin for augmenting potable water supplies (ABS 2010).

Over 80% of the Basin is dedicated to agriculture and depending upon the season it produces 35 to 40% of total gross value of agricultural production in Australia (ABS 2008a). Although only 2% of farm land is irrigated, it accounts for one third of the Basin gross value of production from irrigation activities (ABS 2009). This accounts for why water reform policy reform is a gradual process.

The Basin has two major river systems, the Darling River running north to south, and the Murray River and its major tributary the Murrumbidgee River (the southern connected system) running east to west. An estimated 440,000 km of river system in the Basin supplies water to over 30,000 wetlands covering at least 25,000 km^2 (MDBA 2010b).. 16 wetlands have international standings under the Ramsar convention (MDBA 2010a).

Water Resources, Irrigation and the Environment

The conjunctive water resource to be shared by all Basin users is approximately 26,000 gigalitres (GL) on average. This bulk of supply is derived from rainfall runoff while both inter-basin transfers and groundwater reserves each supply about 1,200 GL (MDBC 1995). Approximately 46% of water resources, 13,460 GL, are allocated for irrigation use and 206 GL is diverted for the City of Adelaide's potable supplies. The 13,460 GL is often referred to as the Cap on extractions or Cap for short These diversions have reduced annual discharge to the sea from 13,000 GL before development to 5,000 GL (MDBC 2006).

The flow regime within the southern connected Basin system has been highly modified with capital works and management approaches to mitigate supply variability during the peak irrigation demands in spring and summer. These new flow patterns in the southern connected Basin system negate the natural winter peak pulse flows. The northern Basin has summer dominate flows. Although capital investment in the northern Basin has traditionally been lower than the south, recent land forming activities are now directing overland flows into on-farm dams. Both diversions for irrigation and flow modification have resulted in the majority of the Basin ecosystem being described as in poor or very poor condition as historically the short run risk of water variability in borne by the environment (MDBA 2010b).

Resource Variability, Management & Drought

Despite management and capital infrastructure the use of averages to describe water resources in the Basin is misleading due to spatial and temporal variability (Khan 2008). It is estimated that only 4% of the Basin's total average rainfall of 530,618 GL becomes runoff and consequently deviations from that percentage can result in droughts and floods (ABS 2008 b). As data obtained from the MDBA (Foreman peers comm. 2011) illustrates, rarely is rainfall constant. Inflows into the Murray River from 1892 to 2010 reveal: a mean of 11,000 GL; a median 9,000 GL; a standard deviation is 7,800 GL; the maximum recorded inflow was 49,000 GL in 1957; and the minimum annual inflow was only 1,000GL in 2007. Over the same period, inflows from the Darling River arriving to

Menindee Lakes are described as follows: a mean of 2,000 GL; a median of 850 GL; a standard deviation over 3,000 GL; the maximum recorded inflow exceeded 18,500 GL in 1957; and the minimum recorded inflow was 35 GL in 1920. As for any natural system data inevitable new minimums, maximums and trends will emerge from future events. It is however, the historic natural system data that has not only driven the evolution of the environment but the irrigator's response.

Historically, two management approaches for dealing with water supply variability have been adopted. First a short run response of penalising environmental supply to maintain irrigator supplies is adopted, with the goal that sequential time periods compensates environmental flows. Second, announcements concerning the percentage of allocation to be delivered to irrigators, subject to the description of the entitlements risk, are made throughout the year.

The recent drought started in 2000 (The Productivity Commission 2009) and lasted until the 2010. During the initial drought phase the above management strategies were adopted but after multiple successive years of low inflows past known parameters, management changes occurred. For example, by 2005-06 high security licences in the Goulburn region fell to only 30 per cent of their face value (National Water Commission 2011). The reduction in water supply not only caused a short run price response on the allocation market in 2007-08 but ultimately forced significant changes in production and management responses in the subsequent season (Mallawaarachchi & Foster 2009). By 2008-09 Basin wide irrigation diversions were 4,100 GL, approximately one–third of diversions in 2001-02 (MDBA 2010c). By late 2009, arguably for the first time ever, iconic environmental assets received water before irrigators to prevent total ecosystem collapse (MDBA 2011). This drought has forced the re-examination of the sustainable level of diversions in the Basin via the 2007 Water Act.

Sustainable Diversion Limits and the Buy-Back

Water reform has been an evolving process since 1914. In the last twenty-five years a continual cycle of water reform initiatives in the Basin have occurred driven by a need to respond to, the actual or perceived failures of each preceding initiative attempting to achieve a balance between all water users. These initiatives include the 1987 Murray-Darling Basin Agreement, the 1994 COAG Water Reform Framework, the 2002 Living Murray Program, the 2004 National Water Initiative, the 2007 National Plan for Water Security and the 2008 Water for the Future plan (The Senate 2010).

The 2007 Water Act was the first real attempt at rectifying this balance both in terms of commitment and providing the funding to adjust the balance between all users at the public expense (Commonwealth of Australia 2008). Getting this balance right then, involves not only the determination of sustainable limits of diversions but analysing the mechanisms in which water is returned to the environment at public cost. This then involves understanding the economic, social and environmental trade-offs associated with the rebalance.

To achieve this goal this article compares six alternative policy approaches on buying-back water. Firstly the baseline case is provided where no ‘Buy-Back’ policy exists. All remaining policies then examine options for setting up the Buy-Backs policy. The second case study assumes that there is an unlimited budget to purchase water rights and there are no explicit environmental targets. Here if irrigators accept the price from the CEHW then the market is mature in its price discovery. The third scenario examines the economic implications of the introduction of the CEHW's targets when there is no budgetary constraint. The fourth scenario examines if sufficient funding has been provided to meet the CEHW lower bound requirements. The fifth scenario expands on the goals of the third by introducing an explicit environmental outcome. The final scenario examines the implications of setting the CEHW to obtain the upper bounds of the suggested requirements. By comparing different combinations of the policy settings we can determine the fate of the article's three tests. These comparisons can then illustrate the concepts of maximising public expenditure for the greatest public benefit at the lowest opportunity cost for irrigators while achieving a set of alternative environmental targets.

To examine these scenarios we need to know the amount of water required to restore the balance, the total funding available, and the opportunity cost to transfer each unit of water from irrigators to the environment.

Sustainable Diversion Limits

Table 1 near here

Using the best available science the MDBA (2010a) determined that between 2,999 and 7,599 GL of water needed to be transferred to the environment. These volumes then determine the upper and lower bounds used for the Buy-Back scenarios. Table 1 illustrates the amount of water to be transferred to the environment by the catchments used in the model (see next section). That Table also lists the existing entitlements by classification and by catchment before the Buy-Back commenced. The last set of columns details the average prices that have been paid by entitlement security that have been bought under the Buy-back. As the Buy-Back is still continuing and the announced price paid for water is not broken down into the detail required for this model, multiple catchments use the same base price data. So how has the Buy-Back determined the price paid?

Pricing Entitlements

The Buy-Back approached negated existing inter-state water trade rules by purchasing water directly from irrigators. The Buy-Back has been designed as a multistage tendering system, where an announcement is made specifying the total funds available to purchase water in a given region over a set time frame. Irrigators, who wish to participate, then submit non-binding expressions of interest stipulating the price they are willing to accept for a described bundle of entitlements (Horne *et al.* 2010). This allows for the Buy-Back process to maximise their objective function of water for the environment. Successful bids can still be rejected by the irrigators and the total funding to secure water rights does not have to be exhausted. Through time price discovery has occurred as the average price paid for successful bids was publically revealed.

Table 2 near here

Table 2 outlines the estimated reliability for the three entitlement class by state of nature and on average over the three states of nature (see next section). This data is based on estimations from SEWPaC about the reliability of water purchased to supply water on average. The data in Table 1 and Table 2 illustrates that price is a function of entitlement security. As high security entitlements command the greatest price, while the price paid for entitlements in the southern connected system within the Basin (i.e. all catchments in the Table below the Lachlan) are greater than the same entitlements outside these catchments.

This article has adopted a state contingent approach to risk and uncertainty as described in Quiggin & Chambers (2000) to determine the CHEW's risk in obtaining an optimal bundle of entitlements needed to restore the balance while learning about the economics and social trade-offs.

A State Contingent Model

Decision making in agriculture has to incorporate uncertainty. Uncertainty abounds in agriculture where issues as diverse as weather patterns, domestic and international price shocks, biosecurity outbreaks, input shortages and changes to interest rate policy influence not only decision making but the outcome from that decision. In this case which entitlements by classification should the CEWH buy in order to achieve a range of environmental goals? Then what would those decisions mean for irrigators?

The traditional approach to dealing with production uncertainty has been to describe outcomes in stochastic terms. For example, we know that application of fertiliser to a crop of wheat will increase the yield within a given range. The problem with this approach is that production and management inefficiency cannot be separated (O'Donnell & Griffiths 2006). That is, we cannot tell if the failure to achieve an outcome within the described fertiliser function has been due to an application error by the farmer or if a drought occurred. What quickly becomes apparent is that farmers are not allowed to actively alter production systems in response to outside information (Chambers & Quiggin 2007). In other words irrigators are expected to remain passive to environmental influences such as a drought and that the modelled response is a decrease in income either due to the function describing yield (e.g. as water use falls, output falls) and/or changes in price.

The second approach to modelling uncertainty derives from contributions by Arrow (1953) and Debreu (1959). Who provided the insight that uncertainty could be represented by a set of possible states of nature under which a given management response and outcome could be determined. In this case, within each state of nature (i.e. water availability) irrigators are actively able to respond by changing the inputs they use (e.g. water and labour), the product they produce (i.e. whether to stop irrigation and produce a dryland crop) and the technology used to produce output. This allows for production to be described with multi-output technology within a state space. Consequently yields and prices are not states of nature but are outcomes of a given state (Rasmussen 2006). A producer's response to each state of nature (e.g. drought) is based on prior knowledge about that state of nature and past experiences of outcomes from state based decisions (i.e. changes in inputs and outputs). Management efficiency is therefore an ability to recognise the state, allocate the appropriate resources and achieve the target output to meet their objective function. This then allows a state contingent approach to examine both production and decision maker's ability as separate entities (Chambers & Quiggin 2000). The total number of states remains small as states of nature with identical management decisions and outcomes can be merged together.

Discrete stochastic programming using multipoint decisions provides the closest representation from the first approach to examine uncertainty. Although similar in approach to the state contingent approach in trying to separate the producer and output risk and uncertainty it does not have the ability to classify production systems in a state-contingent approach as discussed by Quiggin et al. (2010).

The Model Description

This description of the model represents the global solution and not the sequential solution presented in Author (2007), as this artilce is determing the national benefits of policy. Author (2010) provides far greater detail on the data and assumptions used in this mdoel. Equation 1 provides the objective function for the model which aims to maximise economic return for irrigation in all catchments (k) in the basin. There are 21 catchments in the model (K=21). Economic return E[Y] is derived from the area A of commodity R grown in each region multiplied by the return of that commodity by the probability of that state (S) of nature occurring πS. Return is based on the yield (Q) multiplied by price (P) net the total costs (C) of production in each region of the basin.

(1) $$E[Y] = \sum_{R}\sum_{S} \pi_S \left[A^R \times Q_S^R \times \ (P - C)_S^R\right]$$

Subject to:

(2) $$\sigma_s^{20}/0.64 \ \leq 800 \text{ EC}$$

(3) $$\sum K_s \pi_s \leq \text{CAP}$$

(4) $$Wks_k \leq fks_k$$

(5) $$A_k R_{1..5} \leq AHort_k$$

(6) $$A_k R_{1..27} \leq Atotal_k$$

(7) $$\sum L_{rk} \leq \ L_k$$

This is subject to Equation 2 where Adelaide's water quality must be less than 800 EC in each state of nature. Where is the salinity in milligrams per litre (σ) converted into electrical conductivity (EC) by dividing it by 0.64. The volume of water used in the basin must be less than the available entitlements (i.e. Cap) on average (i.e. as long as the average CAP is not violated you may use more than under the Cap in a given state of nature) as in Equation 3. In the model extractions described for the urban and dryland use under the CAP, all catchments apart from Adelaide are removed from inflow before the model is optimised to ensure that they received their allocations. The Cap has been transformed simply into diversions for irrigation purposes. Equation 4 ensures that water use in a catchment must be less than or equal to the flow in that catchment. Equation 5 states that the area dedicated to horticulture in any catchment must be less than equal to the horticultural constraint in that area. While Equation 6 ensures that total area dedicated to irrigation in any region must be less than the total area available in that region. Equation 6 allows broadacre activities to expand over horticultural area if required. Equation 7 ensures that there is sufficient operator labour to undertake the irrigation activity mix in a region.

As πS Is the probability of the state occurring, $\sum \pi_s = 1$ (i.e. every state is identified), where $0 < \pi \leq 1$ (i.e. the states must have a chance of occurring). Here π 1to3 = (0.5, 0.3, 0.2). The three states of nature (S) are modelled which are represented by alternative Basin wide inflows. These states are Normal (the expected long term average inflows derived from (MDBC 2006)), Drought (0.6 X Normal Inflows), and Wet (1.2 X Normal Inflows). The model uses a conjunctive approach to water resources. Consequently total water inflows are dependent upon inter-basin transfers, surface supplies and ground water supplies. The model uses a directed flow network where the Basin is divided into 21 catchments (K) which consists of 19 irrigation areas plus Adelaide and the Coorong (default for flow to sea).

The area of production by catchment is defined by A which is a matrix of production systems $(\mathrm{K} \times \mathrm{R}) \times \mathrm{S}$. There are 23 production systems (R) consisting of 21 irrigation activities, plus Adelaide Water plus a dryland production system. Catchments are based on disaggregated Catchment Management Regions (CMRs) to help model the directed flow network of both water and salt (Murray-Darling Basin Ministerial Council 2001). Here water flows (fks) out of a given catchment are equal to inflows (net of evaporation and seepage) less extractions (net of return flows). Extractions are determined endogenously by land use decisions as described below, subject to limits imposed by the availability of both surface and ground water. This structure allows for the determination of total irrigation use, the flow to the Coorong and water quality arriving at Adelaide.

The second critical factor in describing A is the matrix R where the state contingent production systems are defined. Each state of nature for each r will derive an independent representation of yields (Q), prices (P), costs of production (C) and input requirements (N) and each matrix has a form of (21 X 27). The production systems are derived from $(\mathrm{K} \times \mathrm{M}) \times S$, where M represents commodities. A commodity is a single enterprise in a given state in a given catchment. This data is based on a series of regional gross margin budgets that provide the data for the five inputs modelled (N= water, land, labour, capital and cash input). This version of the model has 15 distinct commodities (M) plus urban water for Adelaide and water for the Coorong. Consequently there are $(M+2)\times S$ distinct state-contingent commodities see Table 3.

Table 3 near here

Some commodities are produced using more than one technology (i.e. capital intensive water saving irrigation investment such as drip systems versus low capital investment systems such as flood irrigation), see the third column of Table 3. The fourth column represents commodities for which irrigation practices change in the drought states to low or no water use. The fifth column illustrates production systems where only in the 'Wet' state of nature does irrigation occur. This describes 'opportunity irrigation' which occurs when large volumes of general and supplementary security water rights are actually met. The final column illustrates which commodities can be mixed and matched to build new state production systems. Obviously this cannot apply to perennial commodities. This combination of technologies and ability to develop state contingent data production sets allows M to increase to R. This report has introduced a flexible cropping rotation for the rice production system that has not been used before. This production system switches to a dryland wheat crop in the drought state of nature.

Area is divided into two classifications horticulture and broadacre commodities(i.e. broadacre crops and pasture), for each k based on irrigated area in 2001 (ABS 2004). 2001 was considered the last normal year in the Basin. The model allows for irrigation expansion by allowing a 45% increase for R horticulture activities and a maximum increase of 80% in total area irrigated. Irrigated area in k is constrained by Equation 9 (which ensures that horticultural productions systems can only be grown on horticultural land) and Equation 10 (where the total area of land irrigated must not exceed maximum area). These two equations then prevent the model being dominated by horticultural R and allow broadacre R to expand into horticultural area if profitable. Any land not allocated to irrigated area becomes a dryland enterprise. The model can therefore illustrate catchment (k) based expansion or contraction in irrigation systems based on opportunities for irrigators.

Yield (Q) has a dimension of $(K \times R) \times S$ and represents the output derived for that state of nature. Net return per hectare is described in the model as (P-C). Where price (P) paid for output has a matrix of $(M \times S)$. For simplicity it has been assumed that the price paid in all regions for each commodity is uniform by state of nature. Production costs are represented by (C). Here cost for producing one hectare of commodity R for each K in each S can be written as the sum of capital costs (i.e. capital costs do not change by state of nature and are modelled as an annual cost) plus operator labour costs (LC) (i.e. hours (L) is multiplied by a constant price (LP)) plus variable costs (VC) as in Equation 8. Equation 9 details variable costs which are derived from the sum of casual labour (CL) (i.e. hours multiplied by a constant price) plus contractor costs (Con) plus machinery costs (Ma) plus chemical costs (Ch) plus water use (W) multiplied by water price (Wp) plus other costs (O).

(8) $$R_{ks} = \sum (CC_k + LC_{ks} + VC_{ks})$$

(9) $$VC_{ks} = \sum (CL_{ks} + Con_{ks} + Ma_{ks} + Ch_{ks} + (W_{ks} \times Wp_{ks}) + O_{ks})$$

When modelling water use, three constraints are critical and are represented by Equation 6, 7 and 8. Dealing with them in reverse order, the amount of water used in a catchment in a state of nature (Wks) cannot exceed the volume of water flowing in the catchment (fks). Then the total volume of water used in the Basin (∑KSπS) must be less than the Basin CAP. This equation allows for water to be carried over in low flow years. The Cap data (or CDL & SDL) for each k is was provided by ABARES for this study.

Equation 11 deals with the amount of operator labour (L) required to produce ∑r in k. Here we ensure that the amount of labour in a region (derived from ABS 2004 data and based on number of farms X 2 people X 2,500 hours/person) is adequate to meet the needs the chosen production systems.

Salinity is now modelled as a constraint rather than a dynamic impact on production negating the discontinuous function described in Adamson et al. (2007). Salt loads (tonnes) are represented in state contingent terms reflecting salt immobilisation in soil in drought times and mobilisation during the wet states. Salinity level (σ_s^k) is determined by the state contingent salt load (tonnes) entering the catchment and the flow at that catchment (see Equation 10). The constraint is based on the requirement that 95% of the time the EC at Morgan must be less than 800 EC (MDBC 2007). In the model Morgan is represented by Adelaide (k=20) and can be represented by Equation 2 where salinity level (mg/L) (i.e. Equation 10) is concerted into EC units.

Salt determined by

(10) $$\sigma_s^k = s_s^k / f_s^k$$

Because the model is solved on an annual basis, the process of capital investment is modelled as an annuity representing the amortised value of the capital costs over the lifespan of the development activity. This provides the flexibility to permit the modelling of a range of pricing rules for capital, and to allow the imposition of appropriate constraints on adjustment, to derive both short run and long run solutions.

The state contingent approach allows for discontinuous environmental and production functions to be classified as alternative functions within each state of nature. This specification of environmental, urban or private requirement by state of nature then helps determine the type and number of water property rights needed to meet that demand by state of nature. As MDBA data does not specify when (i.e. which state of nature drought, normal, wet) water is required therefore the on average supplied will be examined only. If greater detail was forthcoming in the future then the introduction of constraints determining water required by states of nature could be introduced and it would deliver alternative outcomes for the model.

To date only, Dixon, Rimmer & Wittwer (2011) have examined the implications of the Buy-Back. Here they used of a generalised computerised equilibrium model to determine the economic implication from the removal of water from a region as area irrigated is replaced with dryland and the income receipts from water sales. A critical aspect of that review and this is the ability to differentiate between alternative water entitlement structures and encapsulating a river flow network. These factors then enable a judgement to occur about where to source water from to ensure environmental gaols are achieved at least cost to irrigators. These results here only represent a first round implications of the Buy-Back program and cannot address the second round implications to the wider economy as discussed in only Dixon, Rimmer & Wittwer (2011).

Results

Table 4 near here

The results for all analysis are found in Table 4 to Table 8. Where Table 4 details the economic return by state of nature from irrigation and residual dryland area not dedicated to irrigation and the annuity from water sales. Table 5 illustrates the amount of water used for irrigation and the amount of water purchased under different buy-back settings. Table 6 provides a proxy for improving the quality of the environment by providing the flow (GL) to the Coorong lakes by state of nature. Table 7 outlines the entitlement type (high security, general security and supplementary water) and number (GL in article worth) to implement each costed project.

Table 5 near here

If we examine the case without the buy-back policy we see that the economic return from the basin is on average $2.5 billion, ranging from a low of $775 million in a drought state of nature to over $4.1 billion during wet states of nature (see Table 4). In order to achieve this irrigators throughout the Basin would use over 12,800 GL of water ranging from 7,800 GL in drought states of nature and exceeding 19,200 GL when water is plentiful (see Table 5). After this water was used then an average of 4,500 GL would flow to the Coorong Lakes with a range of no inflow during droughts to about 6,000 GL in wet states of nature (see Table 6). Obviously as there is no policy to enact, there is no cost to purchase entitlements (see Table 7).

Table 6 near here

The second policy option asks the question, how much water irrigators would be willing to sell to the government based upon the historic prices paid under the Buy-back. In this case there is a bottomless pit of funding available and there are no identified environmental targets (i.e. any water is good water). In this case a massive voluntary sale of water assets to the government occurs as the price paid is greater than the return from irrigation. It is suggested that over 3,800 GL, 4,400 GL and 200 GL of high, general and supplementary security entitlements would be sold (see Table 7). These licences would be expected to return nearly 6,900 GL of water to the environment on average, with a range of only 4,700 GL in droughts to over 7,800 GL in wet states of nature (see Table 5). The total volume sold is less than actual delivery to the environment based upon the rules discuss in the preceding section and illustrated in Table 2. This amount of water returned to the environment would then increase the average flows to the sea by about 1,000 GL on average compared to the no buy-back option (i.e. 5,500 GL versus 4,500 GL listed in Table 6). More importantly we can see that instead of receiving no inflows during a drought state of nature that the Coorong would be expected to receive inflows of well over 800 GL (see Table 6). This policy would also provide an extra $800 million of economic rent in the basin with a significant realignment in the drought where not only has the return from agriculture increased in comparison to the no buy-back policy but the stabilising effect of the annuity from water sales increases returns in the drought case from $775 million up to over $2.1billion (see Table 4). This change in income in drought states of nature could possible relive pressure on future drought support (PC 2009) under the unlikely scenario that producers invested the entre value of asset sales into long term assets that consistently delivered a fixed dividend with no risk. If such a policy was to be enacted then it is estimated that it would cost the Australian tax payer some $14.7 billion dollars in payments for water licences, excluding current and future administration costs of water purchases and management of the assets (see Table 7). It is possible that the price paid under the Buy-Back includes a premium to help offset future costs from drought support and programs designed to offset existing externalities from over water use.

Table 7 near here

The third scenario examines the buy-back policy that specifies specific environmental targets for each of the catchments set at the lower bounds of estimates (see Table 1) but there is no budget constraint. In this scenario there is no requirement for when the water has to be returned rather on average the targets are reached as illustrated in Table 5 where the water returned to the environment is 2,885 GL. To do this near $6 billion would be spent buying only high (1,900 GL) and general security (1,400 GL) entitlements (see Table 7). However, it is interesting to note that despite on average more water (300 GL) is returned to the Coorong Lakes from the status-quo, that the water would only arrive in the normal and wet states and there would still be no inflow during droughts (see Table 6). Overall the economic rent would increase on average by $300, in thanks to the annuity of $540 million (see Table 4).

Table 8 near here

The fourth scenario is when both the MDBA lower bound targets (see Table 1) and the budgetary constraint of $3.1 billion apply. There is no requirement for when the water has to be returned rather on average the targets are reached as illustrated in Table 5. Here we see that the target has been reached (2,885 GL) but now public funds are directed at purchasing mainly supplementary entitlements (6,500 GL) and general security entitlements (1,250 GL, which is just less than the third scenario). Very little high security entitlements are purchased (295 GL) in comparison with the scenario 2 and 3). In this case there are it's where the water is sourced from (see Table 8) that provides alternative flows at the Coorong Lakes (see Table 6). In this case here the removal of the supplementary water negates producers making greater returns in the wet states of nature (see Table 4) however, the annuity from water sales offsets this so that on average the return in the basin is on par with the base case. In other words unlike the second scenario it does not transfer wealth to irrigators.

A critical part of this analysis identifies that even though you can readdress the 'balance' it doesn't necessarily lead to significant environmental benefits. In the fourth scenario an extra 270 GL of water flows to the Coorong in droughts which is an improvement from the base case but if key indicators of environmental improvements were required we may not be able to achieve them? The fifth scenario applies the same rules as the fourth scenario but this time a minimum flow of 500 GL must reach the Coorong during drought. In this case the results from the fifth scenario and almost identical to the fourth scenario except there is a change in water use by state of nature (see Table 5). In this case just only changing the commodity mix in two regions (Murray 3 and Lower Murray Darling) you can increase the flows to the Coorong Lakes during the drought for a reduction in agricultural revenue of about $4 million on average. Then to achieve these targets the Buy-Back would need to target specific areas from where to purchase the rights from.

The sixth scenario is like the fourth scenario but this time the amount to be bought back from irrigators is set at the upper bound of the MDBA targets (see Table 1) and the policy budget has been increased from $3.1 to $10 billion. In this case it has been assumed to use the entire budget set aside initially for the Water Act to assess how much water could be purchased. This analysis notes that only $3.1 billion has been set aside for the Buy-Back, and a further $5.8 billion has been allocated for capital works. There is an on-going debate that the money set aside for water savings under capital works is misallocated. It has been estimated that it costs from 2.5 to 5.5 more to purchase water via capital works (Grafton 2010).

In this case the solution estimates that on average despite the net return from irrigated and dryland activates being less than the base case by over $600 million (see Table 4) the annuity payment of $940 million compensates for the loss of water for irrigation. This policy returns more water to the environment on average nature (see Table 5) than the no targets and unlimited budget (scenario 2) for over $4 billion less in public expenditure as the money is spent on a different basket of entitlements (see Table 7). The realignment of entitlements towards the environment also returns substantially more water to the Coorong than any other policy option (see Table 6).

Attempts were made to examine the least amount of public finance required to reach the MDBA upper range of targets and it was estimated that it would still cost $9,977 million to achieve this. Consequently due to the trivial nature of the difference in the program costs and the accuracy of the model these results are not examined in detail.

Discussion

This analysis of the social policy of rebalancing water assets back to the environment has two principal limitations that must be discussed. Firstly this model assumes that the water returned to the environment has a value equal to that of its use in irrigation. This environmental benefit is expressed in terms of an annuity paid to irrigators who sell their entitlements. This negates the whole benefit of the program to rebalance water resources as any financial benefit from improving environmental assets in terms of reduced public and private expenditure on mitigating resource use externalities (e.g. funding to keep the Murray's mouth open, salinity mitigation works etc); or direct economic benefits from improving other environmental services are not included.

This is in part countered by the model only examining the first round long run solution to a policy. This model there for does not consider the impacts on the wider community from changes in commodities that require less inputs; and the short run costs of producers changing production systems. It is highly possible that these costs may be offset by other public expenditure processes in the future and this could be justified based on the other unaccounted benefits described above.

It is also important to consider that the model solution will not reflect reality but rather provides a guide on the possible options to society to consider. As individuals will respond to policies differently based upon their individual set of internal and external influences that policy manipulation will still be required to set the actual reliability of the entitlements during a season to ensure that operations requirements are met.

These solutions only provide a small number of options available to policy makers and this is a fundamental problem. Until decision makers decide what they actually want society and the environment to look like rigorous analysis of the policy options cannot commence. The continual delay at decision making will continue to prevent resources shifting to meet the desired outcome. This delay therefore ends up costing society both in terms of missed opportunities but with mixed signals preventing resources being squandered.

It is critical that just buying back water is not the answer as if there is no measureable outcome or target you can spend a lot of money achieving nothing (see scenario 4 and 5 where despite spending $3.1 billion there is no increased flow to the Coorong during a drought).

Pannell (2009) and Possingham (2001) argue that unless policies designed to address natural resource externalities have clear goals, they have suboptimal outcomes. As Rostow (1959) explains that until the political and social objectives are set, that understand how the law of diminishing marginal return applies equally to natural resources, demand elasticises and production function discontinuities, then economic growth is slowed. In the case of water (Mallawaarachchi et al. 2010) discusses...

"An integrated analysis that makes environmental considerations explicit, could estimate the benefits of alternative environmental allocations and determine the optimal trade-offs between consumptive and non-consumptive uses of water. It could thus highlight potential synergies and opportunities to maximise social returns from the government investment."

Once these targets are known, they can be given priority. This then allows for greater examination of the management options as the actual allocation of environmental entitlements to assets will be seasonally limited and the decision of which areas get water first will still need to occur. Although currently a separate issue to the policy question of what types of entitlements to purchase to maximise your chance as the environmental manager, it could become a binding constraint in this analysis if the actual reliability of the entitlements and/or price to purchase entitlement alter.

The volume of water rebalanced to the environment and the actual nature of the environment desired by society creates further sets of problems not covered in this article or model. If society wishes to realign the environment to what it used to be then how the environmental manager orders and supplies water (i.e. revision of winter dominated flows in the south) within the existing or in fact new water storage strategy has not been examined. Currently the model only assumes the existing storages practices and it is an annual based model. The model could be enhanced to include these features but it is outside the scope of this article.

Summary

The failure to examine both environmental (i.e. social costs) and economic considerations that in part has negated the true benefit of the Basin Plan and the on-going water buy-back strategy. The $3.1 billion to restore flows to the Basin provides a clear signal of social policy choice. However, the adoption of the mantra that any environmental flow is good flow ignores the basic premise of: the law of diminishing returns for environmental goods, the demand elasticises for alternative water property rights; and the discontinuities for both the producer and environments production functions. This failure then prevents the optimising of public expenditure for the greatest public good at the least private cost of transferring resource back to the environment to mitigate resource use externalities.

The Buy-back mechanism appears to for fill the mature market conditions of offering a price that negates private loss and is able to purchase water from all areas allowing economic growth to occur. This finding is confirmed by Dixon, Rimmer & Wittwer (2011). However, unless clear goals are stipulated the program may only act as a wealth transfer to irrigators with little benefits to the environment under drought conditions. The debate on how well the program is funded is still unresolved. In part as the cost of purchasing water via capital investment is unsound and conversely the revised Basin Plan may suggest lower targets.

Bibliography

Author 2007, ---, Australian Journal of Agricultural and Resource Economics, vol. , no., pp.

—— 2010, XXXX Model Documentation,

Australian Bureau of Statistics (ABS) 2004, AgStats on GSP 1996-97 to 200-01 Catalogue no. 7117.0.30.001, ABS, Canberra.

—— 2008a, 'Experimental Estimates of the Gross Value of Irrigated Agricultural Production, 2000–01 to 2006–07, Catalogue no. 4610.0.55.008, ABS, Canberra.

—— 2008b, Water and the Murray-Darling Basin - A Statistical Profile Australia 2000–01 to 2005–06: ABS Catalogue No. 4610.0.55.007, ABS, Canberra.

—— 2009, Value of Agricultural Commodities Produced Australia 2007–08, Catalogue no. 7503, ABS, Canberra.

—— 2010, Australian Demographic Statistics: June Quarter 2010, ABS, Canberra, Chambers, RG & Quiggin, J 2000, Uncertainty, production, choice, and agency: the state-contingent approach, Cambridge University Press, New York.

Commonwealth of Australia, 2008, Water Act 2007, by Commonwealth of Australia, Canberra.

Dixon, PB, Rimmer, MT & Wittwer, G 2011, 'Saving the Southern Murray-Darling Basin: The Economic Effects of a Buyback of Irrigation Water', Economic Record, vol. 87, no. 276, pp. 153-68.

Foreman, J *peers comm.* 2011, River Inflow Data Murray Darling Basin Authority, Canberra.

Grafton, Q, R. 2010, Economics of Water Reform in the Murray-Darling Basin, Centre for Water Economics, Environment and Policy: Research Paper 10-04, The Australian National University, Canberra.

Hone, S, Foster, A, Hafi, A, Goesch, T, Sanders, O, Mackinnon, D & Dyack, B 2010, Assessing the future impact of the Australian Government environmental water purchase program, ABARE, Canberra,.

Khan, S 2008, 'Managing climate risks in Australia: options for water policy and irrigation management', Australian Journal of Experimental Agriculture, vol. 48, pp. 265-73.

Mallawaarachchi, T, Adamson, D, Chambers, S & Schrobback, P 2010, Economic Analysis of Diversion Operations for the Murray-Darling Basin Plan: Returns to irrigation under reduced water availability: A commission study for the Murray-Darling Basin Authority, UQ Business School Commercial, The University of Queensland.

Mallawaarachchi, T, & Foster, A 2009, Dealing with irrigation drought: the role of water trading in adapting to water shortages in 2007-08 in the southern Murray-Darling Basin ABARE research report 09.6 to the Department of the Environment, Water, Heritage and the Arts, Canberra.

Murray-Darling Basin Authority (MDBA) 2011, Basin Salinity Management Strategy 2009-10 Annual Implementation Report, MDBA, Canberra.

——2010a, Guide to the proposed Basin Plan: Volume 1 Overview, MDBA, Canberra,

—— 2010b, Guide to the proposed Basin Plan: Volume 2: Technical Background, MDBA, Canberra,

—— 2010c, Water Audit Monitoring Report 2008–09, Murray-Darling Basin Authority, Canberra.

Murray-Darling Basin Commission (MDBC) 1995, An Audit of Water Use in the Murray-Darling Basin: Water Use and Healthy Rivers - Working Towards a Balance, MDBC, Canberra.

—— 2006, 'Murray-Darling Basin Water Resources Fact Sheet', MDBC, Canberra.

—— 2007, Murray-Darling Basin Commission Annual Report 2006–2007, MDBC Publication No. 27/07, MDBC, Canberra.

Murray-Darling Basin Ministerial Council (MDBMC) 2001, Integrated Catchment Management in the Murray–Darling Basin 2001–2010, by MDBMC, MDBC, Canberra.

National Water Commission (NWC) 2011, Australian water markets: trends and drivers 2007-08 to 2009-10, by National Water Commission, Canberra.

Pannell, D 2009, 'Making the Most of ‘Caring for our Country’', paper presented to ABARE Outlook 2009, Canberra, 3-4 March 2009.

Possingham, HP 2001, 'The business of biodiversity: applying decision theory principles to nature conservation', Tela, vol. 9, no. 1, pp. 1-37.

Quiggin, J & Chambers, RG 2000, Uncertainty, Production, Choice and Agency. The State-Contingent Approach, Cambridge University Press, Cambridge.

Randall, A 1981, 'Property Entitlements and Pricing Policies for a Maturing Water Economy', The Australian Journal of Agricultural Economics, vol. 25, no. 3, pp. 195-220.

Rasmussen, S 2006, 'Optimizing Production under Uncertainty: Generalization of the State-Contingent Approach and comparison with the EV Model', Royal Veterinary and Agricultural University, Food and Resource Economic Institute, Unit of Economics Working papers FOI 3.

Rostow, WW 1959, 'The Stages of Economic Growth', The Economic History Review, vol. 12, no. 1, pp. 1-16.

The Productivity Commission (PC) 2009, Government Drought Support: No. 46, February 2009, PC, Canberra.

—— 2010, Market Mechanisms for Recovering Water in the Murray-Darling Basin, Final Report, PC, Melbourne.

The Senate 2010, Sustainable management by the Commonwealth of water resources, Environment and Communications References Committee, Senate Printing Unit, Parliament House, Canberra.

Table 1 MBDA Buy-Back Targets

	Buy-Back Targets (GL)[1]		Existing Entitlements (GL)[2]				Price Paid ($/ML)[3]		
	Minimum	Maximum	High	General	Low	TOTAL	High	General	Low
Condamine	102	260	68	96	144	308	$2,276	$836	$161
Border Rivers QLD	28	126	9	80	120	209	$2,276	$836	$161
Warrego Paroo	5	13	12	11	25	47	$2,276	$836	$161
Namoi	31	123	247	144	144	534	$2,050	$836	$161
Central West	20	189	110	317	317	743	$2,050	$1,268	$161
Maranoa Balonne	102	260	68	80	120	268	$2,276	$836	$161
Border Rivers Gwydir	116	348	18	317	317	651	$2,239	$836	$161
Western	228	249	-	173	404	577	-	$836	$161
Lachlan	44	158	27	238	356	621	$2,050	$683	$161
Murrumbidgee	483	1,422	279	1,450	966	2,695	$2,050	$991	$218
North East	195	439	408	80	20	508	$2,123	$1,283	-
Murray 1	29	66	15	156	39	211	$2,248	$1,283	$218
Goulburn Broken	547	1,511	1,356	395	99	1,849	$2,237	$1,283	$196
Murray 2	312	704	76	782	195	1,053	$2,248	$1,283	$218
North Central	251	585	1,204	250	62	1,516	$2,333	$1,283	$200
Murray 3	292	659	60	625	156	842	$2,248	$1,197	$218
Mallee	82	185	197	26	7	230	$2,209	$1,197	$199
Lower Murray Darling	52	117	16	200	100	46	$2,248	$836	$161
SA MDB	82	185	554	-	-	554	$2,242	-	-
TOTAL	2,999	7,599	4,724	5,241	8,737	13,460			

1 MDBA 2010c

2 Author 2010

3 Data derived from http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/average-prices.html data accessed Feb 2010

Table 2 Reliability of Water Entitlement Security

	High Reliability				General Security				Low Security			
	Normal	Drought	Wet	Avg	Normal	Drought	Wet	Avg	Normal	Drought	Wet	Avg
Condamine	1.00	0.75	1.00	0.95	0.60	0.20	0.80	0.58	0.10	0.00	1.00	0.35
Border Rivers QLD	1.00	0.75	1.00	0.95	0.60	0.20	0.80	0.58	0.10	0.00	1.00	0.35
Warrego Paroo	1.00	0.75	1.00	0.95	0.60	0.20	0.80	0.58	0.10	0.00	1.00	0.35
Namoi	1.00	0.75	1.00	0.95	0.80	0.40	0.90	0.75	0.10	0.00	1.00	0.35
Central West	1.00	0.75	1.00	0.95	0.70	0.30	0.80	0.65	0.10	0.00	1.00	0.35
Maranoa Balonne	1.00	0.75	1.00	0.95	0.60	0.20	0.80	0.58	0.10	0.00	1.00	0.35
Border Rivers Gwydir	1.00	0.75	1.00	0.95	0.80	0.30	0.80	0.70	0.10	0.00	1.00	0.35
Western	1.00	0.75	1.00	0.95	0.80	0.20	0.70	0.65	0.10	0.00	1.00	0.35
Lachlan	1.00	0.75	1.00	0.95	0.50	0.30	0.75	0.54	0.10	0.00	1.00	0.35
Murrumbidgee	1.00	0.75	1.00	0.95	0.70	0.40	0.80	0.67	0.10	0.00	1.00	0.35
North East	1.00	0.75	1.00	0.95	0.85	0.50	0.95	0.81	0.10	0.00	1.00	0.35
Murray 1	1.00	0.75	1.00	0.95	0.85	0.50	0.95	0.81	0.10	0.00	1.00	0.35
Goulburn Broken	1.00	0.75	1.00	0.95	0.85	0.50	0.95	0.81	0.10	0.00	1.00	0.35
Murray 2	1.00	0.75	1.00	0.95	0.85	0.50	0.95	0.81	0.10	0.00	1.00	0.35
North Central	1.00	0.75	1.00	0.95	0.85	0.50	0.95	0.81	0.10	0.00	1.00	0.35
Murray 3	1.00	0.75	1.00	0.95	0.85	0.50	0.95	0.81	0.10	0.00	1.00	0.35
Mallee	1.00	0.75	1.00	0.95	0.70	0.40	0.80	0.67	0.10	0.00	1.00	0.35
Lower Murray Darling	1.00	0.75	1.00	0.95	0.70	0.40	0.80	0.67	0.10	0.00	1.00	0.35
SA MDB	1.00	0.75	1.00	0.95								
Adelaide	1.00	0.75	1.00	0.95								

High reliability water is based on the assumption that it is met 95% of the time

Table 3 Production Systems in the Model

Classification	Commodity	Multiple Technologies	Flexible & Fixed Rotations	Wet Water use	Multiple Combinations
Horticulture	Citrus	Yes			
	Grapes				
	Po me Fruit				
	Stone Fruit	Yes			
	Vegetables		Yes		
Broadacre	Cotton		Yes	Yes	Yes
	Grain				Yes
	Legume				
	Oilseeds				Not activated
	Sorghum				Not activated
	Oilseeds				Not activated
	Rice		Yes	Yes	Not activated
	Wheat				Yes
Pasture	Dairy	Yes			
	Beef				Not activated
	Sheep				Yes

Table 4 Economic Return ($'million)

	Ag Return (Irrigated+ Dryland)				Annuity from Water				Sum of
Buy-Back Policy	Normal	Drought	Wet	Average	Normal	Drought	Wet	Average	Average
Without	$2,215.4	$775.0	$4,174.0	$2,514.9	$0.0	$0.0	$0.0	$0.0	$2,515
No Targets, Unlimited Budget	$1,918.3	$889.8	$3,291.6	$2,124.6	$1,267.2	$1,267.2	$1,267.2	$1,267.2	$3,392
Low Target, Unlimited Budget	$1,978.0	$760.8	$3,829.7	$2,290.1	$543.9	$543.9	$543.9	$543.9	$2,834
Low Target, Budget =$3.1 B	$2,008.3	$755.5	$3,707.5	$2,267.5	$292.9	$292.9	$292.9	$292.9	$2,560
Low Targets, Budget = $3.1 B, Coorong Flow Requirement	$2,008.7	$768.0	$3,685.3	$2,263.5	$292.9	$292.9	$292.9	$292.9	$2,556
High Target, Budget = $10 B	$1,717.7	$972.6	$2,826.0	$1,901.2	$944.2	$944.2	$944.2	$944.2	$2,845

Table 5 Water Used for Irrigation & Volumetric Licences Sold (GL)

	Irrigation Use (GL)				Water Returned to Environment (GL)			
Buy-Back Policy	Normal	Drought	Normal	Average		Drought	Wet	Average
Without	11,016	7,803	19,274	12,851				
No Targets, Unlimited Budget	4,876	2,845	11,708	6,520	7,198	4,736	7,826	6,894
Low Target, Unlimited Budget	8,242	6,136	16,978	10,442	3,059	2,016	3,174	2,885
Low Target, Budget =$3.1 B	9,167	6,751	15,033	10,444	1,808	841	6,042	2,885
Low Targets, Budget = $3.1 B, Coorong Flow Requirement	9,216	6,493	14,972	10,398	1,808	841	6,042	2,885
High Target, Budget = $10 B	4,901	3,660	8,015	5,587	5,510	3,023	13,413	7,383

Table 6 Flow to the Coorong (GL)

Buy-Back Policy	Flow to the Coorong (GL) Normal	Drought	Wet	Average
Without	5,443.2	0.0	5,948.3	4,506.1
No Targets, Unlimited Budget	5,997.9	871.6	7,969.6	5,564.2
Low Target, Unlimited Budget	5,855.2	0.0	6,285.7	4,813.3
Low Target, Budget =$3.1 B	5,833.0	267.3	6,500.0	4,919.9
Low Targets, Budget = $3.1 B, Coorong Flow Requirement	5,799.2	500.0	6,542.9	4,962.5
High Target, Budget = $10 B	6,968.6	1,523.2	8,464.5	6,328.3

Table 7 Entitlements Required (GL) & Cost to Implement ($'m)

Buy-Back Policy	Water Rights to Purchase (GL) High	General	Supplementary	Cost to initiate Policy ($m)
Without	0.0	0.0	0.0	$0
No Targets, Unlimited Budget	3,833.8	4,401.9	202.5	$14,708
Low Target, Unlimited Budget	1,945.2	1,448.8	0.0	$5,953
Low Target, Budget =$3.1 B	294.6	1,268.8	4,562.6	$3,100
Low Targets, Budget = $3.1 B, Coorong Flow Requirement	294.6	1,268.8	4,562.6	$3,100
High Target, Budget = $10 B	2,081.5	3,266.0	8,392.4	$10,000

Table 8 Budget versus No Budget comparison Entitlements By Security (GL)

	Targets, No Budget			Targets, Budget Constraint		
	High	General	Supplementary	High	General	Supplementary
Condamine	71.6	57.8	0.0			290.0
Border Rivers QLD	9.5	32.8				80.0
Warrego Paroo	5.3					14.3
Namoi	32.6					88.6
Central West	21.1				0.0	57.1
Maranoa Balonne	71.6	57.8				290.0
Border Rivers-Gwydir	18.4	140.7				331.4
Western		175.4				325.7
Lachlan	28.4	31.8				125.7
Murrumbidgee	293.7	304.5			100.4	1,187.7
North East	204.9			99.8	98.6	57.1
Murray 1	15.9	17.4				83.4
Goulburn Broken	575.4			56.4	487.0	281.7
Murray 2	79.5	292.0			144.0	558.3
North Central	263.9				232.4	178.3
Murray 3	63.6	285.9			167.5	446.6
Mallee	86.3			52.1	38.8	18.6
Lower Murray Darling	17.3	52.8				148.0
SA MDB	86.3			86.3		
	1,945.2	1,448.8	0.0	294.6	1,268.8	4,562.6

PREVIOUS WORKING PAPERS IN THE SERIES

MURRAY DARLING PROGRAM

M03_1 Drought policy: A state-contingent view, John Quiggin and Robert G. Chambers (2003).

M04_1 Discounting and policy options for sustainable management of the Murray-Darling River system, John Quiggin (2004).

M04_2 Water rights for variable supplies, John Freebairn and John Quiggin (2004).

M04_3 Sustainable management of the Great Artesian Basin: an analysis based on environmental economics and law, John Quiggin and Poh-Ling Tan (2004).

M04_4 Optimal timber utilisation strategies for Wik people on Cape York Peninsula, Tyron Venn (2004).

M04_5 Portable sawmilling costs for landholders in Western Queensland, Tyron Venn, Robbie McGavin and William W. Leggate (2004).

M04_6 Designing, developing and testing financial models for non-industrial private forestry, Steve Harrison, Nick Emtage, John Herbohn and Tyron Venn (2004).

M04_7 A Wik forestry industry on Cape York Peninsula: visions and realities, Tyron Venn (2004).

M05_1 Modelling basin level allocation of water in the Murray Darling Basin in a world of uncertainty, David Adamson, Thilak Mallawaarachchi and John Quiggin (2005).

M05_2 Commercial forestry: an economic development opportunity consistent with the property rights of Wik people to natural resources, Tyron Venn (2005).

M05_3 The precautionary principle in environmental policy and the theory of choice under uncertainty, John Quiggin (April, 2005).

M05_4 Risk and water management in the Murray-Darling Basin, John Quiggin (April, 2005).

M05_5 Accommodating indigenous cultural heritage values in resource assessment: Cape York Peninsula and the Murray-Darling Basin, Australia, Tyron Venn and John Quiggin (2005).

M05_6 Are non-use values distance-independent? Identifying the market area using a choice modelling experiment, Giovanni B. Concu (2005).

M05_7 Investigating distance effects on environmental values: a choice modelling approach, Giovanni B. Concu (2005).

M05_8 The potential cost to New Zealand dairy farmers from the introduction of nitrate-based stocking rate restrictions, Mark Neal (2005).

M06_1 "One size fits all"? – the relationship between the value of genetic traits and the farm system, Mark Neal and Bill Fulkerson (2006).

M06_2 State-contingent modelling of the Murray Darling Basin: implications for the design of property rights, David Adamson, Thilak Mallawaarachchi and John Quiggin (2006).

M06_3 Urban water supply in Australia: the option of diverting water from irrigation, John Quiggin (2006).

M06_4 Agricultural intensification, irrigation and the environment in South Asia: issues and policy options, Mohammad Alauddin and John Quiggin (April 2006).

M06_5 Water use and salinity in the Murray-Darling Basin: a state-contingent model, David Adamson, Thilak Mallawaarachchi and John Quiggin (2006).

M06_6 The metagovernance of markets: the politics of water management in Australia, Stephen Bell and John Quiggin (2006).

M06_7 Choosing the best forage species for a dairy farm: the whole-farm approach, Mark Neal, James Neal and Bill Fulkerson (2006).

M06_8 Conservation policies, environmental valuation and the optimal size of jurisdictions, Giovanni B. Concu (2006).

M07_1 Choice modelling and laboratory experiments for non-market valuation: a framework, Giovanni B. Concu (2007).

M07_2 Climate change and climate uncertainty in the Murray-Darling Basin, David Adamson, Thilak Mallawaarachchi and John Quiggin (2007).

M07_3 Re-examining economic options for import risk assessments, David Adamson and David Cook (2007).

M07_4 Willingness to pay and willingness to accept for changes in native vegetation cover, Nanni Concu (2007).

M08_1 Options for salinity mitigation in the Murray-Darling Basin, Peggy Schrobback, David Adamson and John Quiggin (September, 2008).

M08_2 Managing the Murray-Darling Basin: some implications for climate change policy, John Quiggin (2008).

M08_3 Opportunity costs of restoring environmental flows to the Snowy River, Liam Wagner, John Quiggin and David Adamson (February, 2008).

M09_1 Targeting environmental water from irrigators in the Murray Darling Basin, Sarah Chambers and David Adamson (2009).

M09_2 Turning water into carbon: carbon sequestration vs water flow in the Murray-Darling Basin, Peggy Schrobback, David Adamson and John Quiggin (2009).

M09_3 Climate change, mitigation and adaptation: the case of the Murray-Darling Basin in Australia, John Quiggin, David Adamson, Sarah Chambers and Peggy Schrobback (2009).

M10_1 Climate change, irrigation and pests: examining heliothis in the Murray Darling Basin, David Adamson (July 2010).

M10_2 Water policy after the drought, John Quiggin (June 2010).

M10_3 Risk, uncertainty and the guide to the draft Basin Plan, John Quiggin (2010).

M11_1 Property rights and water buy back in Australia's Murray Darling Basin, David Adamson, Max Oss-Emer and John Quiggin (2011).

M12_1 The 2011 Basin Plan, climate change and the buy-back, David Adamson (2012).

M12_2 Water trading as a risk-management tool for farmers: new empirical evidence from the Australian water market, Alec Zuo, Céline Nauges and Sarah Wheeler (2012).