Risk and uncertainty in water planning

Climate change and risk

Climate change introduces profound risks and dynamic uncertainties, with the IPCC predicting more severe droughts in the mid-latitudes and the intensification of tropical monsoons. In response, more innovative and adaptive approaches to water governance are required.

During the Millennium drought, against a backdrop of escalating concerns about climate vulnerability, Australia's national science organisation, CSIRO (2008 & 2010) warned emphatically that it is prudent to plan for hotter and drier futures in South Eastern Australia.

Under the Water Act, the Basin Plan is required to assess risks and prepare for climate change. The Water Act (Commonwealth 2009) ushered in a new regime of planning for the MDB, requiring a Basin Plan based on the best available scientific and socio-economic assessments.

During the preparation of the Basin Plan, from 2009 to 2012, formalising the volume of extractive water rights to be recovered for environmental water and setting a sustainable diversion limit (SDL) became the central focus of water policy debates. However, the 2012 Basin Plan does not factor in any specific adjustment for the reductions in water availability due to climate change (Commonwealth of Australia 2012) because climate change impacts were deemed to be too uncertain

The majority of climate models predict reduced rainfall and runoff in the MDB. There are multiple lines of evidence indicating that tropical influences on weather systems are expanding southward and the southern storm tracks that historically brought cool season rains to southern Australia are also contracting pole-ward. These factors are likely to change the amount, seasonality and reliability of rainfall, with episodic large floods punctuating longer periods of drier conditions likely for southern Australia.

As this science became more conclusive, in both 2008 and 2010 Commonwealth Scientific and Industrial Research Organisation (CSIRO) cautioned that it was prudent to plan for drier futures in South Eastern Australia and reduced water availability in the MDB. This warning raises several substantive questions: What enables planning for deeply uncertain futures if past climatic and hydrological conditions are no longer suitable guides to future conditions? With stationary approaches to hydrology redundant, what flexible approaches can be used to explore uncertain futures?

Uncertainty about future climates and their hydrological and ecological impacts requires a range of adaptive responses including on-going systemic risk assessment. Systemic assessments of climate, water resources and catchment processes are required, but reliance on historic water availability and modelled averages may be mal-adaptive, particularly if step changes result in major changes to run-off and stream flow. With the uncertainty induced by climate change questions of how to better handle risk across a range of uncertainty becomes paramount. Scenario planning offers techniques that can accommodate a range of uncertainties enabling consideration of how to confer adaptive capacity. However, despite comprehensive modelling, the 2012 Basin Plan made no specific reduction in estimates of long-term water availability.

With the Basin Plan makes no specific adjustment for anticipated reductions in total water availability due to climate change raising some significant, unresolved issues. In particular, given climate forecasts, there are substantive risks that under drier climate sequences many water rights holders will have significantly reduced water allocations, as occurred in the Millennium drought. Regardless as to whether they are intended for extractive or environmental uses, future climates may render these water rights 'drier' and of less value to either irrigators or environmental holders.

Despite explicitly acknowledging the risks to water availability posed by a changing climate, the 2012 Basin Plan defines the total water resources available as unchanged by climate change with the SDLs based on averages of the historic flows and climatic conditions (Commonwealth 2012). Adopting this approach emphasises the sharing or rebalancing of water between extractive users and the environment, but generally not on how to handle reduced amounts of water that are possible as a result of a drying climate.

If extreme dry climate sequences eventuate, water available to be allocated to both extractive and environmental water rights will be severely reduced. For example, under some extreme dry scenarios, outflows from the Murray River system could be severely reduced, with some estimates of reductions in average flows of over 60%. If this eventuates, substantially less water will be available for holders of either extractive or environmental water rights, with extreme impacts on riverine ecosystems and irrigation dependent industries, as occurred during the Millennium Drought, which had reduced inflows of about 40% below average.

A drying climate puts river health and environmental water at risk because extractive rights are generally given priority over non-entitlement water, with the latter representing over 70 per cent of all 'environmental' water.

Concerns about the implications of delaying efforts to adjust to the impacts of climate change include eroding the confidence of water users and river managers in the reliability of the Basin Plan and the potentially poor targeting of public investment in infrastructure, claiming that even moderate climate change could make some irrigation or environmental infrastructure redundant, suboptimal and mal-adaptive. If drier climates sequences eventuate, further adjustments to extractive water use may be required but Governments may defer these adjustments to the environment's detriment.

Risk assessments and climate science

Uncertainty about future climates requires systemic risk assessments able to anticipate the potential for catastrophic shifts and transformations in large-scale riverine ecosystems.

With the many complex feedbacks, improved ways of assessing and incorporating the risks and uncertainties driven by climate change are needed in contemporary water planning.

Recognising the potential significance and nature of these risks, while working at the MDBA I commissioned reviews of climate science and climate risks from leading Australian scientists. These were all published by the MDBA.

The science of climate has improved due to substantive research. The climate beyond the instrumental record confirms that dramatic swings through wetter and drier phases are typical of the MDB and that the probabilities of drought or floods occurring changes dramatically due to the powerful influences of the oceans surrounding Australia (CSIRO 2010 and 2012).

Changes in temperature and precipitation will drive dynamic ecosystem responses and influence the dynamics of large-scale eco-hydrologcial processes, such as forest water use with consequential impacts on the water yield of streams. An increased frequency of forest fires, succession in vegetation communities, and fundamental changes in the processes that determine plant water use have the potential to alter water balance at the basin scale. Increased heat could result in relocation of irrigated crops.

For the MDB over the longer term, Donohue et al (2011) estimated that 94% of precipitation (P) is returned to atmosphere via evapotranspiration (ET) with 6% forming all the streams, wetlands and recharge and only about 2% flowing out the Murray mouth before irrigation development. Runoff and stream flows are sensitive to change in the driving variables of P and ET and therefor could change dramatically as a result of climate change if one or more variables change – eg ET increases, or P is reduced - especially in the 12% of the MDB that generates 66% of the stream flow because in "these high yield catchments runoff is most sensitive to changes in climatic conditions" (Donohue 2011).

To determine future surface water availability, CSIRO (2008) combined climate and hydrological models, modelling water availability under a range of climate scenarios. After the most comprehensive hydro-climatic modelling to date, CSIRO (2008 p8) concluded that despite considerable uncertainty, a pronounced drying trend was anticipated due to climate change.

Importantly, CSIRO (2008) warned that the greatest reduction would occur in the south east of the MDB where the majority of the runoff is generated. This includes the mountainous areas that generate the run-off supplying the major water storages in the southern Basin. Only 6.5% of the MDB contributes more than 50% of the runoff and because "this area is predominately forested, changes in vegetation water-use in these high water yielding catchments driven by hydro-climatic change and ecohydrological functioning change are important for long-term planning of water resources" yet there is significant uncertainty about how higher CO2, temperatures and changes in seasonality of rainfall will impact on stream flows (Donohue et al 2011). The non-stationarity of forest water use may compound predicted reductions in precipitation in these areas that generate significant runoff (Donohue et al 2011).

The South Eastern Australian Climate Initiative (SEACI) a major research program focused on the MDB's hydro-climatic systems confirmed CSIRO's (2008) findings regarding drying trends.

Two synthesis reports intended for policy audiences summarise the key findings (CSIRO 2010; CSIRO 2012). SEACI Phase 1 emphasised that the majority of climate models used by the CSIRO predict drier futures and therefore it is prudent to plan for conditions drier than the long-term historical conditions (CSIRO 2010).

The drying trend is likely to be particularly acute in the southern Basin, resulting in reduced runoff, including in the Murray headwaters where reduction in stream flow of up to 40% are possible (CSIRO 2010).

SEACI 2 concluded that with the strong probability of a significant underlying drying trend "water resource managers need to ensure their planning and management processes are robust and adaptive across a wide range of future climate and stream flow scenarios" (CSIRO 2012).

Importantly, the causes of declining cool season rainfall were identified. SEACI found multiple lines of evidence that the tropics are expanding southward, exerting drying influences on the climates of South-eastern Australia (CSIRO 2012).

Long-term reductions in cool season rainfall and reduced stream flows are associated with changes in the global atmospheric circulation via an expansion of the tropics, with the Hadley Cell circulation expanding at the rate of 0.5° of latitude (approximately 50 km) per decade (CSIRO 2012). Combined with the pole-ward contraction of the southern storm tracks that historically brought cool season rains, these changes in global circulation patterns provide an explanation for the drying trend, indicating a future climate characterised by below average autumn, winter and spring rainfall (CSIRO 2012).

As a result the traditional dam 'filling seasons' for Southern Australia is unlikely to be as reliable in the future as it has been in the past. Reductions in rainfall account for most of the reduction in runoff with rainfall declines amplified fourfold in runoff reductions but changes to the seasonality of rain also contributes to reduced runoff (CSIRO 2012).

In summary, climate research consistently indicates that a reduction in water availability in the Basin in the future is highly likely and that ecosystem processes at the catchment scale contribute further uncertainty.

Averages and models

All numbers about water, rivers and climate, whether simple statistics or sophisticated models are abstractions representations like a map, a painting or an essay.

In describing climatic conditions reference is made to the 'average' with deviations from it, frequently called 'anomalies' implying the abnormality of the non-average conditions, but conditions coincidently conforming to the "average" are unusual due to fundamental drivers of Australia's climate with it dramatic wet or dry phases. Australia's highly variable rivers are functionally different, depending on the wet or dry climate phases which alter them in almost every respect, including flood frequencies) but their average flows are a result of combining all flow data, including episodic floods and drought flows sequences. Reconstructions of the hydro-climate beyond the instrumental records demonstrate that recurrent droughts punctuated by floods typify longer-term patterns, while conditions that imitate the statistical averages are rare.

Averages as statistical representation disguise significant spatial and temporal variations. "Averaged" water can never satisfy thirst or irrigate crops the way "wet" water can. A mission to locate blue lines on maps delineating rivers like the Darling, Paroo or Warrego may find floods kilometers wide or vast, dry clay pans.

Long-term average water availability and stream flow averages are drawn statistically by combining large floods flows with lower flows during extended droughts divided by the number of years and are therefore rarely reflective of actual conditions. Yet the MDBA decided that the Sustainable Diversion Limit (SDL) would be based on "long term averages" as the unit of measure (Commonwealth of Australia 2012), although the Water Act was not prescriptive, providing the MDBA with options for the use of formulas, averages or measured units (Commonwealth 2009).

Consideration of how to use formulas that incorporate and reflect the deeply variable climate is worthy of further research. Given the inherent variability of Australia's climate, it is important that our plans, policies, attitudes and understanding are based on accepting and working with the inherent climate variation that drives Australian hydrological systems.

This construction of normal using averages and the embedding of these into water plans in a country characterised by high variability exemplifies the social constructions of normal climate. In Australia's variable climate "all averages are a lie" distorting the fluctuating phases of water scarcity and abundance that drive "boom-bust" ecosystems. While irrigation development has been successful at providing more reliable water supplies, the use of averages for water planning may reflect a culturally engrained yearning for a sense of a 'normality' that seeks to deny or overcome the highly variable nature of Australian climatic and riverine systems. Ideas of 'normal' conditions embedded in Australia's water policy may be driven by the perceived unreliability and scarcity of water relative to the wet country origins of early English colonists that resulted in a prevailing view that this dry, disappointing country demanded drought-proofing.

The building of vast irrigation schemes resulted in politically powerful constituencies and institutions that have grown to dominate water policy. It is therefore feasible that, the difficulty of more fully incorporating climate change impacts into the MDB reforms may be the legacy of ingrained cultural perspectives, literally and metaphorically concreted into the physical and cultural landscape, in the form of large dams and irrigation schemes and the institutions and professions that have evolved to operate them, with embedded rationalities that emphasise reliable water supply and a yearning for a more reliable and 'normal' climate.

Assigning and minimising risk

There are a number of plausible reasons why estimates of future water availability were not reduced to allow for the anticipated impacts of climate change in the Basin Plan.

Firstly there is the uncertainty inherent in climate science predictions, especially in comparison with the 'facts' of the hydrological and climate records. In determining future water availability greater trust was placed in the 'facts' established by hydrological science, then climatological science, reflecting that in environmental controversies uncertainty arises from incoherence amongst competing scientific understandings based on different disciplines, because each has embedded values, established institutional linkages and normative frameworks.

Secondly, the government may have decided that it did not want water reforms embroiled in the politically hostile climate debate occurring. Embroiling water reforms in this political debate would have inflamed the already heated debates, but largely separate about water and climate change. Tony Abbot, who led Australia's Conservative Opposition, was a vocal opponent of climate change policies during the Plan's development during the period 2009 to 2012.

Finally, another potential reason is an attempt to minimise adverse reactions to the triggering of the risk assignment clauses (48,49 and 50) in the National Water Initiative (COAG 2004) that states that water access entitlement holders bear the risk of climate change. The National Water Initiative's Clause 48 assigns climate risks to entitlement holders who*: "bear the risks of any reduction or less reliable water allocation, under their water access entitlements, arising from reductions to the consumptive pool as a result of:*

1. *(i) seasonal or long-term changes in climate; and*
2. *(ii) periodic natural events such as bushfires and drought."*

In contrast, clause 50 assigns Governments the responsibility for bearing the *"risks of any reduction … arising from changes in government policy (for example, new environmental objectives). In such cases, governments may recover this water in accordance with the principles for assessing the most efficient and cost effective measures for water recovery"* (COAG 2004).

In accordance with the NWI principles of risk assignment, if reductions in consumptive water mandated through the Basin Plan were based on climate change then water entitlement holders would bear the risk. By not triggering clause 48, the costs of planned reductions were borne by taxpayers. This would have been more acceptable to water entitlement holders, the majority of whom were irrigators.

Irrigators publicly demonstrated their displeasure about the reforms with staged managed protests, burning the Guide to Plan in 2010 to maximise media coverage of their opposition. It may be that these groups did not want the NWI climate risk clause (48) activated because it clearly assigns risks from climate change to water entitlement holders. This risk was neutralised by minimising any reductions in water availability attributed to climate change, demonstrating that policy typically evolves through a succession of minor incremental change that minimise disturbance to establish regimes.

As reforms unfold, choices are made about which 'facts' are legitimised and which science is trusted and used as the basis of policy and which is discounted as too uncertain. Due to their history and institutional linkages certain disciplines are more relied upon and trusted while others are considered less relevant. The MDBA relied more on hydrology then climatology with instrumental measurements of climatic conditions and stream flows providing greater certainty then predicted climate futures with their intrinsic uncertainty.

With the end of stationarity the past may be an inadequate guide to the future. Planning for hotter and drier conditions is both judicious and pragmatic because overall, there is consistent scientific advice about the high likelihoods of a significant drying trend in the MDB (CSIRO 2008, 2010, 2012).

Meeting the aspiration of future water resource plans to be based on the best available science requires concurrent commitments to investing in robust science in a dynamically changing climate and ensuring that key agencies have capabilities for science policy-integration.

To support anticipatory policy in the face of the potential scale and magnitude of climate change increased investment in climate and ecological sciences are needed. However, the MDB reforms also demonstrate the complex and dynamic interplay between science and policy and the importance of capacity for dealing with complex change processes involving risk, change and uncertainty.

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