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Opportunity costs of restoring environmental flows to the Snowy River

Liam Wagner, John Quiggin and David Adamson

Schools of Economics and Political Science
University of Queensland
Brisbane, 4072
rsmg@uq.edu.au

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

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Liam Wagner, John Quiggin and David Adamson

Risk & Sustainable Management Group[1],
The School of Economics,
University of Queensland

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Abstract:

The construction of the Snowy Mountains Hydro-electric Scheme in the 1960s resulted in the diversion of 99% of the Snowy River's natural flow into the Murray and Murrumbidgee river systems. In 2000, the NSW, Victorian and Commonwealth governments agreed to restore between 21 per cent and 28 per cent of the natural flow. In this paper, we examine the implications of the Agreement for the value of water use in the Murray-Darling Basin.

Opportunity costs of restoring environmental flows to the Snowy River

'*Let the river run*', has been a consistent call heard amongst stakeholders within the Murray-Darling Basin . Following the construction of the Snowy Hydro Scheme in the 1960's 99% of the flows previously running into the Snowy River were being diverted westward to the Murray and Murrumbidgee rivers.

In 2000 an agreement was signed by the Commonwealth, Victorian and NSW governments to restore between 21 per cent and 28 per cent of the original flow to the Snowy. Progress towards implementation of this agreement has been slow (Hunt 2008). Nevertheless, Water for Rivers, the corporation charged with acquiring water to restore flows states the target will be achieved by 2012 (Water for Rivers 2007).

Other things being equal, any increase in flows to the Snowy implies that flows to the Murray-Darling Basin must be reduced,. Even if restoration of flows to the Snowy is accompanied by the implementation of water –saving initiatives, the opportunity cost of diverting flows from the Murray-Darling remains relevant.

Reduced flows to the Murray-Darling Basin could have a variety of consequences relating to the opportunity costs associated with restricting available water for electricity generation and for the irrigation for arable land. Reductiosn in flows could change the biophysical condition of the catchments downstream and the quality of drinking water for Adelaide (Pigram, 2000).

Given a policy commitment to restoring flows to the Snowy, it is necessary ot consider the most cost-effective method of implementing that commitment. Three possibilities may be considered:

(a) Purchasing water from allocations to the Murray,
(b) Purchasing water from allocations to the Murrumbidgee,
(c) Purchasing water saved through efficiencies in irrigation systems or on-farm water use.

The current policy relies primarily on the third of this options and has allocated a budget of $375 million towards this goal. In this paper, we consider the costs and benefits of the first two options.

1. The Snowy Hydro Scheme

The two main roles envisaged for the snowy scheme were to augment irrigation and the production of electricity. Augmentation of irrigation allows for water run-off from snow fall melt to be stored and used in irrigated agriculture. The electricity produced by the scheme sold at tariff rates, was intended to raise capital to pay for its construction.

One of the main goals and continuing achievements of the Snowy scheme is the significant role of the provision of secure and clean water to the Murray-Darling basin. The scheme as a whole can provide a minimum of 2088 GL/year of water to the basin, which provides additional water for irrigated agriculture that has an estimated value of $4.5 billion/year. This secure provision of water to the region represents an estimated 40% of the gross value of Australian agricultural production.

Prior to the implementation of the Snowy Hydro Scheme the average flow down the Snowy River was 3.2 GL/day (Pigram 2000). Following the construction of Lake Jindabyne the average flow at this point on the Snowy is approximately 25 ML/day, which equates to less than 1% of natural flows. These release arrangements set out in the 1960's from Jindabyne Dam only considered the interests of electricity generation and downstream flow to the west of the divide (Pigram 2000). The environmental flows into the Snowy were not considered, nor were there any community or ecological interests taken into account (Pigram 2000 and 2002).

In response to community concerns over environmental flows to the Snowy River, the New South Wales, Victorian and Commonwealth governments initiated an inquiry to establish if these flows could be restored. The inquiry was to explore the continued viability of Snowy Hydro and the possible privatisation of the scheme while also trying to find a balance between the competing interests for water from the river. In 1998 the inquiry established several options for the restoration of flows [Pigram 2000].

Political pressure to increase environmental flows to 28% of pre-hydro construction levels came to a head in 1999, when independent Craig Ingram ran for the Victorian Legislative Assembly ran on a restoration of flows platform [ABC 1999, 2002]. Ingram went on to enable the opposition to form a minority government if the Snowy River Alliance's reform charter was accepted as state policy.

An agreement to restore flows was reached in December 2000, where the New South Wales, Victorian and Commonwealth governments reached a consensus on the outcomes of the Snowy water inquiry. A commitment was made to invest of $375 million over 10 years to restore 21% of average natural flows. This is equivalent to restoring 212 GL/year down the Snowy River and an allocation of 70GL/year of additional dedicated environmental flows to the river Murray. A further increase in flows was also to be provided to the Snowy Mountain Rivers which includes the upper Murrumbidgee River.

This agreement also provided for an additional 7% of further flows to the Snowy River may be achievable via the implementation of major capital works, which would achieve additional water savings in the southern Murray-Darling Basin. The capital works program would encompass both public and private partnerships where water savings allocated to the governments used to offset increased flows to the Snowy and provide environmental flows to the Murray River. It should also be mentioned that there is a proviso on this agreement that no adverse impacts on water entitlement should occur for irrigation within the basin.

2. The model

The model which is used in this paper to examine the effect of the restoration of environmental flows to the snow is presented in (Adamson, et al., 2007a). We shall give a brief explanation of this model and its solution methodologies in this section.

The river system in this model is constructed as a directed network divided into catchments which we denote as k=1..K. The catchments within the Murray-Darling basin are linked by flows of salt and water which is endogenously determined by state contingent expectations. The flow of water out of any given catchment is equal to the inflows (net evaporation and seepage losses), minus extractions (which is also includes net return flows).

Agricultural and water usages in each catchment is modelled by a representative farmer with agricultural land area Lk. This model examines the 18 catchments which correspond to the Catchment Management Authority regions within the basin. In addition this model also includes water use within Adelaide and the flows to sea of the remaining water from the basin.

All of the catchments are in turn sequentially linked on the basis of existing flow patterns (Adamson, et al., 2007b). This network of catchments encompasses the cumulative water volume and salt loads from Condamine-Balonne catchment in Queensland through to the Lower Murray-Darling catchment which incorporates the South Australian portion of the basin where the river system runs into the sea.

State contingent modelling such as this investigation, relies on a defined number of possible states S, which correspond to different levels of precipitation and other climatic conditions. This model consists of three states of the world, which correspond to wet, normal and dry states. The status of the river in this model for each region and state of the world is measured by flow and salinity variables. In this model salinity is used as a general measure of water quality. This generalisation for river quality is used as most other measures are reduced by excessive water extractions.

Activities

With each catchment within the basin, land allocated across R different activities. This model excludes some activities from certain regions which reflect soil types and climatic conditions within that region which are not consistent with production activity being analyzed.

Each hectare of land an activity is represented by:

(i) Output of each state-contingent commodity with dimension M x S.

(ii) Water use in each state of nature with dimension S.

(iii) Any other inputs committed on execution of the model with dimension N.

These inputs include classical elements of production such as capital, labour, land and a generic cash input. So for regions within the basin the land allocated to a given activity r within the range of activities R, in region k is denoted by l_r^k and the vector of land allocations in region k is represented by l_k. Thus in general any activity is represented by M x S output coefficients, N input requirements and S state-contingent water requirements. Therefore for each region k, the matrix A_k of activity of coefficients has dimension R x M x S, the matrix B_k of input requirements has dimension R x N.

Constraints can be imposed on variability in total area under irrigation and on total volume of irrigation which is consistent with the MDBC cap (Adamson, et al., 2007b). The supply of external contract labour is incorporated into the generic cash input. This model assumes that input and output prices associated with production and commodity sales are the same across all regions. This model however allows the implementation of various rules for setting water prices to reflect region specific property rights.

The level of productivity in a given state of nature will depend on salinity, which in turn depends on upstream water usage within the basin. The constraints imposed on water availability are determined by the interaction between upstream water use, institutional arrangements and other policy variables. This extended model based on Adamson et al. 2007b, uses region-specific gross margin budgets which reflect differences in production conditions between catchment regions. Furthermore specific soil type information is used in production constraints for each commodity within each region.

This model is solved on an annual basis so that the process of capital expenditure/investment is modelled as an annuity which represents the amortised value of capital costs over the development activity life span. This provides flexibility for the model over a range of pricing rules for short run marginal costs (SRMC) and long run marginal costs (LRMC). Furthermore, this method allows for the imposition of appropriate constraints on adjustment to produce short run and long run solution concepts.

Solution Method.

This model uses two solution concepts. For a full discussion of these concepts we refer the reader to (Adamson, et al., 2007), for a full analysis of the construction of this model.

The *sequential solution*method allows water users at each stage of the system to maximize individual returns with respect to water use subject to constraints placed on water use and availability, salinity, land area and labour. However this method allows individuals the ability to act without taking into direct account of the effect of their actions on downstream users.

The *global solution*is the allocation that maximizes the surplus for the basin as a whole, subject to possible institutional constraints for water allocation. This solution method is analogous to dynamic programming, which determines the value of water at the final stage of the system and optimal upstream allocations by recursive backward induction.

In both sequential and global solutions, we assume that allocations to each region are constrained by the Cap on extractions,. The Cap limits average extractions of water to the levels prevailing when the policy was introduced in 1994. We further assume that where water is acquired from a given catchment (Murray or Murrumbidgee) the Cap for that catchment is reduced accordingly.

5. Results and discussion

Baseline solution

Initially we will provide current values produced by the model as a starting point for comparison of the two solution concepts described previously. It can be seen from table 1, that under in the sequential solution, producers use more water (nearly 400GL) than in the global solution method.This extra water allows for an additional 34,000Ha to be used for agricultural production, and a modest increase in the total However, the value of agricultural production is increased only marginal and gains are offset by reduced environmental flows, and by the increase in the salinity of water in Adelaide. Hence, the social returns in the global solution are estimated at $5385 million, compared to $5217 million in the sequential solution.

Three options for purchase of 250 GL for diversion to the Snowy are described in Table 1. These are: purchase of 250 GL from the Murrumbidgee, purchase of 250 GL from the Murray and purchase of 125 GL from each catchment. Since all three options have outcomes that are similar in many respects, we will examine in detail the change in the sequential solution arising from the Murrumbidgee purchase option, and discuss the other options and solution concepts more briefly.

Purchase of 250GL from the Murrumbidgee Catchment Area.

The purchase of 250GL of water allocation from the Murrumbidgee catchment has a variety of effects on water use, economic returns to agricultureand the value of water in urban and environmental use. As shown in Table 1, the economic value of water use in the Murray-Darling Basin declines by $11 million in the sequential solution from $5217 million to $5206 million. In the global solution the decline is somewhat greater, from $5384 million to $5365 million. The divergence reflects the fact that the marginal social value of water in the sequential solution is lower for upstream catchments such as the Murrumbidgee than for downstream catchments.

As shown in Table 3, the value of agricultural production in the Murrumbidgee catchment is reduced by $17 million in the sequential solution. From Table 3, this reduction arises mainly from a reduced allocation of land and water to rice and grape production. The South Australian component of the Murray Darling Basin however has an increase of utility from this increased water flowing downstream by $4.4 million. Over the entire basin there is a reduction in commodity production with an economic impact of $10.6 million for the sequential solution scenarios.

The water quality to Adelaide is also improved, particularly in the sequential solution,with an average reduction of salt flowing through to Adelaide by 16 and 1.9 EC units for the sequential and global solutions respectively, as shown in Table 1. These results reflect benefits from reduced upstream water use that are not currently incorporated in the incentives facing farmers.

Purchaseof 250GL from the Murray Catchment Area.

The second scenario considered in this investigation is the purchase of 250GL from the Murray catchment area, with a corresponding reduction in the Cap on extractions.

For thesequential solution method, Table 1 shows that the economic value of water use for the Basin as a whole is $14 million As shown in Table 2the net value of agricultural outputthe Murray catchment declines by $15 million. These results are similar to those derived in the previous section, for the Murrumbidgee. Changes in land use are also similar, with the reduction in water use being driven by a reduction of 18800 Ha in the area allocated to rice.

The global solution yields similar results. The significant decrease in land use for rice production in both catchments of 20500 Ha, is reassigned to dry land use is an indication of transfer away from high water use crops during water allocation decline. This diversion away from rice represents an overall loss in economic production of $18 million across the basin.

Unlike the Murrumbidgee option, there is little change in Adelaide's water quality reaching Adelaide in either the sequential or global solution

Purchaseof 125GL from the Murrumbidgee and 125GL Murray Catchment Areas.

The final scenario considered in this paper is a mixed option in which 125 GL is purchased from each of the two catchments. As shown in Table 1, the estimated results are fairly close to the mean of the two previous scenarios. This outcome reflects the assumption of a single representative farmer for each catchment, or, equivalently, the assumption that resources are allocated optimally within catchments. If farmers are heterogeneous, and allocation of water resources within catchments is suboptimal, the marginal value of water may vary for different users within catchments. In this case, offering to purchase water from users in both catchments may yield water savings at lower cost than an offer confined to one catchment or the other.

Policy implications

The most important policy issue to be addressed is whether direct purchase of water rights is likely to be more cost-efficient than the provision of subsidies for on-farm water savings. Under the intergovernmental agreement, the sum of $375 million has been allocated for the latter purpose. Assuming a target saving of 250GL, the implied average cost is $1500/ML. It remains unclear, however, whether sufficient cost savings can be realized.

It seems reasonable to assume that the price demanded for sales of water allocations will be equal to the marginal value of water in agricultural production in the catchment concerned. In particular, sellers will take no account of downstream effects of changes in their water use, except to the extent that these effects are incorporated in the prices and institutional constraints they face. Using the model presented above, the likely purchase price of water may be inferred from the decline in the value of agricultural output, for the catchment concerned, in the sequential solution, incorporating constraints such as the Cap.

Since a reduction in water use of 250 GL reduces the average annual value of agricultural production by $15 million in the Murray scenario $17 million, the implied average price is between $60/ML and $68/ML for an annual allocation. This is broadly consistent with observed outcomes in the period prior to the recent drought.

Assuming a discount rate of between 5 and 10 per cent, the cost of purchasing a permanent allocation of 250GL should range between \$170 million (\$17m/0.10) and \$340 million (\$17m/0.05). This compares favourably with the

However, in 2007 and early 2008, prices for temporary transfers of water rights exceeded \$1000/ML. If such high prices persist or recur regularly, on-farm works that could yield permanent savings at a cost of \$1500/ML would be very attractive.

The severity of the drought raises the possibility that flows to the Snowy River could be made state-contingent, with lower-than-natural flows in drought years allowing increased diversions to the Murray-Darling Basin. The economic and ecological implications of such a policy will be investigated in future work.

6. Concluding Remarks

The problem of balancing demand for water use in irrigation with the maintenance, or restoration, of flows to natural environments, is increasingly important in the management of the Murray-Darling Basin. Until recently, policy attention has been focused on initiatives based on the adoption of water-saving technology. Progress under this approach has been limited.

In this paper, we have considered the implications of policies based on the purchase of water rights from irrigators. At the water prices prevailing before the recent drought, such policies appear to be a cost-effective alternative to technology-based approaches. However, it remains to be seen whether prices will return to their prior levels when, and if, inflows return to levels closer to the historical average.

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Table 1: Summary of results:

	Model	Econ ($m)	Water (GL)		EC at Adelaide		Irrigated Land (000 Ha)
			Irrigation	Environment	Average	Dry	
Current	**Sequential**	$5,217	10535	6307	482	537	1775
	Global	$5,385	10130	6557	467	519	1740
Purchase 250GL from Murrumbidgee	**Sequential**	$5,207	10285	6322	471	519	1737
	Global	$5,366	10220	6366	465	511	1718
Purchase 250GL from Murray	**Sequential**	$5,203	10410	6236	484	538	1756
	Global	$5,367	10220	6367	466	516	1720
Purchase 125GL from each	**Sequential**	$5,202	10299	6311	477	528	1747
	Global	$5,370	10236	6355	465	514	1718

Table 2: Economic Values

	Current Water Usage		**250GL from Murrumbidgee**		**250GL from Murray**		**125GL from each**	
Catchment	Sequential	Global	Sequential	Global	Prop	Global	Sequential	Global
Condamine	$215	$215	$215	$215	$215	$215	$215	$215
Border Rivers, QLD	$172	$172	$172	$172	$172	$172	$172	$172
Warrego-Paroo	$2	$2	$2	$2	$2	$2	$2	$2
Namoi	$87	$87	$87	$87	$87	$87	$87	$87
Central West	$183	$184	$183	$183	$183	$183	$183	$183
Maranoa-Balonne	$20	$20	$20	$20	$20	$20	$20	$20
Border Rivers-Gwydir	$162	$160	$162	$158	$162	$158	$162	$158
Western	$24	$24	$24	$24	$24	$24	$24	$24
Lachlan	$211	$211	$211	$211	$211	$211	$211	$211
Murrumbidgee	$735	$733	$718	$722	$735	$728	$726	$728
North East	$103	$103	$103	$103	$103	$103	$103	$103
Goulburn-Broken	$436	$425	$436	$436	$436	$436	$436	$436
Wimmera	$35	$29	$35	$28	$35	$29	$35	$29
North Central	$89	$91	$89	$92	$89	$91	$89	$91
Murray	$314	$315	$314	$314	$299	$302	$306	$305
Mallee	$493	$493	$493	$493	$493	$493	$493	$493
Lower Murray Darling	$187	$187	$187	$181	$187	$187	$187	$187
SA MDB	$1,290	$1,299	$1,295	$1,299	$1,290	$1,299	$1,292	$1,299
Adelaide	$144	$149	$144	$149	$144	$149	$144	$149
Environmental flow	$315	$485	$317	$477	$317	$477	$314	$477
Total	$5,217	$5,385	$5,207	$5,366	$5,203	$5,367	$5,202	$5,370

ble 3: Land usage (Ha ‘000).

	Current Water Usage		**Remove 250GL Murrumbidgee**		**Remove 250GL Murray**		**Remove 250GL Equally**	
Production type	Sequential	Global	Sequential	Global	Prop	Global	Sequential	Global
Citrus-High	0	0	0	0	0	0	0	0
Citrus-Low	65	67	77	74	65	67	71	71
Grapes	194	195	182	187	194	194	188	190
Stone Fruit – High	0	0	0	0	0	0	0	0
Stone Fruit - Low	40	37	40	37	40	37	40	37
Vegetables	0	0	0	0	0	0	0	0
Cotton Flexible	504	491	504	493	504	491	504	492
Cotton Fixed	9	9	9	9	9	9	9	9
Rice	578	573	541	548	559	552	550	550
Wheat	0	0	0	0	0	0	0	0
Dairy – High	331	331	331	331	331	331	331	331
Dairy - Low	53	37	53	34	53	37	53	36
Sheep/ Wheat	0	0	0	4	0	0	0	0
Dryland	985	1019	1022	1042	1003	1040	1013	1042