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Policy review of water reform in the Murray–Darling Basin, Australia: the "do's" and "do'nots"*

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The water reforms undertaken in the Murray–Darling Basin, Australia since 2007 have been viewed as a model for other countries seeking to respond to water insecurity. Here, a policy review is provided of this water reform and whether it delivers on key environmental objectives in the *2007 Water Act* (the Act). The evaluation includes a review of the 2012 Basin Plan, a key instrument of the Act, and complementary policies associated with the acquisition of water entitlements for the environment via direct (reverse tenders) and indirect (infrastructure subsidies) means. Using the objects of the Act as a benchmark, an evaluation is provided of the following: (i) planned reductions in irrigation water extractions in the 2012 Basin Plan; (ii) risks associated with the 2018 amendments to the Basin Plan that, collectively, allow for an increase in irrigation water extractions of some 22 per cent, relative to the sustainable diversion limits specified in the 2012 Basin Plan; (iii) Basin-scale environmental outcomes achieved, as of the end of 2018; and (iv) economic effects of direct and indirect methods of acquiring water for the environment. Findings from the review generate the "Do's" and "Do Nots" of water reform for Australia, and possibly other countries, when managing the trade-offs between water for irrigation and the environment.

Key words: Basin Plan, irrigation, regulatory capture, stream flows, trade-offs.

1. Introduction

Many arid and semi-arid locations, mostly located in the mid-latitudes, have high levels of water extractions relative to the available freshwater supplies (Smakhtin *et al*. 2004). In such places, levels of water extractions that exceed 50 per cent of the mean annual river run-off can impose high external costs in terms of ecosystem losses (Grafton *et al*. 2013), as well adversely affecting water quality. Regions where surface water extractions regularly exceed 50 per cent or more of the mean annual run-off include the following: much of the Sahel; parts

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of the western United States and north-west Mexico; most of the Middle East; northern China; north-western India; and the Murray–Darling Basin (MDB), Australia. In some of these locations (north-west Mexico, north-west India and northern China), high surface water extractions are accompanied by groundwater extractions that exceed the annual recharge rate and the groundwater contribution to environmental stream flow (Gleeson *et al*. 2016).

A typical response to water scarcity is to invest in water infrastructure and store it when or where it is relatively abundant, and to transport water from storages and relatively water-rich catchments to locations where there is a high water demand. In many places, much of the capital cost of water infrastructure is not fully incorporated in the price charged to users (Grafton *et al*. 2015). Indeed, several countries, including Australia, provide on-farm and off-farm subsidies to irrigators for water infrastructure (Perry *et al*. 2017) in the belief that this will increase irrigation efficiency, the ratio of beneficial water consumption to the water extracted or applied (Jensen 2007; Perry *et al*. 2009; Grafton *et al*. 2018). It is claimed that an increase in irrigation efficiency allows for the reallocation of water to the environment.

Given irrigation accounts for about 70 per cent of total water extractions globally, and a similar proportion in the MDB, policies that affect irrigators' water use can have a major impact on stream flows (Grafton *et al*. 2018). In the case of the MDB, that encompasses more one million square kilometres (see Figure 1), water infrastructure subsidies have been promoted because, it is claimed, that the acquisition of water entitlements by the Australian Government, supposed to equal half of the calculated reduction in on-farm water losses, will increase stream flows within the Basin (House of Representatives Standing Committee on Agriculture and Water Resources 2017).

Here, the policies implemented in the MDB intended to increase stream flows by reducing surface water extractions by irrigators are evaluated and compared to alternatives. The focus is on the policy insights that arise from the following: (i) the implementation of the Australian Government's multibillion subsidies for on- and off-farm irrigation infrastructure; and (ii) the targets and actions associated with water reform initiated with the *Water Act (2007)* (Commonwealth of Australia 2007). There are several studies that examine different components of water reform (Crase and O'Keefe 2009; Wheeler 2014; Young 2014; Grafton 2017a; Grafton and Wheeler 2018), the MDB environment (Williams 2017), the cost-effectiveness of water reform (Grafton 2010), among others. Here, the contribution is to provide an overall and the most up-to-date assessment of the objectives, implementation and outcomes of MDB water reform from 2007 onwards, with policy insights.

The paper is structured as follows: Section 2 describes the 2007 water reforms that have set the agenda and the processes of water governance for more than a decade; Section 3 provides an overview of the 2012 Basin Plan (Murray–Darling Basin Authority (MDBA) 2012) and its 2018 amendments in relation to its effects on stream and end-of-system flows; Section 4 assesses the net effect of the policies to date on net stream flows, highlights the lack of

Figure 1 The Northern and Southern Murray–Darling Basin. Source: https://www.mdba.gov.au/sites/default/files/pubs/Murray-Darling_Basin_Boundary.pdf. [Colour figure can be viewed at wileyonlinelibrary.com]

cost-effectiveness of water infrastructure subsidies, and reviews the socio-economic impacts of the complementary policies intended to deliver on the 2012 Basin Plan; and Section 5 gives insights from the MDB in terms of the "Do's" and the "Do Nots" of water reform. The paper concludes with a summary of the principal causes of inadequacies of water reform in the MDB and two key policy insights to deliver both cost-effective and environmentally effective water reform.

2. 2007 MDB water reform agenda

Water reform has been an ongoing process in the MDB in response to crises in relation to water quality and water availability for more than a century (Connell and Grafton 2011). Prior to 2007, one of the most significant reforms of the last few decades included the National Framework for Water Reform (Council of Australian Governments (COAG), 1994) developed by the COAG (state and territory governments and also the Australian Government). This was conceived as a 10-year water reform process that led to a cap on overall surface water extractions in 1995 and a process towards the unbundling of water rights from land.

In response to the perceived slow pace of water reform (Lee and Ancev 2009), an unfolding water scarcity crisis in terms of low water storages, stream flows and water quality (Jones *et al.* 2002), exacerbated by the Millennium Drought that began at the start of the 2000s, COAG agreed in 2004 to a National Water Initiative (COAG 2004) to hasten the reform process. COAG agreed to the following: (i) the liberalisation of water markets (Connell and Grafton 2011); (ii) the reallocation of up to 500 billion litres (GL) of water for increased environmental flows (Grafton and Hussey 2007); (iii) the establishment of a National Water Commission (NWC) to support the water reform process; and (iv) transparent and statutory-based water planning. A worsening drought, ongoing concerns about the pace of reform by some states and historical low inflows led to 'A National Plan on Water Security' (2007 National Plan) announced by Prime Minister Howard in January 2007 (Howard 2007; Connell and Grafton 2008).

The 2007 National Plan included 10 key actions over 10 years with total funding of $10 billion for 'addressing once and for all water overallocation in the Murray–Darling'. In addition to direct buyback of water entitlements from willing sellers, the National Plan was to be achieved by three key actions that included the following: (i) a nationwide investment in Australia's irrigation infrastructure to line and pipe major delivery channels; (ii) a nationwide programme to improve on-farm irrigation technology and metering; and (iii) the sharing of water savings on a 50:50 basis between irrigators and the Australian Government to improve water security and increase stream flows for environmental purposes.

Critical to the delivery of the Australian Government's 2007 National Plan were a new set of governance arrangements that included a revised cap on both surface and groundwater use in the MDB. The new governance arrangements gave greater powers to the Australian Government over water from the states and created the MDBA, a government regulatory authority that was charged with setting the sustainable diversion limits (SDLs) and implementing the Basin Plan. A federal election and a change in government in December 2007 resulted in an increase in funding and a renaming of the 2007 National Plan as the 'Water for the Future' in 2008 (Crase and O'Keefe 2009). The 2008 Water for the Future Plan included funding over a 10-year period of up to $3.1 billion to directly buy water entitlements[1] from willing sellers through a series of reverse auctions and $5.8 billion in subsidies for water infrastructure (Grafton 2010) intended to increase irrigation efficiency.

[1] A water entitlement is a state water right that provides for an ongoing entitlement under state law to a share of a consumptive pool in a water resource plan. Depending on the characteristics of the water entitlement, the water resource plan and water availability, a volumetric allocation of water is provided to water entitlements. These water allocations are the physical volumes of water that are allowed to be extracted by irrigators. The water entitlements held by the Australian Government have the same characteristics (and water allocations) as identical water entitlements held by irrigators (see Grafton and Horne 2014).

The 2008 Water for the Future Plan was intended to complement the *Water Act (2007)* and to provide the financial compensation to irrigators that would allow the Australian Government to acquire water entitlements and, thereby, deliver on two key environmental objectives in the Act. Namely: 3d(i) that requires "...the return to environmentally sustainable levels of extraction for water resources that are overallocated or overused"; and 3d(ii) "to protect, restore and provide for the ecological values and ecosystem services of the Murray-Darling Basin.

The *Water Act (2007)* is being implemented through the 2012 Basin Plan (MDBA 2012) and by actions and funding specified in the 2008 Water for the Future Plan. The Basin Plan was legislated in November 2012 following a multiyear process of negotiations between the Australian Government that set the SDLs for both surface water and groundwater by catchment, and the state governments of New South Wales, Queensland and South Australia, and also the Australian Capital Territory (ACT), that have responsibility for implementing water resource plans to give effect to the SDLs. In essence, the SDLs represent, based on long-term averages, the permitted maximum annual water extractions.

3. 2012 Basin Plan and sustainable diversion limits

The Basin Plan that was enacted in November 2012 is supposed to give effect to the objects in the *Water Act (2007)*. Thus, its success or failure needs to be evaluated as to whether it has delivered on the key objects of the Act. A core component of the 2012 Basin Plan was the setting of the SDLs, planned to come into effect on 1 July 2019, relative to baseline diversion limits (BDLs) or what was estimated to be diverted (surface and groundwater).

The 2012 Basin Plan specified, on a Basin scale, a reduction in the average annual level of surface water extractions of 2,750 GL/year, or about 25 per cent reduction relative to long-term historical diversions (MDBA 2011). For groundwater, the BDL for groundwater is defined at 2,386 GL/year in the 2012 Basin Plan, but the SDL is 3,334 GL/year. Thus, the permitted level of groundwater extractions in the Basin Plan is 40 per cent higher than extractions in 2009. It is also 1,733 GL/year more than the SDL recommended by the MDBA only 2 years previously in its *Guide to the Proposed Basin Plan* (MDBA 2010a,b), herewith referred to as the '2010 Guide'.

Due to public concerns by the South Australian Government that threatened a constitutional challenge to the Basin Plan, the 2,750 GL/year reduction in surface water extractions increased by the equivalent of an additional 450 GL/year (Wheeler 2014). This supplemental volume is expected to be delivered by 1 July 2024. This additional 450 GL/year volume of water is treated differently to the planned 2,750 GL/year reduction in diversions and also has a separate and supplemental budget of $1.77 billion. The additional 450 GL/year are supposed to be delivered through 'Efficiency Measures', both on- and off-farm, while ensuring either neutral or improved socio-economic outcomes (Productivity Commission 2018).

3.1 Calculation of surface water SDLs in the 2012 Basin Plan

There is no universally accepted linear relationship between flows and environmental outcomes (Crase *et al*. 2012) and a contested literature exists (see Wentworth Group 2010, 2012) as to what should be the adequate or sufficient volume of water in terms of increased stream flows to achieve the key objects of the *Water ACT (2007)*. The most comprehensive and publicly available assessment of the volumes required to deliver on the *Water Act (2007)* was released by the MDBA in the 2010 Guide that was subject to international scientific peer review. Nevertheless, the 2010 Guide triggered protest following its release (Miller 2011) that led to the resignation of both the Chair and the CEO of the MDBA.

Given the protests following the release of the 2010 Guide, there was a political response to secure a compromise across competing interests so as to ensure passage of the 2012 Basin Plan (Wheeler 2014; Grafton 2017a; Bell 2018a,b). Thus, the SDLs in the 2012 Basin Plan, unlike those estimated in the 2010 Guide that were intended to meet the key goals of the *Water Act 2007*, were devised as a 'fix' for a political problem for the Australian Government and, in particular, for the then Federal Water Minister, Tony Burke.[2] Corroborating evidence for this conclusion is supported by written testimony before the Murray–Darling Basin Royal Commission (MDBRC) in June 2018 by David Bell, the Director of Environmental Water Planning at the MDBA from March 2009 to November 2017. He observed 'In my opinion The Guide to the Proposed Basin Plan (Vol 2) is still the best estimate of (Environmental Sustainable Level of Take) and the science underpinning it (Bell 2018a, p. 4)' and 'My view is that (using the short-hand) approximately 4,000–4,500 GL is the minimum additional water that the Basin's water-dependent ecosystems require' (Bell 2018a, p. 10). In his signed witness statement to the MDBRC, he further stated: 'Around that time the general consensus became that the SDL had to be a number beginning with '2' (two). Around that same time Tony Burke took over as Minister, Dr Rhondda Dickson as CEO and Mr Craig Knowles as Chair of the Board. My view is that they stopped pursuing higher numbers, the likes of which were included in the Guide. Instead, those people who were responsible for landing the plan didn't think they could land it with numbers that high, hence the reason for the shift to a number beginning with two'. (Bell 2018b, p. 6). Thus, the determination of 2,750 GL/year in the 2012 Basin Plan appears to be inconsistent with the *Water Act (2007)* where primacy is given to

[2] To ensure effective, transparent and democratic processes, the justification for political decisions should not be represented as a scientific justification when this is not the case (Bell 2018a,b). Notably, and as reported by Williams (2017), a failure to understand how the SDLs were calculated in the 2012 Basin Plan led the Australian Senate inquiry into the 'Management of the Murray–Darling Basin' in March 2013 to recommend to the MDBA to provide a 'concise and non-technical explanation of the hydrological modelling and assumptions used to develop the 2750 GL/year return of surface water to the environment, to be made publicly available'. (Senate Rural and Regional Affairs and Transport References Committee 2013).

environmental goals and, at a minimum, does not appear to have been calculated using the best available science.

To further understand how the MDBA's recommended SDLs changed between 2010 and 2011, it is instructive to compare the recommended SDLs in the 2010 Guide and the 2012 Basin Plan. The 2010 Guide estimated that 3,856 GL/year was the minimum mean annual increase (adjusted downwards by a 20 per cent confidence limit to 3,000 GL/year as the lowest recommended reduction in surface water Basin-wide diversions) in the volume of surface water for environmental purposes that was needed to deliver on the *Water Act (2007)*. Increases in stream flows were to be achieved by establishing a SDL that would represent the BDL less than the desired increase in stream flows and then calculated as an average annual permitted level of surface water extractions. This 3,856 GL/year decrease in surface water extractions in the 2010 Guide, according to the Murray–Darling Basin Authority (MDBA) (2010b), only had a low likelihood (or high uncertainty) of success in delivering healthy rivers across the Basin. To deliver a high likelihood (or low uncertainty) of success, the 2010 Guide included a second and higher estimated mean annual reduction of surface water extractions equal to 6,983 GL/year (adjusted upwards to 7,600 GL/year by a 10 per cent confidence limit as the highest recommended reduction in surface water diversions).

By contrast to what was proposed in the 2010 Guide, the actual average net increases in stream flows in the Basin under the amended Basin Plan in 2018 (see Section 3.3) are some 2,100 GL/year. This volume is only 54 per cent of the minimum mean annual increase estimated in the 2010 Guide and which, at the time, the MDBA stated had only a low likelihood of achieving the key objects of the *Water Act (2007)*. It is just 30 per cent of the minimum mean annual increase in the 2010 Guide which had a high likelihood of achieving the key objects of the *Water Act (2007)*.

In the Basin Plan that was legislated in November 2012, the Basin-wide surface water SDL of 10,873 GL/year is virtually identical to the average long-term historical watercourse diversions in the Basin of 10,942 GL/year (Murray–Darling Basin Authority (MDBA) 2010a, p. 51). Yet the 2010 Guide (Murray–Darling Basin Authority (MDBA) 2010a, p. 132), when evaluating the effects of a 3,000 GL/year scenario reduction in surface water diversions, estimated that the expected watercourse diversions would be 7,945 GL/year in its 3,000 GL/year scenario. The key point here is that, in the 2 years from 2010 to 2012, the definition of what represents a SDL changed in a way that substantially increased the permitted levels of surface watercourse extractions. This is because, in the legislated Basin Plan, farm interceptions, or water captured and stored by farmers, of 2,384 GL/year are included in the BDL and which, therefore, increases the SDL by the equivalent volume. By contrast, if the SDLs had been calculated as they were in the 2010 Guide, but not in the 2012 Basin Plan, farm interceptions would not be included as part of watercourse diversions. The change in how BDL and SDLs were calculated has had a large impact on 2012 Basin Plan SDLs. For instance, if the BDLs and SDLs had been

calculated as per the method in the 2010 Guide, then Basin-scale surface water SDLs would be 8,489 GL/year, or 22 per cent less than the enacted SDLs of 10,873 GL/year in the 2012 Basin Plan.

3.2 Adequacy of SDL in relation to *Water Act (2007)*

Notwithstanding how and why the MDBA reduced its recommendations about the volumes of water needed to deliver on the environmental objectives of the *Water Act (2007)*, high levels of watercourse diversions are universally recognised as a key contributor to environmental degradation in the Basin (Davies *et al*. 2010, 2012; Grafton *et al*. 2013; Williams 2017). Indeed, a consensus around the need to reduce surface water diversions for irrigation was a key reason why the *Water Act (2007)* was legislated. Moreover, according to the MDBRC, the *Water Act (2007)* '. . .requires environmental considerations to be paramount, and that economic and social outcomes are irrelevant to the determination of an environmentally sustainable level of take, and hence to the setting of a Basin-wide SDL' (MDBRC 2018, p. 5).

The adequacy or otherwise of the SDLs in the 2012 Basin Plan can only be judged by evaluating the long-term Basin-scale environmental benefits of reduced surface water extractions. Some Basin-scale improvements in the environment should already be expected given that full implementation of SDLs is on 1 July 2019. Moreover, following the 2012 Basin Plan amendments that passed on as of 8 May 2018, all of the volumes of water that will be acquired for increased stream flows have already been acquired. Further, the current volumes of water held by the Australian Government for environmental purposes are only marginally greater, or some 200 GL/year larger, than what they were in 2014–2015. In other words, the Australian Government has, for the past four years, a volume of water entitlements similar to what it will ever have in the amended (as of 8 May 2018) 2012 Basin Plan.

The Australian State of the Environment (SOE) Report that was published in March 2017 (Argent 2017) includes a specific report on Inland Water. As noted in Grafton and Wheeler (2018), its findings on the MDB are for the period since 2011 and provide an assessment grade of very poor and deteriorating for the 'state and trends of inland water ecological processes and key species populations'. The SOE Report further observes that 'Longer-term downwards trends in flows seen in nearly 50 per cent of stations, with no change in trends evident since 2011' (Argent 2017, p. 36). In November 2017, the Wentworth Group provided similar conclusions to the SOE Report (Wentworth Group 2017). It observed that there is no evidence, to date, to demonstrate Basin-wide improvements or that long-term deterioration in key river conditions has stopped.

Of equal concern is that recent evidence, rather than finding improvements in key aspects of the Basin environment, shows that the state of the Coorong, Lower Lakes and Murray Mouth is rapidly deteriorating. Of the 40 species of waterbirds used to provide a Whole of Icon Site Score in the Coorong, 23

species were below their long-term (2000–2015) median abundances (Paton *et al*. 2017). While a single year's abundance is not indicative of a trend, the Basin Plan has, so far, failed to deliver on the key targets in the Condition Monitoring Plan for this icon site. More generally, Kingsford *et al*. (2017, p. 9) identify, based on large temporal and spatial scale analyses, that '. . .there is good evidence that declines in waterbird communities were primarily driven by diversions of water upstream' and '. . .declines in waterbird communities coincided with reductions in river flows, despite no changes in rainfall. . .' within the MDB.

An additional concern is recent dredging to keep the Murray Mouth open recommenced in January 2015 as a result of low flows. Yet one of the goals of the 2012 Basin Plan was to ensure there would be no dredging in 95 per cent of years. Pointedly, the simple correlation between South Australian environmental flow releases and barrage flows is only $r = 0.06$ (Grafton and Wheeler 2018). This lack of correlation suggests that the volumes of water entitlements held by the Australian Government are inadequate to ensure sufficient flows at the Murray Mouth, as required in the 2012 Basin Plan.

3.3 2018 Amendments to the Basin Plan

The 2012 Basin Plan allowed for amendments that would increase the SDLs if 'supply projects' (such as building or improving river or water management structures and changes to river operating rules) and/or 'Environmental Works and Measures' could be identified that would be equivalent, in terms of environmental outcomes, to a reduction in surface water extractions while reducing the socio-economic impact of recovering water for the environment in the Basin. To facilitate these supply projects, the Australian Government has agreed to redistribute funds originally allocated for the direct purchase of water entitlements in the 2008 Water for the Future Plan, if so recommended by the MDBA (Department of Sustainability, Environment, Water, Population and Communities 2012, p. 2).

On 8 May 2018, the Australian Senate did not disallow (i.e., it approved) two motions or amendments that, together, increase SDLs in the MDB by, on average, 605 GL/year, as per the SDL Adjustment Mechanism (with an increase in SDLs in the northern MDB by 70 GL/year as per the Murray-Darling Basin Authority (MDBA) 2017a Northern Basin Review).[3] In effect,

[3] The Basin Plan was amended on 14 November 2017 to incorporate a recommendation from the MDBA in its Northern Basin Review to increase the surface water SDL in the Northern Basin from, on average, 320 GL/year to 370 GL/year (Productivity Commission 2018). This amendment was disallowed following a vote in the Australian Parliament on 14 February 2018. Following a political agreement led by the Australian Labor Party's Shadow Minister for Environment and Water, Tony Burke (and who was also the Water Minister when the Basin Plan was enacted in November 2012) and the Federal Agriculture and Water Minister, David Littleproud, the SDL Adjustment Mechanism increased the SDL in the Basin by 605 GL/year (including a 70 GL/year increase in the Northern Basin) compared to the volume in the 2012 Basin Plan, and was also approved.

these amendments mean that reductions in surface water irrigation extractions will be approximately 2,100 GL/year rather 2,750 GL/year, as per the 2012 Basin Plan. This represents a 22 per cent diminishment of the planned reduction water recovery in relation to surface water that was legislated in the Basin Plan in November 2012.[4]

3.4 Environmental risks and the amendments to the 2012 Basin Plan

The SDL Adjustment Mechanism supply projects affect when and where water will be directed and delivered, and, thus, an assessment of their equivalence, or otherwise, to increase stream flows requires a comprehensive physical water accounting of the MDB that includes the water extracted, the water transpired and evaporated, and the nonconsumed water that returns as surface run-off or groundwater seepage. Without such accounting, it is simply not possible to know how supply projects will deliver, or not deliver, on the flows necessary to ensure the key objects of the *Water Act (2007)*. Nor has there been any publicly released cost–benefit analysis of the merits of the SDL Adjustment Mechanism. Further, according to the Wentworth Group (2018), 25 of these supply projects (that collectively represent up to 436 GL/year volumes notionally equivalent to increased stream flows) fail to satisfy 12 minimal conditions that are needed before the projects can demonstrate that they will support the delivery of the environmental objectives of the *Water Act (2007)*.

The critical importance of water accounting in the Basin is further highlighted by the MDBA's own Independent Review Panel that was commissioned in response to accusations of water theft in the northern MDB (ABC 2017). This Review Panel observed: 'Implementing SDLs requires effective water accounting. Achieving compliance with SDLs, protecting environmental flows and control of illegal take all require comprehensive water accounting supported by measurements, calculations, estimates and system modelling' MDBA (2017a, p. 127). Yet, despite more than a decade since the *Water Act (2007)* was enacted, and more than 5 years since the passage of the 2012 Basin Plan, such water accounting still does not exist despite the expenditure of many billions of dollars to increase stream flows for environmental purposes.

The MDBA's modelling of the SDLs, among other evidence, has been used to justify a 70 GL/year increase in surface water SDLs in the northern Basin. Instead of acquiring water entitlements for the environment, the MDBA and the relevant states will implement a series of 'toolkit' measures, but that have no statutory force (Murray–Darling Basin Royal Commission 2018, p. 4).

[4] The 2012 Basin Plan specifies that should only be a 5 per cent reduction (543 GL/year) in SDLs associated with adjustments. To both satisfy this 5 per cent rule and to reduce SDLs by 605 GL/year, rather than the lower 543 GL/year, a minimum of 62 GL of additional water savings through efficiency projects (such as include upgrading irrigation systems and lining water delivery channels) is planned as part of the SDL Adjustment Mechanism.

Disturbingly, according to the MDBA's own Independent Review Panel, between 49 and 75 per cent of surface water diversions in the northern Basin (Murray-Darling Basin Authority (MDBA) 2017a, p. 17) are not currently metered. Further, the MDBA is not able to adequately model flows in the northern Basin and, itself in a 2018 report, observed that 'When flows fall below about 400–500 million litres (ML)/day at Bourke, there is a divergence between the observed and Baseline model flow exceedance curves, indicating the model has difficulty predicting these flows' (MDBA 2018, p. 4). Importantly for delivery of the key objects of the *Water Act 2007*, this same 2018 MDBA report also notes, with respect to the Barwon–Darling, that: 'The maximum dry spell between (low flow) events is approximately doubled in length for many of the flow requirements described when comparing observed flows to the without development flow regime. In extreme cases, the maximum dry spell is >10 times longer which is likely to place ecosystems under severe stress. Periods of low or no flow have increased for gauges downstream of Bourke post 2000 as compared to pre-2000' (Murray-Darling Basin Authority (MDBA) 2018, p. 5).

Another important risk is the extent of floodplain harvesting for which there are very few credible measures, and which is widely practised in the northern Basin. Without measurements of floodplain harvesting, including evaporative losses from storages of harvested water, not only do the water balances of the MDB remain incomplete, but any policy of water allocation and recovery, including the two 8 May 2018 amendments to the 2012 Basin Plan, cannot be properly assessed.

The SDL Adjustment Mechanism has been justified by the need to balance environmental with socio-economic objectives, but the risks they impose to the environmental objectives, and which is given paramount importance in the *Water Act (2007)*, may mean the amendments have not been developed in proper accordance with the Act (Murray–Darling Basin Royal Commission 2018, p. 4). Moreover, according to Wheeler *et al.* (2018, p. 2) in a submission to the Productivity Commission in 2018, the socio-economic evidence used by the MDBA to preclude additional direct purchases of water entitlements for the environment and to use supply projects and 'toolkit' measures cannot be justified on economic grounds.

In sum, a failure to comprehensively measure flows, inadequate flow modelling, low levels of water metering in the northern Basin and the inability to satisfy minimum criteria for many of the supply projects in the southern Basin mean that, combined, the SDL Adjustment Mechanism (Murray-Darling Basin Authority (MDBA) 2017b) and the Northern Basin Review amendments to the 2012 Basin Plan impose substantial additional risks in terms of the delivery of the key environmental objectives of the 2012 Basin Plan.

4. Net change in environmental flows, cost-effectiveness and economic outcomes

As of the end of 2018, there is sufficient evidence to indicate that the environmental objectives of the *Water Act (2007)*, at a Basin scale, are not

being delivered. As discussed in Section 3, there are real concerns as to whether the Basin-wide SDL in the 2012 Basin Plan is set at too high a level given the lack of progress, to date, of Basin-scale environmental outcomes. Here, we evaluate the effects of water recovery in the MDB.

4.1 Net change in Basin environmental flows

There are additional reasons why the 2012 Basin Plan is failing to deliver on the key environmental objectives of the *Water Act (2007)*. Two key factors include the following: (i) 'double-counting' of a proportion of the water entitlements held by the Australian Government for environmental purposes; and (ii) a failure to measure and comprehensively account for return flows, or the nonconsumed fraction of water that returns back to the hydrological system from the fields of irrigators in the form of surface run-off and groundwater seepage.

To appreciate the effect of double-counting, on average, surveyed irrigators in the southern MDB use just 72 per cent of the water they receive (Wheeler *et al*. 2014, table A1 p. 80 for years 2006–2007 to 2010–2011). Thus, the water entitlements held by the Australian Government, and represented by their long-term average annual yield, overstate the net environmental benefit because, on average, some 28 per cent of the water allocated to these entitlements remained undiverted, held in storage and potentially available for stream flows.

The other critical issue is in relation to water recovery, and the volumes of water available for the environment relate to 'recoverable return flows' (Perry *et al*. 2009). These are surface flows to streams and rivers and to aquifers that irrigators view as water 'losses' in that they do not contribute to growing crops. Notwithstanding salinity and water quality issues associated with some return flows, such 'losses' are volumes of water that are, typically, reused downstream and/or provide increased stream flows or recharge aquifers, have value and should be accounted for in what happens to stream flows as a result of water recovery.

In the absence of any comprehensive and publicly available data on return flows, Williams and Grafton (2018) specify the following: (i) the average utilisation (80 and 100 per cent) of the water entitlements by irrigators that were provided to the Australian Government for the subsidies received and (ii) the ratio of recoverable return flows as a proportion of total water savings from water infrastructure upgrades (20–50 per cent). Using published farm-level data on water balances for irrigation in Australia (Roth *et al*. 2013; Silburn *et al*. 2013) and internationally (Evans and Zaitchik 2008), and assuming irrigators provide 50 per cent of the water 'savings' in the form of water entitlements to the Australian Government, they estimate the net change in environmental flows for the $3.5 billion already spent on irrigation infrastructure (on- and off-farm). In their worst-case scenario, irrigation efficiency upgrades, assuming an 80 per cent utilisation rate, instead of

increasing net stream flows as claimed by the Australian Government by some 700 GL/year, may have reduced environmental flows by 140 GL/year. In their best-case scenario, Williams and Grafton find net environmental flows have increased by only 280 GL/year, notwithstanding the benefits of inundation of targeted wetlands from the release of water by the Australian Government for environmental purposes (Stewardson and Guarino 2018).

What is the actual effect on either environmental outcomes or Basin stream flows to date, or likely to be in the future, cannot be established unless there is a comprehensive and independent audit of expenditures and outcomes to date. Such an audit, based on primary data collection (such as remote sensing), should provide a full before-and-after water accounting of the effects of the 2012 Basin Plan and the 2008 Water for the Future Package.

4.2 Cost-effectiveness of the 2008 water for the future package

Grafton and Wheeler (2018, Table 1) detail the average cost in ML of water acquired for the environment through direct purchase of water entitlements and from water infrastructure subsidies. According to the Australian Government data, the cost of direct purchases of acquiring water is some $2,000/ML, while the cost from water infrastructure subsidies is almost $5,000/ML or 2.5 time more, on average, for the equivalent volume of water acquired for the environment. Using the Williams and Grafton (2018) best-case scenario in terms of the reduction in recoverable return flows, the average cost to increase environmental flows from infrastructure subsidies is calculated to be some $12,500/ML ($3.5 billion divided by 280,000 ML rather than 700,000 ML) or more than six times greater than the average cost of direct purchases. The much greater costs of acquiring water for the environment from infrastructure subsidies are consistent with predictions made in 2007 before any expenditures on water recovery (Grafton 2007).[5]

To put these average water entitlement acquisition costs into perspective, there were sufficient funds in 2010 to have already delivered reductions in surface water diversions of 3,200 GL/year and also substantial direct financial support for Basin communities (Wentworth Group 2010). Indeed, on the basis of the MDBA's own assumptions, the 2,750 GL/year reduction in surface water diversions could already have been achieved for approximately $500 million less (assuming average cost of water recovery of $2,000/ML) than what has already been spent on water recovery (some $6 billion) if all expenditures had been on direct purchases

[5] Grafton (2007, p. 4) noted that 'The key point is that expenditure of public money for public benefits, as announced in the water plan, should not be constrained to particular investments or infrastructure, but should be allocated to those approaches that generate the highest marginal water savings'.

of water entitlements from willing sellers. Equally as important, from the perspective of the delivery of the key objects of the *Water Act (2007)*, is that Australian Government water infrastructure subsidies have reduced recoverable return flows and this must be accounted in the determination of SDLs.

4.3 Economic impacts of environmental water acquisitions

The much greater cost-effectiveness of environmental water acquisitions associated with direct purchases of water entitlements relative to subsidies for water infrastructure is detailed in Section 4.2. A justification claimed by the Australian Government as to why it has chosen to spend more than twice as much money, in total, on water infrastructure subsidies is that such subsidies impose lower costs of adjustment on irrigation communities and support broader socio-economic objectives.

Evidence that supports the claim that water infrastructure subsidies provide greater community benefits than the direct purchase of water entitlements is based on MDBA and other rural community commissioned consultancy reports. According to Wheeler *et al.* (2018), many of these consultant studies overestimate the negative local impacts of the direct purchases of water entitlements by failing to account for farmer adaptation, the difference between farm production and farm net revenue, and also do not adequately measure the positive aspects of direct purchases on communities. Further, four recent reports either written or commissioned by the MDBA suffer from the false assumption that irrigator revenues or profits are proportional to water extractions. This assumption does not accord with the facts in the MDB (Kirby *et al.* 2014).

By contrast to consultants' reports, the peer-reviewed academic literature shows that: (i) the direct purchase of water entitlements appears to have a net positive impact on Basin communities because much of the funds from the Australian Government paid to irrigators remains in their regions or is reinvested locally by irrigators (Wheeler and Cheesman 2013; Wheeler *et al.* 2014). Indeed, the direct purchase of water entitlements has been shown to increase the gross domestic product in the Basin (Wittwer and Dixon 2013); and (ii) equivalent socio-economic benefits to communities can be accomplished, relative to water infrastructure subsidies, at a quarter to a third of the cost through the provision of additional services such as health care and education (Wittwer and Dixon 2013).

It is worth highlighting, regardless of the requirements of the *Water Act (2007)*, a partial reallocation of water from irrigation to the environment can also be justified on economic evidence. Indeed, Grafton *et al.* (2011) find that a water reallocation that increased stream flows and reduced irrigation diversions over the period 2001–2009 in the MDB would have increased economic benefits, in present value terms, between half a billion and over three billion U.S. dollars. Hatton MacDonald *et al.* (2011) found the total

willingness to pay to improve key aspects of the Coorong at some A$13 billion.[6] Using robust scientific and economic methods, Akter *et al*. (2014) also show the marginal benefits from increasing stream flows in a key riparian site in the Basin are comparable to the marginal value of water for irrigation. Further, Chu *et al*. (2018) find that, if resilience of the Basin environment is an objective, then water infrastructure investments are an inferior method of achieving this goal compared to limits on overall extractions. Finally, Wheeler (2014) provides an overview that the quantified benefits of water reform outweigh the costs by up to three times.

5. The "Do's" and "Do Nots" of water reform

5.1 The "Do Nots" of water reform

The most likely explanation as to why the Australian Government is prepared to spend billions of dollars on water infrastructure upgrades (on-farm and off-farm) for very little, if any, apparent public benefit is a network of informal alliances between politicians, bureaucracies and irrigator-sector organisations. These alliances helped broker the political compromises to negotiate a Basin Plan that, in 2012, received bipartisan support and, crucially, the support of key state governments. Such alliances are not unique to Australia (Huppert 2013), but (as discussed in Sections 4.2 and 4.3) have resulted in water infrastructure subsidies that have generated much lower increases (if any) in stream flows than was possible, and for a much greater cost per ML, than if water entitlements had exclusively been acquired by direct purchase from willing sellers. This finding is consistent with observations by Marshall and Alexandra (2016), in relation to the MDB, that some irrigator-sector organisations have collaborated to prevent reforms perceived to be contrary to the interests of irrigators, and to maximise irrigation-sector benefits, while also noting irrigator preferences for water recovery can differ to what some of their lobbies argue for in public (Loch *et al*. 2014).

Irrigator lobbyists-government influences affect transparency. This may explain why: (i) in 2004 all governments in the Basin (with exception of the Queensland Government) formally agreed in the National Water Initiative to water accounting (COAG 2004, p. 17) '. . .to ensure that adequate measurement, monitoring and reporting systems are in place in all jurisdictions, to support public and investor confidence in the amount of water being traded, extracted for consumptive use, and recovered and managed for environmental and other public benefit outcomes' yet this goal is still not achieved; and (ii) the Australian Government asked the FAO to remove sections of a 2017

[6] Hatton MacDonald *et al*. (2011, p. 389) found 'Total willingness to pay to increase the frequency of waterbird breeding from every 10 years to every 4 years, to increase native fish populations from 30 to 50 per cent of original levels, to increase the area of healthy native vegetation from 50 to 70 per cent and to improve waterbird habitat quality in the Coorong is equal to A$13 billion using a discount rate of 5 per cent'.

FAO report (Perry *et al*. 2017) that were critical of Australian Government subsidies for irrigation water infrastructure in the MDB (Perry 2018).

Revelations of alleged water thefts in the northern Basin, and subsequent investigations, support the view that, at least in one state, the water policy processes were 'captured'. Dr James Horne PSM, the former Deputy Secretary of the Australian Department of Sustainability, Environment, Water, Population and Communities between 2007 and 2011, and who was responsible for the department's portfolio of water responsibility, is insightful on this issue. Horne (2017) observes: 'For more than a decade, federal and state governments have expressed their commitment to good compliance, the enforcement of water plans, and the importance of strongly supporting fairness to all water users, including the environment. Yet this seems to have been accompanied by a persistent lack of political commitment, and a culture where water theft and compliance with licence conditions have been optional'.

Corroboration of the governance failures and apparent 'regulatory capture' (Stigler 1971) are highlighted in relation to water compliance in New South Wales by Ken Matthews AO who was the founding Chair and Chief Executive of the NWC and previously the Secretary of two Australian Government departments. Matthews states: 'My interviews with members of staff involved in water management suggested a culture of tolerance for expedient work practices in the interests of "outcomes," but at the expense of due and proper process. I saw examples of possible failures to confront unethical behaviour. I heard public servants clearly deficient in their understanding of the Westminster conventions. I observed a group culture diverging from the best traditions of Australian public administration' (Matthews 2017, p. 6).

Identifying governance failures and regulatory capture of public servants by the industry they are regulating (Stigler 1971, p. 3) is easier to identify than to prevent. The MDB water reform process provides insights as to what should not be done and what should be done. The most important "Do Not" is to avoid decision-making from 'on high' that claims to deliver an outcome when the best available evidence shows otherwise. While the 'truth will out' when false claims eventually collide with facts (The Economist, 2018, 19 May), this may come too late to respond to problems that need to be actively and adaptively managed, rather than ignored or dismissed. Unfortunately, highly centralised and short-term decision-making that ignores robust evidence and leads to poor implementation is not unique to water reform. The lessons learnt elsewhere, and in other sectors, suggest there are ways to mitigate against regulatory capture and decision-making that favours particular interests at the expense of a broader public interest.[7]

[7] In July 2017, as Deputy Prime Minister and Minister for Agriculture and Water Resources, the Hon. Barnaby Joyce MP, who was also then Leader of the National Party, was recorded as saying: 'We've taken water and put it back into agriculture so we can look after you and make sure we don't have the greenies running the show basically sending you out the back door. That was a hard ask but we did it'. (Joyce 2017).

5.2 The "Do's" of water reform

First, and foremost, decision-making must be exposed and be transparent. Importantly, decision-makers should be held accountable, and an independent review, audit and recommendation process is required to ensure decisions and actions deliver on reform objectives. The water reform challenge is to make such processes robust to interference and to ensure that auditors have sufficient powers to hold decision-makers accountable for their actions.

Multiple processes have been developed in democracies to provide regulatory oversight. Unfortunately, even when such processes exist, such as with an Ombudsman Office that reports on regulatory failures, or protection for 'whistleblowers', this may be insufficient. For instance, the relevant water department in New South Wales appeared to have consistently ignored recommended actions by the NSW Ombudsman Reports in relation to reporting and compliance of water extractions by irrigators (Ombudsman NSW 2017). In the Australian parliamentary process, senior public servants can be asked questions about their decisions in the Australian Senate Estimates twice per year. While the Senate Estimates process is helpful, the ability to make known poor decision-making is highly dependent on what is already known. Thus, the less transparent is the decision-making, the lower is the ability of such a process to ask relevant and probing questions that are necessary to ensure adequate oversight.

When there is sufficient evidence to believe that information is being withheld, and it is a matter of great public interest, a Royal Commission may be instituted which, within its terms of reference, has the power to summon witnesses to appear before it and require them to answer questions under oath or affirmation. Further, a Royal Commission can also summon witnesses to produce documents or evidence under oath. Failure to comply with a summons issued by a Royal Commission may result in an individual receiving a fine, or possibly imprisonment. Notwithstanding these perceived powers, the Australian Government, through a High Court challenge, has successfully prevented its public servants from appearing before the MDBRC announced by the South Australian Labor Government in November 2017. Further, the South Australian Liberal Government, that formed government in March 2018, has refused to either extend the MDBRC delivery date or to grant it any additional funds.[8] These two actions, together, give the appearance of collusion

[8] On 13 June 2018, it was announced that the Australian Government and the MDBA was seeking a high court injunction to prevent their staff giving evidence to the South Australian Royal Commission into the Murray–Darling (Davies 2018). In response, the Counsel assisting the MDBRC, Richard Beasley, on 18 June 2018 stated publicly in relation to the Australian Government's decision that 'It is part of the Government's job, not a hindrance to it, for it to provide an explanation of decisions it has made' (Briggs and Puddy 2018). Middleton (2018) quotes Independent South Australian Senator Rex Patrick who in relation to the Australian Government's decision to prevent its public servants from appearing at the Royal Commission: 'This decision to fetter the commissioner on purely legal grounds in circumstances where they say they have nothing to hide is conflicted and unsupportable,...' and '... what is the federal government afraid of? What is the federal government trying to hide here?'

between the Liberal South Australian and the Liberal/National Australian Government to diminish the transparency around water decision-making in the MDB (Middleton 2018).

Good governance requires transparency and also regular and independent reviews and audits. These reviews must allow for the use of coercive powers to acquire evidence and, critically, provide a means to avoid or mitigate against regulatory capture while ensuring that decision-makers are fully accountable for their decisions. Unsurprisingly, any Royal Commission requires broad-based public support before it will be instituted because vested interests and decision-makers, who may be held to account when coercive powers are used to make public wrongdoing or mistakes transparent, oppose such inquiries. This is true even when such inquiries are subsequently shown to be in the public interest, provide evidence of alleged criminal and/or unethical and unprofessional behaviour and show regulators 'asleep at the wheel' in terms of imposing punishment when misconduct is revealed (Royal Commission into Misconduct in the Banking, Superannuation and Financial Services Industry 2018; The Guardian 2018).

Given the very high threshold of establishing a Royal Commission or a method of inquiry with coercive powers, a complementary measure to promote transparency and accountability is to establish an independent reporting body. In the context of water, Australia had such a body from 2004 to 2014 in the form of a NWC that had, among its responsibilities, the reporting on water reform by signatory governments to the 2004 National Water Initiative. Following the 2013 election of the Liberal-National Australian Government, funding for the NWC ended. The NWC was subsequently abolished in an Act of Parliament in 2015 with its reporting responsibilities shared between various government departments, including the Productivity Commission. This decision was justified by the claim that the NWC was no longer needed given the substantial progress already made with water reform (Baldwin 2015). The NWC's reporting functions, unlike that of the MDBA, were independent of regulatory or implementation responsibilities. Independence and separation of reporting, regulatory and implementation responsibilities are critical to avoid conflicts of interest and less than transparent reporting.

The failures of the water reform process in the MDB to deliver on key objectives of the *Water Act (2007)* and the funded objectives of a Prime Minister[9] are largely attributable to the lack of independent and transparent

[9] In January 2007, Prime Minister John Howard stated: 'As water becomes more scarce and subject to greater demands, it is imperative that we can accurately measure and monitor the resource and its use. This applies equally at the national and Basin scales, as well as for individual farms.' (Howard 2007). Yet, a decade later, the ABC Four Corners program (aired in July 2017) featured accusations by irrigators that along the Barwon River on-farm levees have been constructed to trap stream flows so as to illegally increase the offtake of those who constructed the levees. The accusation is that, at least in part, the levees were constructed with funds that came from the Australian Government (either directly or indirectly via the relevant state).

reporting and public scrutiny of key decisions, expenditures and actions. This neglect has not happened by chance, but would seem to have been a deliberate strategy to avoid the scrutiny and transparency that may have identified weaknesses in water reform such as the billions spent on water-use efficiency have not generated the claimed environmental benefits and have not been cost-effective. This transparency and oversight challenge was identified by the NWC in its final report where it stated: 'The Commission strongly supports the continuation of independent oversight and the public accountability of governments and government-owned enterprises beyond the life of the Commission' (NWC 2014, p. 6).

Unfortunately, a lack of transparency and public scrutiny remains an ongoing problem in the MDB: the Victorian Ombudsman (2018, pp. 61–62), in relation to an investigation of financial impropriety of Australia's largest rural water corporation (state-owned Goulburn Murray Water), highlighted '...the need for more oversight and support to Boards to ensure they are accountable, responsible and cognisant of current public sector standards and community expectations'. Further, the Victorian Ombudsman found that both the Managing Director and Chair had '...demonstrated a lack of restraint and accountability in spending public funds'. Notably, the Victorian Ombudsman had previously identified similar problems in relation to procurement and financial probity at Goulburn Murray Water in a 2011 report (Victorian Ombudsman 2011).

Despite billions of dollars of expenditures, there has been no publicly available cost–benefit analysis of water recovery. The importance of transparency is highlighted by the accusations of water theft in the northern Basin that were identified in a television programme in July 2017 (ABC 2017). As a direct result of this television programme, there were seven compliance reviews (Productivity Commission p. 251) and subsequent reform of water metering and compliance processes by the State of New South Wales. These investigations would not have happened if there had not been a public revelation of alleged water theft on national television.

Water reform, and its sequencing (Young 2014), like any public policy process, requires comprehensive and regular review that is independent from the decision-makers held accountable for their actions. The Productivity Commission (2018, p. 305) has also identified this as a serious issue such that 'If Basin Governments do not commit to and progress structural reform, the credibility of the MDBA (as both regulator and agent of governance) will be extremely compromised, and the likelihood of successful implementation significantly diminished'. Thus, the Productivity Commission has recommended that the MDBA be restructured into the following: (i) a MDBA Corporation that is the agent of Basin Governments; and (ii) an Independent Basin Plan Regulator that holds governments to account in the delivery of the Basin Plan.

The key point is that the less frequent are reviews, the more they are embedded in existing government departments, and the more reviews can be

influenced by persons who have interests in avoiding adverse findings, the less valuable will be the reporting and auditing. Importantly, the primary goal of such effective reporting and auditing should not be to impose sanctions on past behaviour, but rather to identify weaknesses or failures as quickly as possible and to provide advice and recommendations as to how deficiencies can be mitigated or remedied, and in a transparent way. Such a 'document, review, and improve' process is necessary in any complex policy process, be it in water or in other sectors, if the reform is to not be diverted or redirected away from the public interest and the stated goals of reform.

Beyond the need for transparency is a requirement there be an active and ongoing process that allows for consideration of risks and that engages all stakeholders in evaluation of options (Wyrwoll *et al.* 2018). Multiple participatory processes exist and have been successfully applied to improve water governance (Daniell 2012) in different contexts. The Risks and Options Assessment (ROAD) process developed by the Food, Energy, Environment and Water (FE2W) Network (FE2W Network 2017) combines both causal risk approaches to identify threats, triggers, risks and consequences with ways to manage them through consideration of possible options via participatory processes (Grafton *et al.* 2016). The process is flexible, is applicable across different institutional contexts and can implement methods already developed in relation to evaluating the resilience of water management in the MDB (Chu *et al.* 2018).

In sum, in addition to comprehensive, regular and transparent review, water reform in the MDB highlights the need for risk-based decision-making that includes, in a meaningful way, participatory decision-making based on the best available science and economics. Indeed, there needs to be much more support for long-term, scientific and economic research in the water space, rather than reliance on short-term, perhaps conflicted in their overall objectives, consultancies (Wheeler 2014). This approach will not necessarily ensure water reform is successful or that it achieves all of its goals, especially in the context of 'wicked' water problems (Grafton 2017b). But a rigorous, evidence-based and risk-focused framework that is comprehensively applied is able to identify weaknesses and mistakes, and helps to correct for errors.

6. Conclusions

Since 2007 billions of dollars have been spent on water reform in the Murray–Darling Basin with much of it directed to acquiring water entitlements via direct purchase and water infrastructure subsidies. Yet, despite these expenditures and enabling legislation with the *Water Act (2007)* that has resulted in SDLs on a catchment and Basin scale to be implemented on 1 July 2019, little has been achieved to date in terms of Basin-scale environmental improvements.

Lack of environmental improvements at a Basin scale, as of the end of 2018, is attributed to the following: (i) regulatory capture in relation to water

recovery; (ii) a failure to respond and adapt to peer-reviewed scientific evidence of reform failures; (iii) insufficient consideration of Basin-scale risks; (iv) inadequate participatory processes to engage with all relevant stakeholders, not just some irrigators; (v) failures in monitoring and compliance in the northern Basin; and, perhaps most importantly, (vi) a critical absence of comprehensive Basin-scale water accounting and an auditing process, based on primary data, to identify effects of reform on water flows, including return flows. The end result is that water reform in the Basin will fail in its primary purpose to deliver on key objectives of the *Water Act (2007)* unless there is fundamental change to the policy processes.

In closing, it is worth highlighting two key insights from the failures of water reform in the Murray–Darling Basin. These are as follows: (i) the need for independent and transparent review and audit processes of key decisions, to which the 2018 Australian Government is opposed, coupled with a reform process that allows actions to be modified and updated based on new information and evidence and (ii) a decision-making process that includes explicit consideration of natural and anthropogenic risks, and also incorporates a genuine participatory process with all relevant stakeholders, not just irrigators. Neither of these actions guarantee the success of water reform, be it in Australia or elsewhere, but are necessary for the delivery of cost-effective water reform that is in the public interest.

References

ABC Four Corners (2017). Pumped: who's benefitting from the billions spent on the Murray-Darling? Available from URL: http://www.abc.net.au/4corners/pumped/8727826 [accessed 9 Apr 2018].

Akter, D., Grafton, R.Q. and Merritt, S.W. (2014). Integrated hydro-ecological and economic modeling of environmental flows: Macquarie Marshes, Australia, *Agricultural Water Management* 145, 98–109.

Argent, R.M. (2017). Australia: state of the environment 2016. Inland water. Rep., Dep. Environ. Energy, Canberra. Available from URL: https://soe.environment.gov.au/theme/inland-water [accessed 7 Apr 2018].

Baldwin, B. (2015). Strong water reform continues to progress. Media release 13 May 2015. Available from URL: https://www.environment.gov.au/minister/baldwin/2015/mr20150513.html [accessed 4 Jun 2018].

Bell, D. (2018a). Submission from David Bell to the Murray–Darling Basin Royal Commission, 12 June 2018. Available from URL: https://www.mdbrc.sa.gov.au/sites/g/files/net3846/f/mdbrc-submission-david-bell-nsw.pdf?v=1529042308 [accessed 18 Jun 2018].

Bell, D. (2018b). Witness Statement 14 June 2018 to the Murray–Darling Basin Royal Commission. Available from URL: https://www.mdbrc.sa.gov.au/sites/g/files/net3846/f/david_bell_final_witness_statement.pdf?v=1529025595 [accessed 10 Oct 2018].

Briggs, C. and Puddy, R. (2018). Murray-Darling royal commission rejects federal attempt to block bureaucrats from giving evidence. ABC News. Available from URL: http://www.abc.net.au/news/2018-06-18/royal-commission-rejects-federal-attempt-to-block-bureaucrats/9880434?WT.ac=statenews_nsw [accessed 18 Jun 2018].

Chu, N.L., Grafton, R.Q. and Stewardson, M. (2018). Resilience, decision-making and environmental water releases, *Earth's Future* 6, 777–792.

Commonwealth of Australia (2007). Water Act 2007 [Online]. Commonwealth of Australia, Canberra, ACT. Available from URL: https://www.comlaw.gov.au/Series/C2007A00137 [accessed 29 May 2018].

Connell, D. and Grafton, R.Q. (2008). Planning for water security in the Murray–Darling Basin, *Public Policy* 3, 67–86.

Connell, D. and Grafton, R.Q. (2011). Water reform in the Murray–Darling Basin, *Water Resources Research* 47, 12.

Council of Australian Governments (COAG) (1994a). *Council of Australian Governments' Communique, 25 February 1994, Attachment A – Water Resource Policy*. Council of Australian Governments (COAG), Canberra.

Council of Australian Governments (COAG) (2004). *Intergovernmental Agreement on a National Water Initiative*. Council of Australian Governments (COAG), Canberra.

Crase, L. and O'Keefe, S. (2009). The paradox of national water savings: a critique of "water for the future", *Agenda* 16, 45–60.

Crase, L., O'Keefe, S. and Dollery, B. (2012). Presumptions of linearity and faith in the power of centralised decision-making: two challenges to the efficient management of environmental water in Australia, *Australian Journal of Agricultural and Resource Economics* 56, 426–437.

Daniell, K.A. (2012). *Co-Engineering and Participatory Water Management*. Cambridge University Press, Cambridge.

Davies, A. (2018). High court asked to block SA royal commission from calling witnesses, *The Guardian Australia*. Available from URL: https://www.theguardian.com/australia-news/2018/jun/13/high-court-asked-to-block-sa-royal-commission-from-calling-witnesses [accessed 18 Jun 2018].

Davies, P.E., Harris, J.H., Hillman, T.J. and Walker, K.F. (2010). The Sustainable Rivers Audit: assessing river ecosystem health in the Murray–Darling Basin, Australia, *Marine and Freshwater Research* 61, 764–777.

Davies, P.E., Stewardson, M.J., Hillman, T.J., Roberts, J.R. and Thoms, M.C. (2012). Sustainable Rivers Audit 2: The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010). Vols. 1 and 2. Murray–Darling Basin Commission, Canberra, ACT. Available from URL: https://www.mdba.gov.au/publications/mdba-reports/sustainable-rivers-audit-2 [accessed 29 May 2018].

Department of Sustainability, Environment, Water, Population and Communities (2012). Sustainable Diversion Limit (SDL) adjustment mechanism. Available from URL: file:///C:/Users/quent/Downloads/factsheet-sdl-adjustment-mechanism.pdf [accessed 29 May 2018].

Economist (2018, 19 May). From paddles to puddles Australia's biggest river is running dry, despite plans to save it. Available from URL: https://www.economist.com/asia/2018/05/19/australias-biggest-river-is-running-dry-despite-plans-to-save-it [accessed 4 Jun 2018].

Evans, J.P. and Zaitchik, B.F. (2008). Modeling the large-scale water balance impact of different irrigation systems, *Water Resources Research* 44, W08448.

Food Energy Environment and Water (FE2W) Network (2017). Guide to the Risks and Options Assessment for Decision-Making (ROAD) process version 0.2. Available from URL: https://drive.google.com/file/d/0B6c7dZDoD8WejRHblZMNUNrR2s/view [accessed 4 Jun 2018].

Gleeson, T., Befus, K.M., Jasechko, S., Luijendijk, E. and Cardenas, M.B. (2016). The global volume and distribution of modern groundwater, *Nature Geoscience* 9, 161–167.

Grafton, R.Q. (2007). An economic evaluation of the national plan for water security. In Policy Briefs 3: Dry Water, Crawford School of Economics and Government, the Australian National University. Available from URL: http://www.crawford.anu.edu.au/pdf/policy_briefs/dry_water.pdf [accessed 2 Jun 2018].

Grafton, R.Q. (2010). How to increase the cost-effectiveness of water reform and environmental flows in the Murray–Darling Basin, *Agenda* 17, 17–40.

Grafton, R.Q. (2017a). Editorial: water reform and planning in the Murray–Darling Basin, Australia, *Water Economics and Policy* 3, 1702001.

Grafton, R.Q. (2017b). Responding to the 'wicked problem' of water insecurity, *Water Resources Management* 31, 3,023–3,041.

Grafton, R.Q. and Horne, J. (2014). Water markets in the Murray–Darling Basin, *Agricultural Water Management* 145, 61–71.

Grafton, R.Q. and Hussey, K. (2007). Buying back the living Murray: at what price?, *Australasian Journal of Environmental Management* 14, 74–81.

Grafton, R.Q. and Wheeler, S. (2018). Economics of water recovery in the Murray–Darling Basin, Australia, *Annual Review of Resource Economics* 10, 487–510.

Grafton, R.Q. and Williams, J. (2018). Delivering on the Key Objectives of the Water Act (2007). Joint submission to the Murray–Darling Basin Royal Commission.

Grafton, R.Q., Chu, H.L., Stewardson, M. and Kompas, T. (2011). Optimal dynamic water allocation: irrigation extractions and environmental trade-offs in the Murray River, Australia, *Water Resources Research*. Available from URL: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2010WR009786%4010.1002/%28ISSN%291944-7973.MDBASIN1 [accessed 2 Jun 2018].

Grafton, R.Q., Pittock, J., Davis, R., Williams, J., Fu, G., Warburton, M., Udall, B., McKenzie, R., Yu, X., Che, N., Connell, D., Jiang, Q., Kompas, T., Lynch, A., Norris, R., Possingham, H. and Quiggin, J. (2013). Global insights into water resources, climate change and governance, *Nature Climate Change* 3, 315–321.

Grafton, R.Q., Chu, L. and Kompas, T. (2015). Optimal water tariffs and supply augmentation for cost-of-service regulated water utilities, *Utilities Policy* 34, 54–62.

Grafton, R.Q., McLindin, M., Hussey, K., Wyrwoll, P., Wichelns, D., Ringler, C., Garrick, D., Pittock, J., Wheeler, S., Orr, S., Matthews, N., Ansink, E., Aureli, A., Connell, D., De Stefano, L., Dowsley, K., Farolfi, S., Hall, J., Katic, P., Lankford, B., Leckie, H., McCartney, M., Pohlner, H., Ratna, N., Rubarenzya, M.H., Narayan Sai Raman, S., Wheeler, K. and Williams, J. (2016). Responding to global challenges in food, energy, environment and water: risks and options assessment for decision-making, *Asia & the Pacific Policy Studies* 3, 275–299.

Grafton, R.Q., Williams, J., Perry, C.J., Molle, F., Ringler, C., Steduto, P., Udall, B., Wheeler, S.A., Wang, Y., Garrick, D. and Allen, S. (2018). The paradox of irrigation efficiency, *Science* 361, 748–750.

Guardian (2018, 19 April). Banking royal commission: all you need to know – so far. Available from URL: https://www.theguardian.com/australia-news/2018/apr/20/banking-royal-commission-all-you-need-to-know-so-far [accessed 4 Jun 2018].

Hatton MacDonald, D., Morrison, M.D., Rose, J.M. and Boyle, K.J. (2011). Valuing a multistate river: the case of the River Murray, *Australian Journal of Agricultural and Resource Economics* 55, 374–392.

Horne, J. (2017). A low water mark for the Murray–Darling Basin: political commitment to the Basin Plan is long overdue. *Policy Forum*. Available from URL: https://www.policyforum.net/low-water-mark-murray-darling-basin/ [accessed 9 Apr 2018].

House of Representatives Standing Committee on Agriculture and Water Resources (2017). Making Every Drop Count: Inquiry into water use efficiency in Australian Agriculture. Available from URL: https://www.aph.gov.au/wue [accessed 8 Apr 2018].

Howard, J. (2007). A national plan for water security. Available from URL: http://nailsma.org.au/sites/default/files/publications/national_plan_water_security2007.pdf [accessed 9 Apr 2018].

Huppert, W. (2013). Viewpoint—Rent-seeking in agricultural water management: an intentionally neglected core dimension?, *Water Alternatives* 6, 265–275.

Jensen, M.E. (2007). Beyond irrigation efficiency, *Irrigation Science* 25, 233–245.

Jones, G., Hillman, T., Kingsford, R., McMahon, T., Walker, K., Arthington, A., Whittington, J. and Cartwright, S. (2002). Independent report of the expert reference panel on environmental flows and water quality requirements for the river Murray system. Prepared for the River Murray Project Board. Canberra, ACT.

Joyce, B. (2017). Calls to dump Barnaby Joyce over tape recording of him saying he took over water to stop 'Greenies'. Available from URL: https://www.news.com.au/technology/environment/calls-to-dump-barnaby-joyce-over-tape-recording-of-him-saying-he-took-over-water-to-stop-greenies/news-story/130d00f466ebe4bddce409172d6c3645 [accessed 4 Jun 2017].

Kingsford, R.T., Bino, G. and Porter, J.L. (2017). Continental impacts of water development on waterbirds, contrasting two Australian river basins: global implications for sustainable water use, *Global Change Biology* 1–12. https://doi.org/10.1111/gcb.13743

Kirby, J.M., Bark, R., Connor, J., Qureshi, M.E. and Keyworth, S. (2014). Sustainable irrigation: how did irrigated agriculture in Australia's Murray–Darling Basin adapt in the Millennium Drought?, *Agricultural Water Management* 145, 154–162.

Lee, L. and Ancev, T. (2009). Two decades of Murray–Darling water management: a river of funding, a trickle of achievement', *Agenda* 16, 5–23.

Loch, A., Wheeler, S., Boxall, P., Hatton-Macdonald, D., Adamowicz, W.L. and Bjornlund, H. (2014). Irrigator preferences for water recovery budget expenditure in the Murray–Darling Basin, Australia, *Land Use Policy* 36, 396–404.

Marshall, G.R. and Alexandra, J. (2016). Institutional path dependence and environmental water recovery in Australia's Murray–Darling Basin, *Water Alternatives* 9, 679–703.

Matthews, K. (2017). Interim Report of the Independent investigation into NSW water management and compliance. Available from URL: https://www.industry.nsw.gov.au/__data/assets/pdf_file/0016/120193/Matthews-interim-report-nsw-water.pdf [accessed 9 Apr 2018].

Middleton, K. (2018). Federal government 'colludes' to nobble Walker inquiry. Available from URL: https://www.thesaturdaypaper.com.au/news/politics/2018/08/18/federal-government-colludes-nobble-walker-inquiry/15345144006726 [accessed 18 Dec 2018].

Miller, C. (2011). The future of the Basin: thriving or dying communities?, in Connell, D. and Grafton, R.Q. (eds), *Basin Futures: Water Reform in the Murray–Darling Basin*. ANU E Press, Canberra, ACT, pp. 193.

Murray-Darling Basin Authority (MDBA) (2017a). *The Murray–Darling Basin Water Compliance Review Containing reports by the Murray–Darling Basin Authority and the Independent Review Panel*. Murray-Darling Basin Authority, Canberra, ACT.

Murray-Darling Basin Authority (MDBA) (2017b). *Sustainable Diversion Limit Adjustment Mechanism: Draft Determination Report 2*. Murray-Darling Basin Authority, Canberra, ACT.

Murray-Darling Basin Authority (MDBA) (2018). Ecological needs of low flows in the Barwon-Darling Technical Report. Murray-Darling Basin Authority, Canberra, ACT.

Murray–Darling Basin Authority (MDBA) (2010a). *Guide to the Proposed Basin Plan, Technical Background Volume 1 Overview*. Canberra, ACT.

Murray–Darling Basin Authority (MDBA) (2010b). *Guide to the Proposed Basin Plan, Technical Background Volume 2*. Canberra, ACT.

Murray–Darling Basin Authority (MDBA) (2011). *Plain English Summary of the Proposed Basin Plan — Including Explanatory Notes*. Murray–Darling Basin Authority, Canberra, ACT. Available from URL: https://www.mdba.gov.au/sites/default/files/archived/proposed/plain_english_summary.pdf [accessed 18 Dec 2018].

Murray–Darling Basin Authority (MDBA) (2012). *Basin Plan*. Canberra, ACT. Available from URL: https://www.legislation.gov.au/Details/f2012l02240/Controls/ [accessed 22 Jun 2018].

Murray–Darling Basin Royal Commission (2018). Issues Paper No. 2. Available from URL: https://mdbrcsa.govcms.gov.au/sites/g/files/net3846/f/issues-paper-round_2-mdbrc.pdf?v=1525066265 [accessed 2 Jun 2018].

National Water Commission (NWC) (2014). Australia's Water Blueprint National Reform Assessment 2014 – Part One. Available from URL: http://www.nwc.gov.au/

publications/topic/assessments/australias-water-blueprint-national-reform-assessment-2014 [accessed 18 Oct 2018].

Ombudsman New South Wales (NSW) (2017). *Investigation into Water Compliance and Enforcement 2007–17*. State of New South Wales, Sydney, NSW. Available from URL: https://www.ombo.nsw.gov.au/news-and-publications/publications/reports/state-and-local-government/investigation-into-water-compliance-and-enforcement-2007-17 [accessed 9 Apr 2018].

Paton, D.C., Paton, F.L. and Bailey, C.P. (2017). Condition monitoring of the Lower Lakes, Murray Mouth and Coorong Icon Site: Waterbirds in the Coorong and Lower Lakes. Available from URL: https://www.mdba.gov.au/sites/default/files/pubs/D16-33172-waterbird-condition-monitoring-coorong-lower-lakes-murray-mouth-2016.pdf [accessed 22 Jun 2018].

Perry, C.J. (2018). Testimony before the Murray–Darling Basin Royal Commission. 2018; Hearing 4 September 18 2018. Available from URL: https://www.mdbrc.sa.gov.au/sites/g/files/net3846/f/4_september_2018_hearing_transcript_unofficial_version.pdf?v=1536054197 [accessed 2 Oct 2018].

Perry, C., Steduto, P., Allen, R.G. and Burt, C.M. (2009). Increasing productivity in irrigated agriculture: agronomic constraints and hydrological realities, *Agricultural Water Management* 96, 1,517–1,524.

Perry, C., Steduto, P. and Karajeh, F. (2017). *Does Improved Irrigation Technology Save Water? A Review of the Evidence*. FAO, Cairo, Egypt, pp. 42.

Productivity Commission (2018). Murray–Darling Basin Plan: Five-year assessment. Draft Report August 2018. Available from URL: https://www.pc.gov.au/inquiries/current/basin-plan/draft [accessed 28 Sep 2018].

Roth, G., Harris, G., Gillies, M., Montgomery, J. and Wigginton, D. (2013). Water-use efficiency and productivity trends in Australian irrigated cotton: a review, *Crop & Pasture Science* 64, 1,033–1,048.

Royal Commission into Misconduct in the Banking, Superannuation and Financial Services Industry (2018). Interim Report (Volume 1). Available from URL: file://capfs.anu.edu.au/cap_users$/u4038333/Documents/U-Drive%20Data/My%20Documents/AJARE/Presidential%20Speech/interim-report-volume-1.pdf [accessed 2 Oct 2018].

Senate Rural and Regional Affairs and Transport References Committee (2013). *The Management of the Murray–Darling Basin*. Department of the Senate, Canberra, ACT.

Silburn, M., Montgomery, J., McGarry, D., Gunawardena, T., Foley, J., Ringrose-Voase, A. and Nadelko, A. (2013). Deep drainage under irrigated cotton in Australia: a review, in Wigginton, D. (ed.), *WATERpak: A Guide for Irrigation Management in Cotton and Grain Farming Systems*, 3rd edn. Cotton Research and Development Corporation, Narrabri, NSW, pp. 40–58.

Smakhtin, V., Revenga, C. and Döll, P. (2004). Taking into account environmental water requirements in global-scale water resources assessments. International Water Management Institute. Available from URL: http://core.ac.uk/download/pdf/6405183.pdf [accessed 22 Jun 2018].

Stewardson, M. and Guarino, F. (2018). Basin-scale environmental water delivery in the Murray–Darling, Australia: a hydrological perspective, *Freshwater Biology* 63, 969–985. https://doi.org/10.1111/fwb.13102

Stigler, G.J. (1971). The theory of economic regulation, *Bell Journal of Economics and Management Science* 2, 3–21.

Victorian Ombudsman (2011). Investigation into the Foodbowl Modernisation Project and related matters. Victorian government printer. Available from URL: https://www.parliament.vic.gov.au/papers/govpub/VPARL2010-14No89.pdf [accessed 10 Oct 2018].

Victorian Ombudsman (2018). Investigation into allegations of improper conduct by officers at Goulburn Murray Water. Victorian government printer. Available from URL: https://www.

ombudsman.vic.gov.au/getattachment/Publications/Parliamentary-Reports/Investigation-regarding-officers-at-Goulburn-Murra/Investigation-into-allegations-of-improper-conduct-by-officers-at-Goulburn-Murray-Water.pdf.aspx [accessed 8 Oct 2018]

Wentworth Group (2010). Sustainable diversions in the Murray–Darling Basin: an analysis of the options for achieving a sustainable diversion limit in the Murray–Darling Basin. Wentworth Group, Sydney, NSW. Available from URL: http://wentworthgroup.org/2010/06/sustainable-diversions-in-the-murray-darling-basin/2010/ [accessed 7 Apr 2018].

Wentworth Group (2012). *Does a 3,200 GL Reduction in Extractions Combined with the Relaxation of Eight Constraints Give a Healthy Working Murray–Darling Basin River System?*. Wentworth Group, Sydney, NSW. Available from URL: http://wentworthgroup.org/2012/10/wentworth-group-evaluation-of-3200gl-modeling-with-relaxed-constraints/2012/ [accessed 7 Apr 2018].

Wentworth Group (2017). *Review of Water Reform in the Murray–Darling Basin*. Wentworth Group, Sydney, NSW. Available from URL: http://wentworthgroup.org/2017/11/review-of-water-reform-in-the-murray-darling-basin/2017/ [accessed 7 Apr 2018].

Wentworth Group (2018). Murray–Darling Basin Plan: Five-year Assessment. Submission to the Productivity Commission Issues Paper 19 April 2018.

Wheeler, S. (2014). Insights, lessons and benefits from improved regional water security and integration in Australia, *Water Resources and Economics* 8, 57–78.

Wheeler, S.A. and Cheesman, J. (2013). Key findings from a survey of sellers to the Restoring the Balance programme, *Economic Papers* 32, 340–352.

Wheeler, S., Zuo, A. and Bjornlund, H. (2014). Investigating the delayed on-farm consequences of selling water entitlements in the Murray–Darling Basin, *Agricultural Water Management* 145, 72–82.

Wheeler, S.A., Connor, J., Grafton, R.Q., Crase, L. and Quiggin, J. (2018). Submission to the Productivity Commission's Murray–Darling Basin Five-Year Assessment Issues Paper. Available from URL: http://www.pc.gov.au/__data/assets/pdf_file/0008/227483/sub040-basin-plan.pdf [Accessed 2 Jun 2018].

Williams, J. (2017). Water reform in the Murray–Darling Basin: a challenge in complexity in balancing social, economic and environmental perspectives, *Journal of the Proceedings of the Royal Society of NSW* 150, 68–92.

Williams, J. and Grafton, R.Q. (2018). Missing in action: possible effects of water recovery on net environmental flows in the Murray–Darling Basin, Australia. *Australian Journal of Water Resources* (Manuscript under revision).

Wittwer, G. and Dixon, J. (2013). Effective use of public funding in the Murray–Darling Basin: a comparison of buybacks and infrastructure upgrades, *Australian Journal of Agricultural and Resource Economics* 57, 399–421.

Wyrwoll, P., Grafton, R.Q., Daniell, K.A., Chu, H.L., Ringler, C., Lien, L.T.H., Khoi, D.K., Do, T.N. and Tuan, N.D.A. (2018). Decision-making for systemic water risks: insights from a participatory risk assessment process in Vietnam, *Earth's Future* 6, 543–564.

Young, M. (2014). Trading into trouble? Lessons from Australia's mistakes in water policy reform sequencing, in Easter, K.W. and Huang, Q. (eds), *Water Markets for the 21st Century: What Have We Learned?* Springer, London, pp. 203–214.