

# Risk & Sustainable Management Group

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### Risk, uncertainty and the Guide to the Draft Basin Plan

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## **Risk, uncertainty and the Draft Basin Plan**

For much of the 20th century, the expansion of irrigated agriculture in the Murray Darling Basin, was treated as a self-evidently desirable objective, to be pursued without excessive regard to questions of economic costs and benefits. Irrigation seemed to offer a ‘droughtproofing’ solution to the risks and uncertainties that plague dryland agriculture in Australia.

By the late 1980s, however, the capacity of the Basin to support additional diversions was close to exhaustion. Analysis at the time suggested, in the terminology of Randall (1981) that a move from an ‘expansion’ phase in which resource constraints were relatively unimportant, to a ‘mature’ phase, characterised by increasingly sharp conflicts over access to the resource, was underway. It was hoped that these conflicts could be resolved at low cost through the introduction of market mechanisms.

In reality, however, as noted by Quiggin (2008), the actual outcome was a ‘crisis’ phase, in which the possibility of a systemic collapse loomed ever larger. The only feasible response, it has become evident, is a ‘contraction’ phase, in which claims to the resource are scaled back.

Attempts to deal with the problems of the Basin through the creation of markets in water rights, minimising the role of governments, began with the communique of the 1994 Council of Australian Governments meeting and was developed more fully in the National Water Initiative announced in 2004 (Council of Australian Governments 1994, 2004). The NWI was described by the National Water Commission as ‘Australia's enduring blueprint for water reform’, through which ‘governments across Australia have agreed on actions to achieve a more cohesive national approach to the way Australia manages, measures, plans for, prices, and trades water.’

In practice, however, the NWI failed to resolve many of the key conflicts associated with the mature water economy. Some conflicts between states arose from the need to deal with different systems of water entitlements. Conflicts also emerged between states and within the Commonwealth over the extent to which trade in water entitlements should (or should not be restricted) and over the possibility of transfers of water from rural to urban use.

Most importantly, the NWI did little to resolve the conflict between demands for extractive water use and the needs of the natural environment.

However, only three years after the announcement of the Initiative, based on co-operation between Commonwealth and state governments, Prime Minister John Howard unilaterally announcing the National Plan for Water Security (Howard 2007). Although the National Plan was described as ‘accelerating the implementation of the NWI’ it amounted to an abandonment of the co-operative approach in favour of a Commonwealth takeover of water planning throughout the Murray-Darling Basin. The Plan was a poll-driven exercise produced largely by Howard himself.

The central element of Howard’s plan was the *Water Act 2007*, which called for the newly created Murray Darling Basin Authority to prepare a management plan for the Basin, based on scientifically determined sustainable diversion limits for each catchment. The hope was that this plan would end the uncertainty surrounding water allocations and water rights, and thereby lead to a resolution of the long-running disputes over water use in the Basin. The Guide to the Draft Basin Plan (hereafter, the Guide) was released by the Murray Darling Basin Authority in October 2010. However, far from producing a resolution, the Guide was a source of new conflict.

In this chapter, it is argued that many of the most intractable management problems of the Basin may be understood in terms of the interaction between uncertainty and property rights.

### **Uncertainty and property rights**

As Adamson, Mallawaarachchi and Quiggin (2009) observe<sup>1</sup>, variability and uncertainty regarding natural flows is central to the analysis of irrigated agriculture. It is useful to distinguish between predictable variation (for example, seasonal patterns) and uncertainty, and to further distinguish two kinds of uncertainty: risk and ambiguity. Risk arises when the probability distribution of a given variable is known. Ambiguity, also sometimes referred to as Knightian uncertainty (Ellsberg 1961; Knight 1921), arises when

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<sup>1</sup> This section is based on the discussion in that paper

probabilities are unknown, or when it is not possible to describe all possible outcomes in advance.

Even under stable long term climatic conditions, the probability distribution of inflows to the Murray–Darling Basin displays high levels of risk compared to other major river systems. Farmers and other water users do not respond passively to risk, but choose production strategies to manage risk. To represent this appropriately, it is necessary to analyse production under uncertainty in state-contingent terms. A general theory of state-contingent production is developed by Chambers and Quiggin (2000) and applied to the modelling of the Murray–Darling Basin by Adamson, Mallawaarachchi and Quiggin (2007).

Climate change has introduced ambiguity arising from the fact that our understanding of changes in climatic patterns remains limited, particularly at regional and catchment levels. Thus, while we know that the probability distribution of climatic variables will change from the historically observed values, we cannot yet determine the probability distribution that will be applicable in the future. When concern about the sustainability of irrigation policy in Australia first emerged in the 1980s, the possibility of climate change was not seriously considered in this or other discussions of public policy. Even as late as 1994, the water reform program agreed by the Council of Australian Governments (1994) took little account of climate change.

This is a classic case of ambiguity (Ellsberg 1961). More fundamentally, the example of climate change shows that cannot consider all the possible states of nature that might affect the outcomes of policy decisions or production choices. This problem of ‘unknown unknowns’, made famous by Rumsfeld (2002), has been discussed in detail by Grant and Quiggin (2010).

#### *Property rights under uncertainty*

Any property right may considered as a bundle of state-contingent claims. In some cases, such as those of property rights over consumption goods, the element of contingency is relatively unimportant, while in others, such as the rights associated with the purchase of an insurance policy they are critical. Rights to water for irrigation in Australia are in the latter

category. Different entitlements covering the same volume of water may involve radically different state-contingent allocations.

In theoretical discussions of property rights, it is commonly assumed that a right is specified so that, for every relevant contingency, the right is associated with a given claim. This assumption fits naturally with standard assumptions of unbounded rationality and zero transactions costs. As shown by the first and second fundamental theorems of welfare economics, any Pareto-optimal outcome can be implemented as a competitive equilibrium based on an appropriately chosen

In reality, this can never happen, because it is impossible to identify, in advance, all possible states of nature. As is shown by Grant and Quiggin (2010), a decisionmaker who proceeds as if all possible states of nature have been considered is vulnerable to adverse surprises and to manipulation by more aware participants in the policy process. Moreover, even if participants in the policy process seek to agree on a set of responses to particular contingencies, disagreement will inevitably arise *ex post* as to whether the necessary conditions have been fulfilled. This issue is discussed by Grant, Kline and Quiggin (2009).

#### *Exceptional circumstances*

One example, relevant in the current context is that of ‘exceptional circumstances’ under drought policy. The criteria adopted in 1999 stated that exceptional circumstances assistance should be available only in the event of ‘rare and severe events’ where a rare event is defined as one that occurs on average only once in every 20 to 25 years (Department of Agriculture, Fisheries and Forestry, Australia 2011).

However, the severe drought conditions that prevailed in much of Australia in the decade following the adoption of the criteria resulted in exceptional circumstances assistance being made widely available, often for periods of several years. Various responses to this outcome are possible.

One view is that the drought conditions of the early 2000s were indeed exceptional, and that the drought policy worked broadly as intended. Doubtless, those who formulated the policy would have hoped that the first occurrence of exceptional circumstances would not have been so early or so widespread, but the nature of uncertainty is that extreme events occur with positive probability.

A second view is that, as a result of climate change, droughts are likely to be more frequent and severe in future. On this view, it might be argued that it is necessary to recalibrate the definition of exceptional circumstances to the ‘new normal’.

A third view is that much of the exceptional circumstances assistance provided during the drought was not in fact justified under the stated criteria. On this view, the widespread provision of exceptional circumstances assistance represented a breakdown of the central theme of drought policy, namely that farmers should normally be expected to manage climatic variation.

The incomplete specification of terms like ‘exceptional circumstances’ has proved critical in drought policy, and has substantially affected policy responses to drought in the Basin. Even more significant, for the purposes of the Basin Plan, is the question of whether a new determination about the sustainable volume of extractions from a given catchment represents new knowledge or a change in policy. This issue, discussed in detail below is central to the way in which the risk sharing principles of the National Water Initiative are applied.

### **The National Water Initiative and the assignment of risk**

The trading system set up under the 1994 water reform process provided irrigators with a range of tools for managing farm-level risks arising from uncertain water supply, as well as a marketable asset that could be used to manage financial risk. Thus, in periods of water shortage, farmers facing cash flow problems could sell water entitlements (either temporarily or permanently) to those with a high demand for reliable water supplies.

However, by converting revocable licenses into property rights, the process reduced the capacity of governments and system managers to deal with aggregate uncertainty.

The National Water Initiative (COAG 2004) set out principles regarding the sharing of risk arising from changes in the aggregate availability of water.

Two major principles were announced. The first was that, in future, water allocations should be stated as shares of available water, rather than as specific volumes. This approach deals with fluctuations in water availability by sharing the total amount available among users in proportion to their share. It raises the question of whether it will continue to

be possible, as at present, to distinguish between high-security and low-security rights. The difficulties with this approach are discussed by Freebairn and Quiggin (2006).

The second principle, and one particularly pertinent in the present context, concerned an approach to the sharing of risk arising from changes in the aggregate availability of water. Under this principle, the risk of changes in water availability due to new knowledge about the hydrological capacity of the system will be borne by users. The risk of reduction in water availability arising from changes in public policy, such as changes in environmental policy, will be borne by the public, and water users will receive compensation for such reductions.

The principles of the National Water Initiative were elaborated in more detail in a statement issued by the 2004 COAG meeting (Council of Australian Governments 2004). The Communique specified a framework that assigns the risk of future reductions in water availability as follows:

- reductions arising from natural events such as climate change, drought or bushfire to be borne by water users;

- reductions arising from *bona fide* improvements in knowledge about water systems' capacity to sustain particular extraction levels to be borne by water users up to 2014. After 2014, water users to bear this risk for the first three per cent reduction in water allocation, the relevant State or Territory government and the Australian government would share (one-third and two-third shares respectively) the risk of reductions of between three per cent and six per cent; State/Territory and the Australian government would share equally the risk of reductions above six per cent;

- reductions arising from changes in government policy not previously provided for would be borne by governments; and

- where there is voluntary agreement between relevant State or Territory governments and key stakeholders, a different risk assignment model to the above may be implemented.

### *Risk and the environment*

The National Water Initiative principles contained a crucial ambiguity regarding the allocation of water to the environment. At the time the NWI adopted, it was clear, in general terms, that the existing allocations of water for irrigation use were environmentally unsustainable. On the other hand, there had been no detailed assessment of environmentally sustainable levels of water extraction for the catchments in the Basin. Governments were committed to undertaking such an assessment, a commitment which was formalised by the *Water Act 2007*.

The outcome of the assessments, not surprisingly, was that sustainable diversion limits in all catchments of the Basin should be set below the current Cap. The key question, in terms of the NWI was whether these assessments represented new scientific knowledge or were simply a consequence of a change in policy to require diversions to be restricted to environmentally sustainable levels.

On the first interpretation, water users were to bear the costs of reductions. This interpretation appears consistent with the NWI principles, noting in particular the reference to ‘*bona fide* improvements in knowledge about water systems’ capacity to sustain particular extraction levels’.

On the second interpretation, the cost was to be borne by governments. It could be argued that over-allocation of water rights, or, at least, reckless disregard of sustainability constraints, was conscious public policy in the decades leading up to the imposition of the Cap in 2004, and that the Cap froze existing over-allocation in place. On this view, any move towards sustainability would constitute a change in policy, and therefore the costs of any reduction in aggregate diversions should be borne by government. It is hard to see, on this reasoning, why principles of risk allocation were needed at all.

Nevertheless, in the years following the adoption of the NWI, it became apparent that any attempt to make irrigators bear the risk associated with the determination of limits on sustainable levels of extractive water use would be untenable. A number of factors contributed to this outcome.

First, the severe drought conditions that prevailed for most of the first decade of the 21st century left large numbers of farmers in severe financial difficulty. An uncompensated

reduction in their water entitlements would have forced many to leave agriculture. This was unlikely to be a politically acceptable outcome.

Second, it became apparent that any reduction in water entitlements would entail substantial political difficulties. Even voluntary transfers of entitlements between irrigators faced substantial opposition. The Victorian government, in particular, imposed limits on the volume of entitlements that could be sold from a given irrigation district.

Finally, the adoption and success of the Restoring the Balance in the Murray-Darling Basin (Wong 2008) by the Rudd Labor government demonstrated that purchase of water rights from willing sellers provided a fiscally affordable method of securing large volumes of water for environmental flows. As at 31 December 2009 the Restoring the Balance program had secured the purchase of 766 gigalitres of water entitlements worth over \$1.2 billion (Department of the Environment, Water, Heritage and the Arts 2010).

### **Risk and the Guide to the Draft Basin Plan**

The Guide was released by the Murray Darling Basin Authority in October 2010. The release of the Guide was an opportunity to reach a broad agreement on a sustainable allocation of water rights, taking account of all the prevailing uncertainties.

These hopes have so far not been fulfilled. Rather, the Guide has met with a strong, and largely hostile reaction. The document was publicly burned at meetings of farmers. The chairman of the authority, Mike Taylor resigned and has been replaced by a former minister in the NSW Labor government, presumably more attuned to the political realities.

In large measure the failure of the Guide was due to poor communications. The Guide represented, in effect, an abandonment of the principles of risk sharing set out in the National Water Initiative, and a massive transfer of wealth to irrigators. The failure of communicate this fact was reflected in the hostile response of those who stood to benefit most from the policies put forward in the Guide.

The key proposal is that the entire reduction in diversions proposed in the Plan should be treated as arising from a change in government policy. This proposal appears inconsistent with the risk principles. Proposals for reduced diversions were based on new scientific evidence about the sustainable supply capacity of the different catchments, the risk of

which was supposed to be borne by irrigators.

It could, perhaps, be argued that the unsustainability of existing policies was known at the time the NWI was agreed, and arguably since the imposition of the Cap in the early 1990s. On this view, the requirement to achieve sustainable diversion limits was itself a change in policy and that the associated risk should be borne by governments. However, given such a view, it seems hard to conceive of any risk that would be borne by irrigators, and therefore hard to understand the rationale for the elaborate principles of the NWI.

A more plausible view is that the proposals in the Guide reflect political realities that have changed substantially since 2004. On the one hand, the political feasibility of uncompensated cuts in allocations, always limited, now appears non-existent. On the other hand, the 2007 National Action Plan for Water provided (or at least promised) a Commonwealth ‘bucket of money’ totalling \$10 billion which should be more than sufficient to cover the cost of a reduction in diversions of 3-4000 GL.

#### *Risk and climate change*

The most important unresolved uncertainty in estimates of the capacity of the Basin to sustain diversions for human use relates to climate change. The estimates of Sustainable Diversion Limits used in the Guide were based primarily on historical observations over the period of 114 years since monitoring of the system began. On the assumption of a stable climate, a data set of this length would permit reasonably accurate estimates of the distribution of inflows.

However, climate is changing as a result of greenhouse gas emissions, superimposed on natural cycles such as the Indian Ocean Dipole and El Niño Southern Oscillation. The Guide (vol 2, 4.2) discusses the problems of adjusting the plan to take account of the uncertain impacts of climate change. The solution adopted, which seems reasonable in the circumstances is to defer long-term changes until the next ten-year plan, due to be developed around 2020. For the next ten years, the Guide imposes a 3 per cent reduction in entitlements relative to those that would be derived on the basis of historical data. This, it may be noted, is the only policy in the Guide that could accurately be described as a ‘cut’.

The Guide (vol 2, Sec 5.2) maintains the NWI approach under which the risk of climate change is borne primarily by water users. It remains to be seen whether this allocation will prove politically feasible.

### *Balancing priorities*

The debate over the Draft Basin Plan, already confused and confusing was derailed still further by arguments over whether, and how, social and economic considerations should be balanced against the needs of the environment. These arguments had their genesis in the decision of the Howard government to pass the *Water Act 2007* over the objections of state governments, which necessitated reliance on the Commonwealth's treaty-based power to protect Ramsar-listed wetlands. As a result, the MDBA made public statements to the that it was required to give primary priority to environmental protection.

These statements were inconsistent with the central policy decision of the Guide, namely that the volume of water to be restored to the environment should be between 3000 and 4000 GL. 3000GL was estimated to be the minimum consistent with environmental sustainability, while 4000 GL was estimated to be the maximum that would not entail unacceptable economic impacts.

Obviously, the treatment of environmental and social/economic objectives in the Guide was symmetrical, with each being treated as a binding constraint. Given this symmetry, the insistence of the MDBA, and its chairman Mike Taylor, on the claim that environmental requirements had priority under the Water Act is difficult to understand.

### *On-farm water saving*

The main remaining problem is that the great bulk of NWAP funding has been notionally allocated to finance on-farm water-saving measures. It seems highly unlikely, based on the experience of such ventures as the Food Bowl Modernization Project, that there exist sufficient cost-effective on-farm options to generate the proposed savings. Quiggin (2011) examines the Food Bowl modernization project and concludes that the cost of water released to Melbourne and the environment could be as much as \$10 000/ML, five to ten times, the likely market price.

It seems likely that the infrastructure investments proposed under the National Plan for Water Security will replicate this disastrous outcome on an even larger scale. Given a willingness to purchase water rights at a market price, there is, quite simply no need to provide infrastructure subsidies. If infrastructure investments can realise cost-effective reductions in water losses, the water saved as a result can be sold at the market price, either for environmental or irrigation use, to pay for the investment.

In equity terms, proposals to subsidise investment in irrigation infrastructure make little sense. As noted above, under a policy of repurchasing rights from willing sellers, irrigators are virtually guaranteed to be gainers. Their water assets increase in value, and, if they choose not to sell, the value of farm output is likely to increase as a result of the withdrawal of other irrigators.

Assuming that the Commonwealth is willing to bear the full cost of reductions in diversions, contrary to the risk allocation principles in NWI, it will be necessary to reorient some funding from NWAP/WFF. The central principle should be that of cost-effectiveness. Water-saving projects should be funded only if they can deliver savings at a lower cost than the market price of repurchase of water rights.

A crucial requirement for progress is to minimize the dissipation of scarce public funds on cost-ineffective infrastructure investments. Such funds could be better allocated either to the purchase of entitlements from willing sellers or to social infrastructure.

### **The way forward**

Given sufficient political will, and more skilful communications, it may still be possible to salvage a sustainable policy from the wreckage of the Guide. At this stage, the optimal political strategy is probably to defer any final plan while proceeding with an interim strategy that is, in essence a continuation of the voluntary purchase strategy of Water for the Future, with additional funding to ensure that purchase programs have a positive net economic and social effect on the communities concerned. Both the setting of specific targets for reductions in diversions and the funding of substantial investments in irrigation infrastructure should be deferred until the finalization of the Basin Plan.

Using this incremental strategy, it should be possible to restore substantial volumes of water to the environment at relatively low cost, while addressing many of the adjustment

concerns that have effectively derailed the Guide. A reconsideration of sustainable diversion limits, taking account of environmental, economic and social objectives could then be conducted.

Such a reconsideration must allow sufficient flexibility to respond to new information and unforeseen contingencies, as well as to the seasonal and annual fluctuations in inflows that have always characterized the Basin. The ultimate solution must be a system of property rights, specified in terms of state-contingent allocations to water users and the environment, along with a continued role for government as the ultimate risk manager.

Adamson, D., Mallawaarachchi, T. and Quiggin, J. (2007), 'Modelling basin level allocation of water in the Murray Darling Basin in a world of uncertainty', *Australian Journal of Agricultural and Resource Economics*, 51(3), 263–81.

Adamson, D., Mallawaarachchi, T. and Quiggin, J. (2009), 'Declining inflows and more frequent droughts in the Murray Darling Basin: climate change, impact and adaption', *Australian Journal of Agricultural and Resource Economics*, 53(3), 345–66.

Chambers, R.G. and Quiggin, J. (2000) *Uncertainty, Production, Choice and Agency: The State-Contingent Approach*, Cambridge University Press, Cambridge.

Council of Australian Governments (COAG) (1994), 'Report of the Working Group on Water Resources Policy: Communique', Canberra, February.

Council of Australian Governments (COAG) (2004), 'Intergovernmental Agreement on a National Water Initiative',  
[http://www.coag.gov.au/meetings/250604/iga\\_national\\_water\\_initiative.pdf](http://www.coag.gov.au/meetings/250604/iga_national_water_initiative.pdf)

Department of Agriculture, Fisheries and Forestry, Australia (2011), 'Exceptional circumstances criteria', [http://www.daff.gov.au/agriculture-food/drought/ec/ec\\_handbook#criteria](http://www.daff.gov.au/agriculture-food/drought/ec/ec_handbook#criteria), accessed 23/2/11.

Department of the Environment, Water, Heritage and the Arts (2010), 'Restoring the Balance in the Murray-Darling Basin',

- <http://www.environment.gov.au/water/publications/mdb/restoring-balance.html>, accessed 17 December 2010.
- Ellsberg, D. (1961), 'Risk, ambiguity and the Savage axioms', *Quarterly Journal of Economics*, 75(4), 643–69.
- Freebairn, J. and Quiggin, J. (2006), 'Water rights for variable supplies', *Australian Journal of Agricultural and Resource Economics*, 50(3), 295–312.
- Grant, S., Kline, J. and Quiggin, J. (2009), 'A Matter of Interpretation: Bargaining over Ambiguous Contracts', Risk and Sustainable Management Group Risk and Uncertainty Program Working Paper R09\_3, University of Queensland.
- Grant, S. and Quiggin, J. (2010), 'Inductive reasoning about unawareness', Risk and Sustainable Management Group Risk and Uncertainty Program Working Paper R09\_1, University of Queensland.
- Howard, J. (2007), 'A National Plan for Water Security', 25 January, Statement by the Prime Minister, Canberra.
- Knight, F. (1921) *Risk, Uncertainty and Profit*, Houghton Mifflin, New York.
- Quiggin, J. (2008), 'Managing the Murray–Darling Basin: some implications for climate change policy', *Economic Papers*, 27(2), 160–66.
- Quiggin, J., Chambers, S. and Mallawaarachchi, T. (Eds.) (2011) *Water Policy Reform: Lessons in Sustainability from the Murray Darling Basin* Edward Elgar, Cheltenham.
- Randall, A. (1981), 'Property entitlements and pricing policies for a maturing water economy', *Australian Journal of Agricultural Economics*, 25(3), 195–220.
- Rumsfeld, D. (2002), 'Transcript of press briefing, February 12', <http://www.defense.gov/transcripts/transcript.aspx?transcriptid=2636>, accessed July 12, 2010.
- Wong, Senator the Hon P. (2008), 'Water for the Future', Paper presented at Speech to the 4th Annual Australian Water Summit, Sydney Convention and Exhibition Centre, 29-30 April,



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