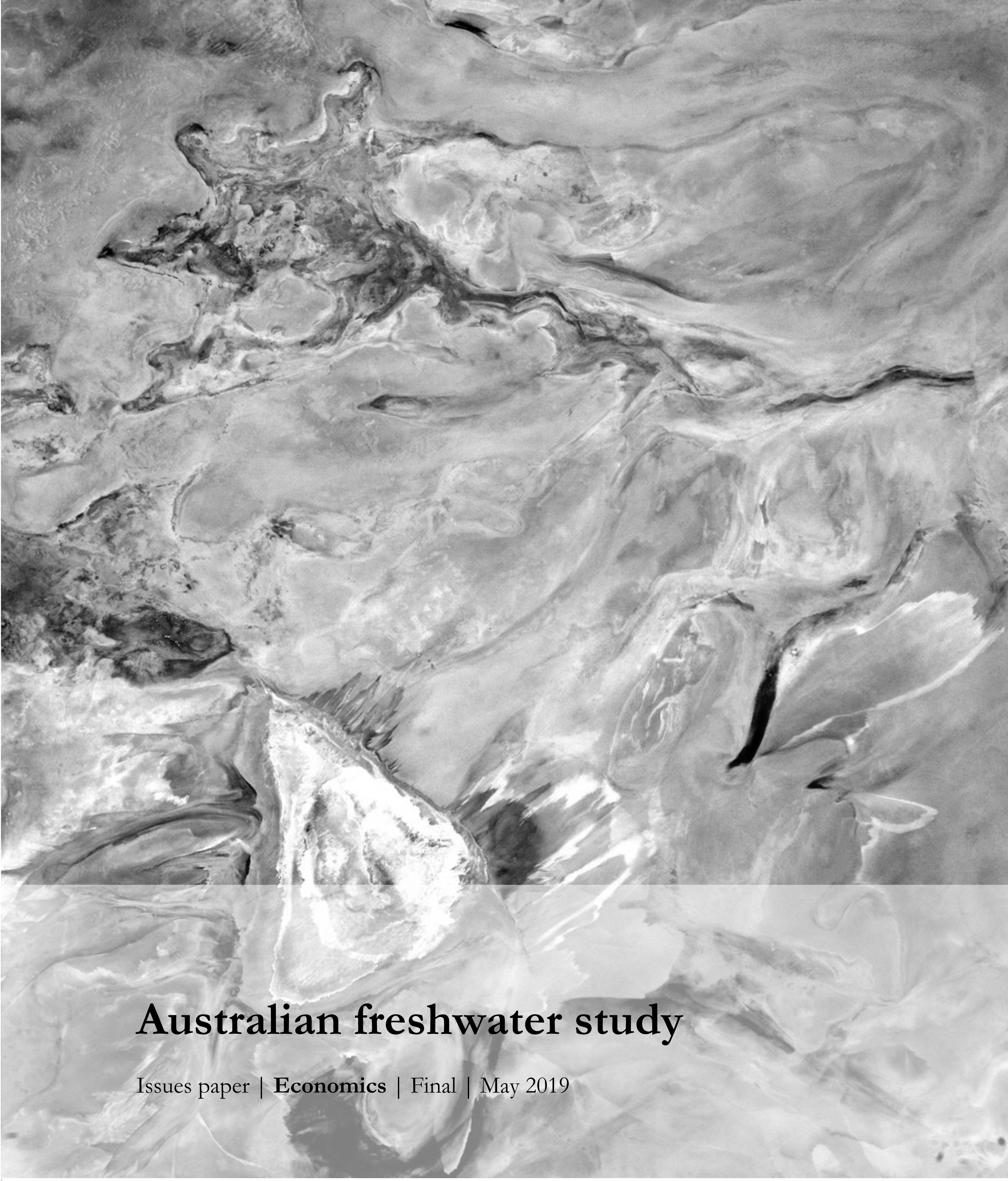

Australian freshwater study

Issues paper | **Economics** | Final | May 2019

The Ian Potter Foundation

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alluvium

Outline

This paper provides an overview of issues related to the economics of the sustainable management of fresh water resources in Australia. It is one of six papers produced for The Ian Potter and The Myer Foundations' Australian Freshwater Study.

About the Australian Freshwater Study

The Ian Potter Foundation and The Myer Foundation have funded a study of major issues affecting Australia's freshwater systems. The Foundations want to better understand the ways philanthropic investment might catalyse changes to the management of Australia's freshwater resources that will protect their ecological integrity, make access to them more equitable, and ensure Australia's long-term water security.

The consulting firms Point Advisory and Alluvium have been commissioned to undertake the study and have prepared a set of short issues papers covering water governance, economics, freshwater ecosystems, First Peoples' water rights, and social values. The issues papers are the first step in the project. They provide a "long list" of major issues facing the management of fresh water in Australia as well as a general indication of options for philanthropic intervention. In parallel, Point Advisory and Alluvium are working on identifying more detailed options for philanthropy to intervene to catalyse change. Both work streams will be consolidated into a final report that matches issues with options and recommends a short list of specific future interventions to the Foundations for more detailed review.

Acknowledgements

Point Advisory and Alluvium would like to thank the Expert Panel Members for the project who gave time to be interviewed and provided references, introductions and reviewed earlier drafts of this paper:

- Professor Stuart Bunn, Griffith University
- Chris Chesterfield, Monash University
- Dr Guy Fitzhardinge, farmer, Northern Australian Indigenous Land and Sea Management Alliance (NAILSMA), World Wildlife Fund (WWF)
- Professor Quentin Grafton, Australian National University
- A/Professor Darla Hatton-MacDonald, University of Tasmania
- Professor Craig Simmons, Flinders University
- Professor Sarah Wheeler, University of Adelaide

We would also like to thank the respondents to the public consultation process who provided feedback, which has contributed to the final paper. While we are very grateful for all of the assistance provided by our Expert Panel, responsibility for the final product and any errors rests with Point Advisory and Alluvium.

Citation: Point Advisory and Alluvium Consulting (2019) Australian Freshwater Study – Economics Issues Paper, report prepared for The Ian Potter Foundation and The Myer Foundation, Melbourne

Image credit: Scott Kelly/NASA, taken 12 October 2015, photo of Australia taken from the International Space Station"#EarthArt A single pass over the #Australian continent. Picture 4 of 17. #YearInSpace", posted to Twitter <https://twitter.com/StationCDRKelly>, accessed via <https://www.flickr.com/photos/nasa2explore/22034472049/in/album-72157659515819800/>

Acknowledgement of First Peoples and Country

We acknowledge Australia's First Peoples and pay respect to the past, present and future Elders of Australia's First Peoples' communities. We honour the deep spiritual, cultural and customary connections of Australia's First Peoples to their lands and waters.

Background

Australia is a dry continent with high spatial and temporal rainfall variation across its catchments. While Australia has around 5% of the Earth's land area, it has less than 1% of global river runoff, and its arid and semi-arid catchments have some of the highest interannual rainfall and runoff variability on Earth.[1][13] Australia also lacks the high mountain ranges that feed major river systems with snowmelt on other continents[2] and the nation's inland rivers have over 1000 times more variation in average annual discharge than equivalent rivers in North America or Europe (see the **Overview Paper** for further detail). [3][13] The Murray-Darling, where most of Australia's high-value irrigated agriculture is located, has the most unpredictable and variable rainfall of the world's large river systems. [4] On average, more water flows through the mouth of the Amazon in a day than is discharged by the Murray in a year. [5], [6]

European settlers have found adapting to Australia's hydrological realities difficult. Australian water policy since the 19th century has primarily aimed at securing more reliable and higher volume water supplies for agricultural and urban development. [1] [7] However, policy-makers have consistently overestimated the potential of supply-side policies premised on reshaping hydrological realities. [8] Consequently, the economics of water policy in Australia have often been far from rational[1], [9], [10] and "water dreaming" remains an influential part of Australia's water policy cycle.[1] [11]

From the 1880s to the 1980s, Australian governments, state and Federal, assumed that financial support for engineering works in major river systems to "drought-proof" the nation and support irrigated agriculture and urban development was a self-evidently rational investment that would contribute to building national wealth. [7] [9], [12] The agricultural sector was a major beneficiary of this public expenditure. Between 1920 and 2000 the area of irrigated agricultural land in Australia increased 10-fold. The majority of the growth occurred between 1950 and 1990, which was the period of greatest public expenditure on irrigation infrastructure and the largest expansion of agricultural water rights allocation.[1][7] The capital cost of building this irrigation infrastructure was not recovered from beneficiaries. Without this subsidy,[2] many farms would not have been financially viable. [9] [12] Cost-benefit appraisal of much of the public investment on irrigation infrastructure during this period suggests that it may not have been an efficient use of the nation's resources. [12]

While many Australian freshwater systems remain in good condition, many others have been profoundly degraded by attempts to re-engineer Australia's hydrology. [5], [7] For example, in the Murray-Darling Basin, attempts to reshape what is, by international standards, a low-flow, unreliable river system in a semi-arid climatic zone to supply water for irrigated agriculture and towns as well as mitigate floods, has led to the Basin containing some of the most extensively engineered rivers in the world. [15] Water extractions for consumptive use match the patterns of infrastructure investment. In 2016-17, irrigated agriculture used around 70% of all water withdrawn from Australian freshwater systems, another 20% was withdrawn for use in urban systems, with the remaining 10% withdrawn for industrial uses. [16] Around 70% of all water used in irrigated agriculture in Australia is withdrawn in the Murray-Darling Basin. [17]

By the late 1980s, funding "nation-building" water infrastructure had left governments with debts as well as an ongoing legacy of maintenance and refurbishment expenses. [18] In a political climate of greater fiscal responsibility, it became increasingly clear to policy-makers that: (a) a narrow, engineering and supply-side

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[1] Water policy "dreaming" has already figured prominently in the lead up to the 2019 Federal election with the former Federal Minister for Agriculture and Water Resources, Barnaby Joyce calling for governments to revisit the ill-conceived Bradfield Scheme to transfer water from the wet tropics of northern Australia south and inland for irrigated agriculture (see https://twitter.com/barnaby_joyce/status/1102397065160679424).

[2] Subsidies for irrigated agriculture are discussed multiple times in this paper. This paper adopts the OECD definition: "a subsidy is the result of a government action, that confers an advantage on consumers or producers, in order to supplement their income or reduce their costs." [14]

focus would remain inadequate to meet the nation's water demands; and (b) existing agricultural water rights systems were ill-suited to Australia's variable climate because they provided entitlements that did not vary with water availability.[19], [20] At the same time, public and policy-maker awareness of the serious environmental problems caused by Australia's engineering approach to developing and using water resources was growing. Significant problems began to be identified with the overallocation of water resources from previous expansion—the most intense period of which had coincided with three decades of unusually high rainfall in the south-east. [1]

A substantial drive to reform Australia's water policy began in the 1990s, initiated by National Competition Policy and the National Strategy for Ecologically Sustainable Development. Water extractions in the Murray-Darling began to be capped in 1995[3] and over the next twenty years, a suite of national water reforms including the 2004 National Water Initiative (NWI) and the 2007 Commonwealth *Water Act* would promote economic efficiency, full-cost recovery for government expenditure, and ecologically sustainable use of Australia's water resources. These reforms have attempted to balance "pro-market, micro-economic reforms with broader social and sustainability goals." [21], [1] However, this balancing act has not always been successful. The politics of reallocating water away from agricultural users in communities previously established on the basis of "nation-building" irrigation remains fraught and has led to major compromises both in the amount of water returned to the environment and the rigour applied to the financial and environmental tests of new public investments in water infrastructure. [10], [22]-[28] The reforms have delivered a water governance and management framework, particularly in the Murray-Darling, built on a complex and unwieldy mix of state- and Commonwealth-administered collaborative planning, market-based instruments and direct regulation. [18], [29]

The Millennium Drought (1998-2010) demonstrated both the limitations of supply-side, infrastructure approaches to national water security[8] and the value of water market reforms.[26], [30], [31], [32] Water trading combined with other demand-side adaptations and higher commodity prices helped maintain most of the gross value of irrigated agricultural production in the Murray-Darling Basin during the drought. The 2001 to 2008 financial years saw a 70% reduction in the use of surface water for irrigation in the Basin. However, this corresponded with a fall in adjusted gross value of irrigated agricultural production of only 10%.[26], [33] While political considerations limited options for demand-side adaptations in urban water systems, those demand-side policies that were implemented helped significantly reduce urban water use during the drought. [34] Despite these adaptations, the period witnessed a crisis-driven return to publicly-funded, supply-side infrastructure solutions—large desalination plants for major cities and irrigation infrastructure "modernization" in agricultural areas. The rigour of the financial and environmental analyses behind these decisions has been criticized by auditors-general and the Productivity Commission; few of these investments represented economically efficient or effective expenditure of public funds. [23], [35]-[37] [10] [38]

The major constraints on water policy reform over the last 25 years have been political. Responses to difficult water policy questions have often prioritised political costs and benefits over economic ones. [31], [42] Urban water policy reform has been constrained by political timidity, which has preferred imposing long-term costs on users to exploring the potential for urban water pricing innovations. Agricultural water policy reform has pre-emptively buckled to a long-standing agrarianism in Australian politics that insulates government funding for agriculture from the critical scrutiny applied to other public expenditures. [9], [39], [40] Notwithstanding these constraints, Australia's water reforms, particularly in relation to water markets, have achieved considerable change and received global acclaim. However, recent environmental crises in the Murray-Darling Basin suggest that it is far from clear whether the reform effort has prepared the nation to cost-effectively and sustainably manage the risks it faces from the next long drought, climate change and population growth. [41] Reform tasks remain just to ensure the NWI's requirements are fully implemented. [42]

[3] Caps on water extractions in the Murray-Darling were introduced in NSW, Victoria and South Australia in 1995 and in Queensland in 1999.

The impact of agrarianism as a constraint on water reform in Australia's major irrigation areas should not be underestimated. Empirical studies reveal that agrarian sentiment remains strong across Australia's population, notwithstanding the nation's very high levels of urbanisation. [43] [39], [40] The general public continue to believe that agriculture should be actively supported by public policy and public finance, that agriculture makes a unique contribution to national wealth and that agriculture forms a critical part of the national character. [40], [43] The belief that agricultural producers protect the environment also remains widespread, [43] even though empirical evidence suggests this is not always the case. [8], [44] The deregulation of the sector over the last 30 years and the removal of many price supports has not diminished bi-partisan backing for policies that build on these agrarian ideals. [40] As a result, irrigation infrastructure subsidies are politically easier to defend than grappling with the major structural adjustment likely to be required to bring irrigated agriculture's water use to a level consistent with the ecological sustainability of Australia's over-allocated river systems. [19] Climate change will only increase the policy challenges as it is projected to cause lower rainfall across much of Australia's major agricultural areas, [45] increasing the tensions between agricultural, municipal and environmental water use. Future water policy reform will need to seriously address regional development issues alongside structural adjustment for parts of the agricultural sector if it is to be successful.

Supplying water of the right quality, in the right place, at the right time, at a price users are willing to pay, with a minimum of ecological impacts presents a set of complex collective action problems amenable to economic analysis and good market design. [46] However, water policy is also subject to considerable path dependency. Future water policy options are constrained by the legacy of over a hundred years of policy choices. [22], [47] Future policy reforms, economic and environmental, will be made in the context of the sunk costs involved in building long-lived infrastructure in our urban and rural water systems. That the economics of much of this water infrastructure investment do not stand up to rigorous scrutiny does not mean we should stop using it. Modifications to major river systems for the benefit of irrigated agriculture have caused ecological damage for more than 100 years, but stopping irrigation altogether will not return these rivers to their original state. [47] Importantly, evidence-based water reforms offer potentially large benefits for Australia relative to business as usual.

Future water policy reform needs to start from where Australia finds itself—with significant environmental damage to highly-allocated river systems, politicised policy processes that favour agrarianism over economic rationality, and a drier future under climate change in major areas of irrigated agriculture. Difficult questions need to be asked about gaps and shortcomings in major policy instruments like the Murray-Darling Basin Plan, the sustainable scale and form of irrigated agriculture, how equitable structural transformation in the sector can be achieved, and the goals and targets for environmental remediation in our over-allocated rivers. One way to approach the economics of these questions may be to return to the origins of the discipline and consider the impact of water policy decisions on the nation's overall wealth. Recent work on measures of "genuine" or "comprehensive" national wealth that account for natural capital value, maintenance and assets-at-risk may be of assistance here. [48] [49]-[54]

Each of the issues raised in this paper suggests lessons can be learnt from past mistakes and reforms can still be made. Effective water policy reform requires robust institutions, particularly where new property rights are created and market-based instruments deployed to achieve policy goals. Australia's water management institutions require strengthening to meet current and future challenges like climate change and environmental degradation. If plans for the expansion of irrigated agriculture in northern Australia are pursued, it will be particularly important to resolve the long-standing issues raised here surrounding the government funding of infrastructure along with the operation of new water rights regimes. [55] [1], [38],[20], [56]. Climate change and population growth present specific challenges to urban water planning and regulation. Despite more than 20 years of reform, urban water management still varies widely across Australia. [36], [42] Even where water utilities are at arms-length from government, political intervention still occurs in independent economic regulator determinations and in specific investment decisions. [42]

Issues identified

1. We do not properly account for, or adequately understand, the natural capital asset value of our freshwater systems and their catchments.
2. Government funding of water infrastructure has not always been justified on legitimate public interest grounds.
3. Further reform is needed to ensure economic and regulatory instruments contribute to delivering the environmental outcomes required to protect and restore freshwater ecosystems, particularly in the Murray-Darling Basin.
4. Regulatory, planning and investment frameworks for urban water constrain the full consideration of options, from stormwater reuse to scarcity pricing, necessary to provide our cities with a diversified and resilient portfolio of urban water services.

1. We do not properly account for, or adequately understand, the natural capital asset value of our freshwater systems and their catchments.

To its early authors, economics (or political economy) was the study of the wealth of nations. [57]-[59] The neoclassical synthesis and the rise of Gross Domestic Product (GDP) as the key measure of national economic performance in the second half of the twentieth century witnessed a shift in much economic analysis from wealth (a stock) to measures of the flows of production and consumption. While measuring such flows contributes to evaluating current standards of living, these approaches do not help evaluate the sustainability of aggregate economic activity or particular economic policies because they do not account for changes to a nation's capital asset base—or its wealth—over time. [60], [61] As the UK Government's Natural Capital Committee points out, "an economy can run down its assets yet, at the same time, record high levels of GDP growth, until a point is reached where the depleted assets act as a check on future growth". [62] Sustainable management of Australia's natural capital assets requires a better understanding and accounting of their value.

Freshwater systems are an important part of any economy's capital assets, which include: manufactured (or reproducible) capital such as buildings, roads, manufacturing planet; human capital, such as the skills, education and health of the population; and natural capital, such as forests, fisheries, and freshwater systems. [50][[49], [63], [64] The total worth of these assets constitutes a nation's wealth. To assess the sustainability of current economic activity, we need to understand changes in our capital asset base arising from current production and consumption patterns. [60] [65] [66] [48] [67] [61] Given that sustainability is ultimately a question of intertemporal allocation of resources, a wealth- or capital-based assessment of sustainability suggests that a nation is on a sustainable development path if, and only if, the total value of its capital asset portfolio does not decline over time.[48], [66]

A wealth- or capital-based approach to sustainability has been proposed by Nobel Laureates in economics Kenneth Arrow[48], [66], Joseph Stiglitz and Amartya Sen[60], and has been recently adopted by the World Bank for preliminary comparative analysis of the wealth of nations.[61] Natural capital has a prominent place in wealth-based assessments of sustainability for two major reasons: (a) the degradation of natural capital assets has increasingly become a hard constraint on twentieth century models of development; and (b) an increasing amount of empirical evidence demonstrates that depleted natural capital cannot be substituted by other factor inputs. [50] [51], [65], [68] The unique place natural capital assets have in unpinning our economies has led proponents of wealth-based sustainably to propose an aggregate natural capital rule for sustainability: "the aggregate level of renewable natural capital should be kept at least constant and the value of the economic rents from the depletion of non-renewable natural capital should be invested in renewable natural capital". [51]

Applying this rule has radical implications for policy-making, some of which will be explored below.

The NWI explicitly acknowledges Australia's freshwater resources as natural capital assets. [69] However, much of the economic appraisal of policies and investments affecting Australia's freshwater systems focuses on flows rather than stocks with attention given to changes in production and consumption, and employment and income (see for example, [70] [71] [72] [73] [74]). Consequently, such analysis tends not evaluate policy or investment decisions with reference to any net loss in natural capital or changes to a comprehensive measure of national wealth or give full consideration to inter-temporal issues. Yet our water policy reform process raises such important empirical questions. For example:

- has the water reform process of the last 25 years, alongside the many billions of dollars of public funds spent on irrigation and urban water infrastructure, increased or decreased the value of Australia's portfolio of capital assets and the nation's overall wealth?
- has our approach to water reform been cost-effective in comparison to other policy alternatives that could have been pursued?

The limitations in our ability to value Australia's freshwater systems as natural capital assets is probably the greatest barrier to providing an empirical answer to the first question and this has implications for any answer to the second. The eminent economist Sir Partha Dasgupta has pointed out: "[u]ntil that ignorance is lifted, policy analysis will remain crippled, and sustainability will continue to be a notion we admire but cannot put into operation." [65]

Properly valuing natural capital assets like freshwater ecosystems is a difficult empirical challenge. They provide most of their services for free and have a number of unique characteristics that conventional economic analysis struggles to adequately represent. [50] For example, freshwater ecosystems, like most natural capital assets, are not built out of discrete marginal units; they come in systems full of connections and dependencies, the science of which is rarely settled. Change in the functioning of such ecosystems is rarely linear and they are often subject to critical thresholds, which when crossed can radically change the services they deliver and their asset value. [50] [68] When properly maintained above critical thresholds, freshwater ecosystems operate like a perpetual fund and continue to return valuable services indefinitely. [75] In addition, it is being increasingly recognized that there are significant links between freshwater ecosystems and other land-based natural capital ecosystems, and the health of our waterways can depend on the health of our land. These inter-relationships make management much more difficult, and the marginal analysis used in conventional economic appraisal is often inappropriate for valuing such assets or properly evaluating the impacts of policy proposals on their future value. Indeed, the cumulative impact of a series of policy proposals or investments that pass traditional cost-benefit analyses seeking to "optimise environmental, social and economic outcomes" [76] may lead to the overall degradation of critical natural capital assets.[50]

Despite the empirical challenges, effective management of natural capital assets like freshwater systems requires valuation, balance sheets and measures to account for change in value over time. [50] [49], [51] However, even where such accounting is in its infancy, the characteristics of natural capital assets combined with the aggregate natural capital rule outlined above, point towards a set of requirements for natural asset management and correspondingly for water policy. Policy decisions should:

1. be orientated towards the identification of assets-at-risk
2. better understand capital maintenance requirements
3. clearly identify safe operating thresholds taking account of uncertainty and future climate risk. [50], [77] [49], [51]

Elements of this approach are visible in existing water policy frameworks. For example, the Commonwealth *Water Act*'s definition of an "environmentally sustainable level of take" (s.4) is consistent with the need to manage natural capital assets with reference to safe operating thresholds. Similarly, the Murray-Darling Basin

Authority has acknowledged the need to manage the freshwater ecosystems of the Basin at a level that does not "irretrievably damage the attributes of the Basin that enable it to be so productive." [78]

Nevertheless, substantial gaps remain between the articulation of such policy goals and their implementation in Australia. For example, despite more than twenty years of intensive management and billions of dollars of expenditure, the rivers of the Murray-Darling Basin remain in a highly degraded condition—leading one commentator to characterize water policy for the Basin as involving "a river of funding and a trickle of achievement". [10] The most recent State of the Environment Report on Australia's inland waters shows ecological processes in the Basin to be "very poor", with a deteriorating trend. [79] Work completed by the Wentworth Group of Concerned Scientists in 2019 suggests that despite over 2,000 GL of water being recovered for the environment, studying observed flows reveals that there has been "no improvement or even a decline in water flows since the implementation of the Basin Plan." [80] And the Australian Academy of Science's report into the 2019 fish kills at Menindee reported that there was "not enough water in the Darling system to avoid catastrophic decline of condition through dry periods." [81] Climate change impacts are likely to increase the pressures on freshwater ecosystems in the Basin and decrease their natural capital value unless there are significant reductions in agricultural water extractions. [81]-[83]

Despite the requirements of the NWI and the *Water Act*, Australia appears to have adopted a high-risk approach to asset-management strategy for the freshwater assets of its most economically productive agricultural region. Current management has increased the risks of catastrophic decline in the Basin's rivers [81] and reduced their bequest value to future generations of Australians. Adopting a high-risk strategy compromises the capital asset value of an essential resource with few to no substitutes on the driest inhabited continent on Earth. The risk also exists that mistakes made in the Murray-Darling Basin will be repeated in the proposed expansion of irrigated agriculture in Australia's undeveloped north. Existing proposals for northern development do not appear designed to close the gap between sustainability goals for freshwater systems and their implementation in the south. [84]

In the United Kingdom, the creation of a national Natural Capital Committee alongside an assets-based approach natural capital policy questions has given rise to a 25-year environmental plan built around the three requirements for policy decisions listed above as well as the following three policy pillars:

1. *public money for public goods*: public subsidies should support the provision of environmental public goods, not private benefits;
2. *polluter pays principle*: externalities should be internalized;
3. *net environmental gain*: compensation in natural capital (rather than any other factor of production) should be paid if natural capital assets are damaged. [50]

What can be done

Australia should consider:

- Adopting a natural capital focus to water policy analysis and decision-making based on the three policy requirements and policy pillars outlined above. These could be combined within a long-term strategic plan for the management of Australia's freshwater capital assets as part of a broader, wealth-based approach to sustainability.
- Providing the funding required to improve the nation's natural capital accounting and valuation for all natural systems and their integration into a broader wealth-based assessment of the sustainability of our economic programs.
- Adopting the aggregate natural capital rule for sustainability in all policy-making.

An independent, national freshwater resources think tank tasked with promoting research and generating evidence-based and innovative water policy options from a natural capital perspective could contribute to developing the methodologies required to provide for the rigorous accounting to track the changes to

Australia's freshwater natural capital assets over time as well as the development of policy and project evaluation tools required to take natural capital values into account.

Philanthropic organisations can consider:

- supporting the establishment of an independent, national freshwater resources think tank with the above priorities
- supporting the development of a national water research information "hub" to drive further research into natural capital accounting for freshwater systems
- supporting civil society organisations and other experts to develop and widely circulate a publicly accessible "users guide" to natural capital assessments and public policy development practices for citizens and journalists outlining key questions to ask of politicians about water policy decisions.

2. Government funding of water infrastructure has not always been justified on legitimate public interest grounds

Surface water supply infrastructure is capital-intensive and long-lived. Governments are major funders because of its large fixed costs and considerable economies of scale. [46] However, water infrastructure's benefits are usually concentrated in specific geographic locations. This combination of characteristics sometimes leads governments to prioritise perceived political costs and benefits over economic costs and benefits in investment and cost-allocation decisions. [85] Some government investments in new and refurbished water infrastructure continue to benefit specific geographical and industry constituencies, while costs are socialised. When such infrastructure expenditure is less cost-effective than alternatives available to deliver the same policy goals, any political benefits come at a substantial opportunity cost to the nation. [86]

This issue is not unique to water infrastructure nor to Australia. [87] Examples of government expenditure on transport, telecommunications, water and energy infrastructure with poor financial, economic and environmental outcomes can be found in most developed nations. It is not uncommon for political expediency to lead governments to overstate benefits, understate costs, ignore opportunity costs, and fail to be transparent about the reasons and influences behind large infrastructure investment decisions. [85], [88], [89], [90] While the most egregious example of such water infrastructure policy failure in Australia is most likely the Ord River Scheme, [91], [1], [38] the discussion below focuses on Commonwealth expenditure on irrigation infrastructure in the Murray-Darling Basin from the implementation of the 2008 *Water for the Future* package. This example shows how government prioritisation of political costs and benefits over economic and environmental accountability can stymie reform efforts, limit economic, social and environmental benefits, and increase social, economic and environmental risks. It demonstrates that when Ministers do not strive to make unbiased decisions based on all available evidence, governments struggle to deliver long-term public benefits in infrastructure investment decisions and society faces a "democracy deficit". [88], [89], [92]

Building on the previous Howard government's *National Plan for Water Security*, the Rudd government's 2008 *Water for the Future* program (WFF) pursued a dual strategy to achieve the policy goal of recovering water for the environment in the Murray-Darling Basin: (a) the purchase of water entitlements from willing sellers by the Commonwealth to be transferred to a newly created Commonwealth Environmental Water Holder (CEWH); (b) substantial public subsidies for on- and off-farm irrigation infrastructure and infrastructure upgrades designed to increase irrigation efficiency and "save" water for the environment. [26] *Water for the Future* allocated $3.1 billion to the purchase of Basin water entitlements through open tender through the Restoring the Balance (RTB) program, and $5.8 billion to water infrastructure subsidies through the Sustainable Rural Water Use and

Infrastructure (SRWUI) program. [26] Unlike most other OECD nations, where irrigation subsidies declined during the period 1986-2017, Australian government subsidies for irrigated agriculture began to grow after 2009.[194] Six examples of the ways in which a political calculus of costs and benefits dominated economic and environmental accountability in the allocation of public money across these two strategies are outlined below.

2.a. Governments preferred irrigation infrastructure subsidies to water entitlement purchases even though subsidies were the more expensive option with less certainty they would deliver stated policy outcomes

Despite the requirement that both RTB and SRWUI programs provide "value for money in recovering water", [93] economists had already warned that subsidising irrigation infrastructure was unlikely to be a cost-effective mechanism for recovering water for the environment and was likely to generate more private than public benefits. [24] The Productivity Commission concluded in 2010 that infrastructure subsidies were "not a cost-effective way for governments to recover water for the environment." [93] Subsequent analysis confirmed earlier warnings [94] and suggests that irrigation subsidies in the Murray-Darling Basin have been at a minimum two-and-a-half times more expensive per megalitre, and in some cases more than six times more expensive, than water buybacks in obtaining water for the environment. [26], [95]-[97]

Establishing how much water for the environment is delivered by infrastructure subsidies for irrigation efficiencies is considerably more difficult than with water buybacks. [95] [26], [96] The Productivity Commission concluded in 2018 that despite years of implementation and billions of dollars of expenditure, the "overall impact of improved irrigation efficiency on water resources is not precisely known." [98] A crucial problem is that improvements in field-level irrigation efficiency cannot be simply aggregated to deliver Basin-scale reductions in water use. [99] [100] Water not evaporated or transpired by crops and other plants at field level (e.g. surface water runoff) is not "lost" or "wasted". It returns to the watershed. For example, it may be captured for use in another field, returned to a river or travel downwards to replenish a groundwater aquifer. [99], [101] Consequently, the potential basin-scale gains from improving field-level irrigation efficiency are highly uncertain and their quantification remains controversial. [93], [98], [99], [101] How the government deals with these uncertainties is not clear as the full methodology used to quantify water recovery from infrastructure upgrades is not published. [102]

Subsidies for irrigation upgrades to improve efficiency can also lead to "rebound effects" where improved irrigation efficiency increases long-term water requirements and dependency on water extractions (e.g. increasing irrigated land area and storage), changes cropping patterns (e.g. providing incentives to switch to perennial crops), and reduces environmental flows. [98], [103]-[105] Such effects have been in found in empirical studies of major shifts to more efficient irrigation technology. [103] Despite the clear differences between the two strategies for environmental water recovery, water buybacks (the cheaper and more effective option) were capped by Commonwealth legislative change in 2015 before environmental water recovery goals were met. In fact, there was a significant change in buyback policy after 2013 (when Barnaby Joyce become water minister), where the Commonwealth moved away from reverse auction open tenders that purchased significant volumes of water at a cost-effective price, to only 'strategically' buying water from large corporate companies at questionable cost-effectiveness. The change in buyback policy was done without any publicly available cost-benefit assessment of the two approaches even though billions of dollars of public money and the ecological integrity of a major river system were at stake. [25], [26]

2.b. Irrigation upgrades and water entitlement buybacks had other, potentially conflicting, policy objectives, which were included without a strong evidence base

While the primary objective of the RTB and SRWUI programs was to recover water for the environment, two other objectives were included. The programs also aimed to: (a) "'soften the blow' to irrigators" facing the possibility of reduced future extractions; and (b) "secure a long-term sustainable future for irrigation communities". [93] These additional objectives were linked to the programs without public consideration of more equitable, cost-effective and economically conventional structural adjustment assistance measures delivered through their own policy instruments (e.g. targeted community assistance, improved provision of public services, retraining). [97] In 2010, the Productivity Commission identified the risks associated with mixing multiple policy objectives in the programs, referring to a long-standing economic policy principle: "[a]ttempting to achieve multiple objectives with one instrument may compromise effectiveness and efficiency." [93] In addition, there was no strong evidence base to show that reducing water available for irrigation and making more water available for the environment was a significant threat to the "long-term sustainable future" of irrigation communities. [26] [70]

Economic modelling and applied research has repeatedly shown that reducing water available for irrigation has not to date had a strong negative impact on agricultural production and associated employment. [26], [104]-[107] There is strong evidence that the creation of perpetual water entitlements within well-functioning water markets, in and of itself, provided substantial economic benefits to irrigators. [30], [106], [108] Water markets combined with innovative irrigator farming practices to enable irrigators to maintain production and sustain viable businesses when less water was available. [30] Water entitlement trade has provided income to pay down debt and water entitlements are an asset that can be used as collateral for farm debt.[106],[121] Indeed, there is evidence that there may be "significant socio-economic negative impacts associated with on-farm irrigation infrastructure." [104] And a focus on infrastructure expenditure, as advocated by some industry groups, fails to represent the broad range of irrigator preferences—44% of irrigators responding to 2014 research preferred market-based water recovery expenditure to irrigation expenditure.[194]

Despite the accumulating evidence that infrastructure subsidies were not cost-effective, the Murray-Darling Basin Authority (MDBA) Chair maintained at a meeting with irrigators in 2011 that "[w]e have made it very clear that our plan says there should be a bias towards investment in infrastructure as opposed to taking water out of communities." [95] Consultants' reports commissioned by Basin governments and government authorities that support the contention that recovering water for the environment causes severe economic impacts in Basin communities[73], [109] have been shown to be fundamentally inconsistent with economic principles and evidence that farming practices and communities are able to innovate and adapt to lower consumptive water availability. [107], [111] Recent work commissioned by the MDBA on the impacts of water recovery confirms that "while agricultural output and employment may decline from water recovery, unemployment in total declined and mean household incomes rose [in the Murrumbidgee catchment] because of outmigration of people from the Basin to be employed in expanding non-agricultural sectors of a diversified economy." [110] This conclusion is supported by research and modelling available in 2013, which suggested that "infrastructure upgrades are inferior to public spending on health, education and other services in the Basin. For each job created from upgrades, the money spent on services could create between three and four jobs in the Basin."[97]

2.c. Governments did not publicly consider the long-term implications of favouring irrigation infrastructure expenditure

Planning for the SRWUI program's investment of public funds in irrigation subsidies did not include public consideration of widely-held concerns that irrigation renewal would lock in agricultural practices and a geographic distribution of agricultural activity that could be poorly suited to the Basin's hydrological realities and maladapted to future climate changes. [86] Nor did it consider a staged approach to water recovery, for example, by rationalizing investment across irrigation regions after buyback occurred, to improve overall irrigation district efficiency in areas that were still considered viable. At the time the SRWUI program was announced, it was already clear that "unsustainable land and water management practices that violate the system's carrying capacity can impose significant costs on regional communities."[195] What was required was an adaptive and flexible approach to shift agricultural practices in the Basin towards more resilient "multi-layered and inclusive practices that promote better soil conditions, land coverage, and water management," [111] SRWUI subsidies have supported the continuation of a 20th century, supply-side water policy focus that will not help Basin communities prepare for the future drying impacts of climate change. [21], [86] Public investment in irrigation infrastructure without full-cost recovery from irrigators has also likely introduced significant distortions in the price signals provided by water markets that may support unsustainable irrigation practices. [112]

2.d. Governments have not properly considered the costs of ongoing degradation of the Murray-Darling Basin's river systems and the benefits of alternative expenditure on environmental restoration

Prioritisation of subsidies for irrigation renewal and a legislative cap on water buybacks has slowed the recovery of environmental water for the Basin. Although the costs of damage to some important wetlands has been evaluated, there has been no full public costing of the ongoing degradation of the Basin river systems as a whole (see Issue 1 above). Similarly, estimates of the benefits of restoring the ecological integrity of the Basin's freshwater systems have not been publicly considered. This is despite the MDBA making it clear in 2010 that "[I]f the focus does not swing back towards considering water required for the environment, then the nation risks irretrievably damaging the attributes of the Basin that enable it to be so productive." [78] Good public policy requires the thorough and disinterested evaluation of all costs and benefits of government decisions. [42]

2.e. Governments have not prioritised simpler and cheaper improvements to water measurement and accounting systems to support proper water market functioning

The Commonwealth, states and territory governments that were party to the NWI agreed to substantially improve water "measurement, monitoring and reporting systems " across the Basin "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." [69] Water markets alone had been shown to deliver improved economic and social outcomes for irrigation communities and it was clear from at least 2004 that significant improvements in water measurement, accounting and compliance regimes would improve water market efficiency and benefits. [69], [93] However, despite the expenditure of billions of dollars on irrigation infrastructure upgrades, this foundational requirement for efficient market functioning has not been fully implemented across the Basin. Notable accounts of water theft and governance failures were documented in NSW in an official inquiry after being brought to the nation's attention by the media. [114]-[116] Subsequently, former Australian Federal Police Commissioner, Mick Keelty was appointed as Northern Basin Commissioner. In April 2019, Keelty publicly raised concerns regarding potential conflicts of interest between "politicians, lobby groups and businesses operating in the water market" and corruption risks. [113] In late 2018, the Australian Government announced the launch of its $20 million Hydrometric Networks and Remote Sensing Funding Program designed to "develop remote sensing and other technologies to enhance monitoring, measurement and compliance in all Basin jurisdictions". This program may belatedly contribute to providing the metering and monitoring data required to begin addressing some of these issues. [114]

Conclusion

We do not know what the opportunity costs to Australians were "by way of other priority public expenditures that had to be foregone given governmental fiscal constraints" when such large public subsidies were provided to the irrigation sector in the MDB. [86] But given the sums expended, they are likely to be considerable. Whether much of the government investment in irrigation infrastructure in the MDB was compliant with NWI cost-recovery principles remains questionable. A major ongoing risk to the nation is the potential for the mistakes of politicised public investment for the benefit of a limited group at the expense of all Australians to be repeated if agricultural development of Northern Australia is pursued. [115]

What can be done

The NWI provides a set of clear requirements for infrastructure investment. For example, that water recovery measures are subject to an assessment of costs and benefits and that investment costs are fully recovered from beneficiaries. These should be complied with for all future infrastructure investment programs. The Productivity Commission also provides a clear program of action to address this issue and to help ensure NWI compliance. However, above and beyond these requirements and recommendations, there is a broader requirement for governments to foster "a culture of analytical rigor and disinterested infrastructure policy," [88] which has been largely absent during decisions about infrastructure investment in the MDB. [92]

The Productivity Commission recommends that "*where governments wish to provide funding for water infrastructure, they should ensure that:*

- *NWI-consistent entitlement and planning frameworks are in place before any new infrastructure is considered, including in northern Australia where such structures are often weak or nonexistent*
- *an independent analysis is completed and made available for public comment before any government announcement on new infrastructure is made. The analysis should: assess the economic and financial viability of the new infrastructure; quantify the economic benefits delivered and the recipients of those benefits; and assess users' willingness to pay for the infrastructure through a combination of ongoing infrastructure charges and the purchase of water entitlements*
- *they do not provide grant funding for infrastructure, or that part of infrastructure, that is for private benefit. Government grants should be limited to those projects, or parts of projects, delivering a clearly articulated and evaluated public good*
- *the financial risk of new infrastructure is reduced by requiring the presale of water entitlements as a precondition for commencing construction.*

Governments need to exercise caution in any decision to provide finance (such as loans) for new infrastructure where the private sector is unwilling to accept the same risks. That unwillingness may be a commercially and economically sound decision. Governments should only provide loans (or financial support) once robust decision-making frameworks are in place that, in addition to the points above, provide for:

- *a selection of projects on merit, without favour or bias*
- *ongoing monitoring against agreed performance measures and the implementation of remedial action should the investment underperform*
- *public reporting of investment performance*." [37]

An independent, **national freshwater resources think tank** tasked with promoting research and generating evidence-based and innovative water policy options as well as providing independent reviews of government water policy implementation could contribute, in partnership with other civil-society organisations, to improving infrastructure investment decision-making by governments. Such a think tank could play a similar role if governments decide to proceed with development plans for northern Australia. Current development proposals include the potential for billions of dollars of investment in water infrastructure for irrigated agriculture, including a number of large dams. [84] In particular, the think tank would provide another independent source of information on the impact of various vested interests in decision-making.

Philanthropic organisations can consider:

- supporting the establishment of an independent, national freshwater resources think tank
- supporting long-term research independent of government agencies that avoids politicised research agendas and highlights the role of vested interests in influencing water policy
- supporting the development of a national water research information "hub" to ensure scientific, socio-economic, cultural and public policy research on water resources management is publicly available
- supporting civil society organisations and an independent, national freshwater resources think tank to support evidence-based policy that ensures economic and environmental accountability dominate decision-making processes
- supporting civil society organisations and an independent, national freshwater resources think tank to link land and water policy with broader regional economic development and priorities alongside structural adjustment needs.
- supporting civil society organisations and other experts to develop and widely circulate a publicly accessible "users guide" to good public policy development practices for citizens and journalists outlining key questions to ask of politicians about water policy decisions.

3. Further reform is needed to ensure economic and regulatory instruments contribute to delivering the environmental outcomes required to protect and restore freshwater ecosystems, particularly in the Murray-Darling Basin

Australia has implemented a range of economic and regulatory instruments to improve the management and use of freshwater systems and reduce environmental impacts. Economic instruments have included water pricing and reform; subsidies (including those discussed in the previous section), voluntary water rights buy-backs, and the creation of markets for tradeable water rights. These have been implemented alongside more direct top-down regulation and catchment management planning instruments. [116] Indeed, while economic instruments are often preferred to "command and control" regulation on efficiency grounds, [117] in fact markets rely fundamentally on governments' capacity to create and enforce property rights, set sustainable diversion limits, monitor compliance and provide the ongoing institutional capacity needed to manage water's complexity as an economic good and an important natural capital asset. [122], [123] Government decisions about economic instrument design as well as the creation and maintenance of institutions with the capacity to implement, manage and regulate the operation of these instruments determines whether they will be effective in their contribution to achieving environmental objectives. It is far from clear whether Commonwealth and state governments have ensured that the current design and implementation of the economic and regulatory instruments deployed in over-allocated river basins such as the Murray-Darling are adequate to meet the environmental objectives required by relevant legislation.[28]

3.a. Poor implementation of economic and regulatory instruments such as the "cap" in "cap and trade" market instruments, rigorous water accounting or the monitoring and enforcement of market rules reduces such instruments' ability to deliver desired environmental outcomes

"Markets connect; prices inform." The success of modern market economies and the attraction of governments to using market-based economic instruments to achieve policy goals rests on these two principles. [118] Well-designed and implemented, market-based water-trading regimes should deliver efficient allocation of resources towards policy goals with a minimum of government intervention in individual decisions. Australia has developed some of the most highly sophisticated water markets in the world in the Murray-Darling Basin. [26] These water markets have two key elements: (a) they operate within sustainable diversion limits (SDLs) set by government agencies to "cap" water extractions in each catchment alongside a set of hydrological and water movement rules; and (b) the creation of tradeable property rights in water, separate from land, to allow for efficient trade of water. The creation of these property rights consequently has been used to facilitate the buyback of water rights from willing sellers, to reduce consumptive use and allow the transfer of water rights to the environment as a legitimate user. [119], [120] The introduction of water markets alongside other water reform policy instruments during the past two decades represents a major policy shift from the previous water management regime in the Basin. Critical elements of this policy shift have been resisted by many irrigators and irrigator representative bodies, albeit the majority of irrigators have shown strong support for water markets, especially temporary water markets. [121]

The use of Basin water markets to recover water for the environment can only contribute to delivering the environmental outcomes legislated in the *Water Act* alongside other economic and regulatory instruments if limits on water extraction are set at an adequate level, rules are set in place regarding transfers and hydrologic impacts, water accounting is comprehensive, metered and accurate, institutions are robust, and compliance is rigorously monitored and enforced. [122] The efficient operation of the price mechanism in water markets also requires the removal of subsidies that distort the decisions of market participants. [112] [64] However, evidence suggests that the design and implementation of economic and regulatory instruments in the Basin as part of Australia's water policy reform process have been subject to a number of influences common to the implementation of such major policy shifts worldwide. [92], [123], [124] [125]

"Cap and trade" markets by definition limit access to a resource for which there is high demand, whether to water for irrigation or the atmosphere as a carbon sink. This changes prices, which change financial flows, which change the viability of existing business practices built around the status quo. These changes are always difficult politically because they create winners and losers. [118] One strategy for the losers, or those who perceive themselves as likely to become losers because they believe change will be difficult, is to lobby governments to: (a) set the cap at a less stringent level; (b) provide industry subsidies; and/or (c) weaken market rules and monitoring and enforcement regimes. [96], [125]([126] They can also attempt to capture market regulators and administrators. Evidence presented at the recent South Australian Murray Darling Basin Royal Commission suggests that such strategies have been deployed by those with a vested interest in maintaining high levels of water extraction in the Basin. [28]

For example, instead of a rigorous, evidence-based focus on setting an "environmentally sustainable level of take" (ESLT) that has a high likelihood of protecting and restoring the ecological integrity of the Basin's river systems, the Basin Plan appears to have set an ESLT and corresponding SDLs with the primary objective of keeping the perceived socio-economic impacts of limiting water extractions for irrigation to a minimum. [28], [56] Similarly, key institutions have been compromised by vested interests leading to poor compliance and enforcement of market regulations and water extractions in NSW and Queensland. [124] [127] Such outcomes are not uncommon when policy attempts to recalibrate the level at which industries are able to exploit a valuable natural capital asset for private gain. The European Union and Australian emissions trading schemes suffered from many of the same issues. [125] While there are often sound economic and equity reasons to provide well-targeted structural adjustment assistance to those negatively impacted by the implementation of policy to protect the long-term integrity of natural capital assets, such assistance needs to be designed and implemented separately from the major elements of the policy reform process. Compromising policy reform to limit its impact hinders the structural transformations required to meet policy objectives. Current evidence in the Basin suggests that this structural adjustment has been handled poorly. [42], [128]

None of this should be taken to suggest that the combination of economic and regulatory instruments to improve the management of water in the Basin has not delivered co-benefits in line with other NWI objectives. The Basin's water markets have allowed water to move to higher value uses and enabled irrigators and other consumptive users to increase their business flexibility, reduce debt and increase innovation and adaptation. [26], [31], [98], [129], [130] However, at the core of the *Water Act* is an environmental requirement to limit extractions to an "environmentally sustainable level" in order to deliver a volume of water for the entire Basin that is enough to restore and protect the Basin's freshwater ecosystems. The delivery of adequate volumes of environmental water requires limiting extractions for consumptive use, primarily by irrigated agriculture, as well as significantly improved management of water quality and environmental flows. There is significant evidence that the Basin's current water policy settings will not assist in delivering the *Water Act's* environmental objectives, particularly in the context of climate change. [15], [123], [131]-[133] The current management of planned environmental water suggests that the impacts of reductions to water available in the Basin from climate change will be borne primarily by the environment. [134] Only further policy reform can change this outcome.

3.b. Markets for ecosystem services can provide incentives to drive efficient achievement of other natural resource management outcomes essential for restoration and protection of Australia's freshwater systems as well as linked marine and terrestrial ecosystems, but the quality of outcomes markets deliver depends on good design, management and enforcement

Adequate volumes of water are a necessary, but not sufficient condition for protection and restoration of aquatic ecosystems. In the Murray-Darling and in other Australian river systems, improving water quality is also important to restore and protect the health of freshwater ecosystems and linked marine and terrestrial ecosystems. Well-designed markets can help improve water quality outcomes. For example, the NSW Government's statutory Hunter River Salinity Trading Scheme has operated successfully since 2003. The Scheme is a "cap and trade" scheme that allows for salt load licensing and trading to reduce Hunter River salinity. [135], [136] The Scheme's success required high quality data and hydrological modelling of the river, resolution of long-standing tensions between farmers, miners and power station owners, and a shared focus on environmental outcomes. [136] Ongoing operation of the Scheme involves the use of real-time data from an integrated telemetry system that acquires data from a water quality and flow monitoring network, weather stations, pumping stations, power stations and wastewater treatment facilities. [135]

The potential for nitrogen trading in Queensland catchments that drain into the Great Barrier Reef provides an example of an opportunity for the future use of markets to drive environmental outcomes. Farming fertiliser runoff causes nitrogen pollution in catchments that drain into the Great Barrier Reef, which damages reef ecosystems and is associated with crown-of-thorn starfish population outbreaks. [137], [138] However, current management efforts to reduce the discharge of terrestrial pollutants like nitrogen into the Great Barrier Reef "remain largely ineffectual with little chance of meeting the required targets in the specified timeframes." [137] In this context, a "cap and trade" nitrogen market mechanism has been proposed to incentivise farm-level reductions in fertilizer use with a consequent drop in end-of-catchment inorganic nitrogen loads. [138] A study simulating such a market mechanism in the Tully catchment in the Wet Tropics found that nitrogen trading would be a cost-effective method to reduce the load of dissolved inorganic nitrogen and improve water-quality. [139] The Great Barrier Reef Water Science Taskforce acknowledges that while data and enforcement and monitoring tools are not yet available, further "collection of data and development of farm-based tools would provide the underpinning for a cap and trade scheme for the future." [140] Simiarly, carbon soil markets are another important economic instrument that could greatly improve both the productivity of land and the protection of freshwater systems. [141]

Markets such as these provide one policy instrument to better manage wider environmental impacts in Australian catchments. The incentives they provide can be used to improve land, water and biodiversity management. "Cap and trade" markets with their focus on a quantitative and measurable environmental goal also drive innovation because they prescribe an outcome rather than a particular means of achieving it (e.g. they avoid focussing on specific technological solutions). However, there remain a number of challenges to the widespread implementation of environmental markets, which include:

- ***Environmental markets work best where environmental outcomes can be specifically defined and managed within a single jurisdiction***. The Hunter River has a single objective (salinity reduction) and operates in a single catchment in NSW. Coordinating multiple markets for broader water quality outcomes across a trans-jurisdictional river basin like the Murray-Darling would be more challenging and requires significantly more market design effort and resources for monitoring and compliance.
- ***Adequate regulation and monitoring combined with high-quality, accurate data are essential for efficient and effective markets***. Hunter Salinity Trading Scheme managers have much more available data for market management than that available to the MDBA, particularly for some parts of the northern Basin where there remain serious concerns about proper metering, flood plain harvesting, and the protection of environmental water as it travels through the system. [56], [124], [142], [143] Environmental water is a national asset purchased at considerable public expense. Unfortunately comprehensive systems, including accurate, real-time metering and other basic monitoring and enforcement regimes are not yet in place across the Murray-Darling Basin to ensure that this national asset is protected and available to be used as planned. [143]-[145] Similarly, the potential for nitrogen markets in Great Barrier Reef catchments will remain limited until better data and monitoring systems are available.
- ***Market design needs to be aligned with freshwater system hydrology and ecology to deliver effective outcomes***. Market features designed to increase the economic efficiency of markets can create unintended environmental outcomes. For example, surface water transfers out of areas vulnerable to salinity can reduce field-level water availability below the minimum required to flush salts out of the root zone with consequent increases in soil salinity. [146] Similarly, the timing of water extractions and transfers may be

economically optimal for irrigators, but sub-optimal for the delivery of environmental outcomes. [122] Good market design can often manage such unintended consequences, but it requires clear identification and implementation of a primary policy goal (e.g. environmental protection and restoration) aligned with hydrological realities. [147]

- *The process of setting limits and ensuring high-quality monitoring can be captured by vested interests.* This has been discussed in some detail in Issue 2 above.
- *Market designers can struggle to ensure broader values are integrated and considered in market operation*. [148] For example, separate mechanisms are likely to be required in water and other ecosystems services markets to ensure that First Peoples' rights are respected (see First Peoples' Water Rights issues paper for options). Similarly, multiple instruments are needed to deliver environmental outcomes where these are dependent on matching market operations to underlying hydrological realities and the management of a range of environmental requirements including water volume, water quality and the timing of environmental water flows. As a general principle, there should be as many instruments as there are policy targets. [147] [149]
- *The impact of subsidies needs to also be considered*. Subsidies for irrigation infrastructure likely distort existing water markets and increase the risks of environmental degradation. [112] [64]

3.c. Environmental NGOs play a vital role as trusted brokers and innovators within existing market structures. When they work within markets as water holders, their work is complementary and cannot replace the heavy-lifting required by governments

Environmental NGOs have played an important role in environmental markets for many years by acting as trusted brokers and innovators. [150] They have the potential to provide complementary mechanisms for the acquisition of water rights in existing water markets for use in achieving environmental, agricultural and social outcomes using approaches like "impact investment". [151], [152] Impact investments are "investments made into companies, organisations, and funds with the intention to generate social and environmental impact alongside a financial return."[153] One example is the "Water Sharing Investment Partnership" (WSIP) created by The Nature Conservancy (an international environmental NGO) in collaboration with the Murray-Darling Wetlands Working Group (a local conservation group) and Kilter Rural (an asset manager). [154] The WSIP has created a MDB Balanced Water Fund and an Environmental Water Trust as its two primary vehicles, building a considerable portfolio of permanent water entitlements with the twin goals of providing "water security for Australian farming families while protecting culturally significant wetlands that support threatened species." [154], [155]

The Balanced Water Fund sells and leases water allocations associated with its portfolio of water entitlements to farmers to generate its return on investment alongside donating water to the Environmental Water Trust for targeted wetland restoration in areas of "high ecological and Aboriginal cultural significance." [154] The Nature Conservancy believes it can resolve the potential for competition between agricultural, environmental and First Peoples' water needs by strategically structuring the Balanced Water Fund. The Fund is structured to allocate water entitlements to sales and leases to irrigators in dry years, when water is valuable, and donate water to the environment and First Peoples in wet years, when farmers have lower irrigation water requirements and water can be allocated to wetland inundation to match natural flow patterns. [154]

By linking water donations to an "impact investment" model that generates a return for investment, The Nature Conservancy believes it has provided a solution that "generates environmental and social benefits at a far greater scale than could be achieved under a traditional philanthropy-funded model." [154] It arguably also provides a model of investment that promotes the potential for outcomes that demonstrate it is possible to deliver jobs and environmental benefits. However, this aspect of the Fund is not that dissimilar to the Commonwealth Environmental Water Holder (CEWH), which also makes water allocations available for agricultural use when forecast conditions mean priority environmental watering requirements can be met. [156]

Some commentators have suggested that impact investment innovations like the Nature Conservancy's Water Sharing Investment Partnership "necessitate a reconsideration of environmental water recovery initiatives within the Basin, from a largely government-led process to one that will involve a flexible mix of competition and collaboration between government and non-government actors." [152] While additional impact investment models that can add to water available for the environment in areas like the Murray-Darling should be welcomed and can provide important examples of policy innovation, there are important differences in scale between government and non-government actors that must be recognised. The Balanced Water Fund's current water holdings are likely to be at least two orders of magnitude smaller than those of the CEWH. The goal of the Balanced Water Fund is to eventually provide for the total purchase of 40 GL of water entitlements to be used for irrigation sales and leases as well as environmental and First Peoples' water. If achieved, this target represents less than 1.5% of the CEWH's current goal. [154]

Given these considerable differences in scale, impact investment models are likely to remain a small, albeit welcome, complement to a predominantly government-led process of environmental water recovery in systems like the MDB. They provide an important mechanism for nimble policy innovation by trialing different approaches to coordinating resources and investment for environmental and social benefit, which may later be taken up at scale by governments. However, non-governmental investment cannot replace or fully compensate for poor government-led outcomes because the scale at which the majority of non-government actors can work is too small. If current water recovery volumes for the Murray-Darling are too low to achieve the protection and recovery outcomes required by the *Water Act*, it remains the work of government to increase them. Non-government organisations can play a critical role here in holding governments to account for their failure to deliver environmental outcomes required by legislation. [56], [92], [158]

What can be done

Limiting water extractions for environmental objectives

It is clear that the experience of setting limits to water extractions in the MDB was not a "value neutral", technical exercise in which it would be possible to "optimise economic, social and environmental outcomes". [15], [123] Instead, setting limits to irrigation extractions presented policy-makers with a "wicked problem" requiring value judgements be made under conditions of great uncertainty. [159], [160],[161] No "optimal" solution existed that could be delivered by application of technical methods because there was (and is) no consensus in defining the problem itself. [159], [160], [162] Different interest groups have different value systems and are pursuing different and conflicting interests. [159], [160]

Nevertheless, as pointed out by international peer reviewers of the *Guide to the proposed Basin Plan*, the politically contentious nature of limiting water extractions for environmental benefit requires governments be explicit and transparent about the value judgements that drive decision-making and assume responsibility for their decisions. [15] This did not happen between 2010 and 2012. Instead, the idea of "optimising economic, social and environmental outcomes" appears to have become a "fig leaf" covering more politically motivated decision-making. [88], [95]

Avoiding such outcomes in future, whether in a re-examination of Murray-Darling Basin SDLs or in the expansion of water markets to northern Australia as part of broader development projects, requires the abandonment of any pretense that "optimal" solutions exist that allow a "balance" to be struck between economic, environmental and social outcomes. Seeking to "simultaneously grapple with economic, environmental and social outcomes" is more likely to "achieve the optimisation of none of them." [123]

Market instruments tasked with delivering environmental outcomes must be widely understood by all stakeholders as providing a mechanism for the efficient achievement of a set of primary environmental objectives. [147] Sequencing options for implementation of changes to water market design need to be carefully explored along with their probable implications to minimize political impediments to achieving policy outcomes and ensure that appropriate transitional assistance can be provided to affected groups. [108], [161]

Decision-makers need to adopt a robust, open and transparent process of assessment and decision-making that reviews and tests options for delivering environmental outcomes alongside explicitly acknowledged risks and uncertainties. Possible socio-economic impacts need to be openly assessed alongside publicly-available, independent reviews of different approaches to structural adjustment and compensation. [15] Funding must be made available for independent, peer-reviewed, high quality environmental and socio-economic analyses. Socio-economic studies should not be used to compromise environmental outcomes—the proper role of such studies is to provide policy makers with an evidence base with which to design effective structural adjustment packages. [161] The Murray–Darling Basin Ministerial Council's December 2018 decision to apply socio-economic criteria to efficiency measures projects is likely to struggle to avoid this issue. [114]

Improving monitoring and compliance

The Australian Government announced the launch of its $20 million Hydrometric Networks and Remote Sensing Funding Program designed to "develop remote sensing and other technologies to enhance monitoring, measurement and compliance in all Basin jurisdictions" on 27 November 2018. The Murray-Darling Basin Ministerial Council welcomed this funding at its meeting on 14 December 2018 and all jurisdictions supported the "Commonwealth's commitment to draft legislative amendments to the *Water Act 2007* to strengthen the MDBA's compliance and enforcement powers," which include new offences and penalties to deal with water theft. [114] The Productivity Commission has identified that the MDBA's role as the trusted advisor and agent of governments in the Basin Plan's implementation as well as being the regulator of the Plan compromises the MDBA's credibility and the effective implementation of the Plan. It also reduces community confidence in the MDBA and Basin governments. The Productivity Commission has recommended that the MDBA be split into two agencies: a Murray-Darling Basin Agency and a Basin Plan Regulator. These future changes may deal with some of the monitoring and compliance issues identified above (see the ***Governance*** issues paper for further details).

Philanthropic organisations can consider:

- supporting the establishment of an independently-funded national freshwater resources think tank to undertake independent research to provide an evidence-base for innovation in water market design and implementation
- supporting the development of a national water research information "hub" to ensure scientific, socio-economic, cultural and public policy research on water resources management is publicly available
- supporting civil society organisations with the resources and skills to independently evaluate policy decisions on water market design, operation and governance structures
- supporting civil society organisations and other experts to develop and widely circulate a publicly accessible "users guide" to best practice methods for conducting government decision-making processes where important and contested value judgements must be made
- contributing to or establishing innovative and experimental approaches to investment in water markets and associated environmental markets that provide environmental and social benefits.

4. Regulatory, planning and investment frameworks for urban water constrain the full consideration of options, from stormwater reuse to scarcity pricing, necessary to provide our cities with a diversified and resilient portfolio of urban water services.

Australia's major urban areas currently have high levels of water security. [42] This is not the case in all regional and remote communities. [42], [163] Irrespective of present water security, climate change and population growth present long-term urban water security challenges in many parts of Australia. [164] [42] Urban water planning, investment and management practices require ongoing improvement to ensure the future climate resilience and cost-effectiveness of urban water services for Australia's growing cities as well as its regional communities. [42], [164] Current regulatory, planning and investment frameworks for urban water constrain the full consideration of options.

Water utilities face a series of difficult challenges from climate change and population growth. [164] Their long-lived, capital-intensive assets require robust and careful planning. However, climate change and population growth present planners with considerable uncertainties. [164], [165] Many of these uncertainties are irreducible on the timescales required for infrastructure decision-making. Water infrastructure planning has traditionally operated under the assumption that variations and extremes occur with probabilities that can be inferred from the historical record and used for risk management and cost-benefit analysis of investment options. Climate change and population growth uncertainties increase the planning challenge for urban water utilities primarily because they make historical rainfall and temperature records as well as demand growth projections unreliable references for future planning. [166] Climate change alters the probabilities of events—e.g. droughts and extreme rainfall—in ways that we do not understand, even if we can project the likely trends at coarse scales. [166] Decision theorists refer to these changes as being subject to “deep” uncertainty. [167]

If future conditions differ markedly from the conditions for which assets were designed, investments may no longer deliver expected service-levels and general water security. As a result, water utilities’ financial and services performance can be compromised. [168] Water-supply and wastewater infrastructure also shape urban development for longer than the lifetime of individual assets as cities and economies reorganise themselves around the services provided. [167] Consequently, urban water infrastructure decisions can lock in levels of water use, crowd out alternative options and cause feedback effects that increase long-term water requirements, worsening future water shortages. [169] Adaptive management strategies can appear an obvious option, [69] however, while such strategies can be successful, particularly on the demand-side, they are often difficult to implement for water-supply infrastructure. [170]

Urban water managers have begun to respond to the risks presented by climate change and greater awareness of Australia’s high rainfall variability occasioned by the Millennium drought. [164] Major urban water utility planners began to reconsider their use of historical rainfall records to calculate probabilities for future supply-yield estimates in the 2000s. Perth ceased using this approach in 2009. [171] All major water utilities have now undertaken climate change studies and incorporate climate change risks in to their decision-making and planning processes. [171] However, the regulatory environment in which urban water utilities operate, the limitations of existing planning frameworks, political sensitivities surrounding water pricing and water supplies and community perceptions of the suitability of some supply options (e.g. potable reuse, rural-urban water transfers) all constrain the effectiveness of planning for uncertain climate and population futures. [42], [172] A number of these constraints are explored further below.

4.a. Approaches to infrastructure investment planning and appraisal like standard cost-benefit analysis may not identify investments that are robust under conditions of future uncertainty like those created by climate change and population growth

While some water utilities began to apply “real options” approaches to planning for major supply augmentation decisions during the Millennium drought, [164] cost-benefit analysis remains the standard approach to evaluating infrastructure investments where a rigorous approach to investment appraisal is used. The Productivity Commission has documented numerous occasions where major investments have been made without thorough cost-benefit analysis being undertaken at all. [42] Standard approaches to cost-benefit analysis may not be well suited to the evaluation of investments under conditions of deep uncertainty like those created by climate change and population growth because they are too reliant on the assumptions used in the analysis. If future conditions deviate from assumptions used, the investments and decisions they inform may not perform as expected. [173], [174] Even where probabilistic techniques from traditional risk analysis are used with sensitivity testing, decisions made using standard cost-benefit analysis techniques remain dependent on the probability distributions chosen. [167], [173]

Standard cost-benefit analysis approaches seek the “best” or “optimal” option based on best-estimate assumptions about the future (e.g. population size, changes in rainfall patterns). In contrast, robust decision making (RDM) techniques ask which option, out of a set of possibilities, performs satisfactorily over the widest range of plausible futures. [175] RDM recognises that "optimal" solutions under one set of assumptions about the future can fail under different assumptions and that the most robust option is often not the best performing one under any single or small set of plausible futures. [176] RDM techniques are particularly useful for the evaluation of mixed portfolios of investment options from both the supply and demand sides with differing characteristics under conditions of deep uncertainty—precisely the problem now faced by urban water utilities. [177] The RDM approach helps decision-makers identify and manage trade-offs, respond to multiple performance objectives, and consider demand and supply sides within broader system requirements. RDM techniques also help decision-makers challenge conventional assumptions about "efficiency" and "least-cost", which often privilege the status quo over more innovative approaches to urban water management like Integrated Water Cycle Management (IWCM) (see discussion below). [173], [175] Some of the world's largest water resource agencies have used RDM techniques to explore robust investment options in the context climate change and population growth uncertainties, but RDM has yet to be widely used in Australia. [168], [170], [174], [178], [179]

4.b. Regulatory frameworks may constrain the use of innovative planning, decision-making and water services delivery approaches that better manage future uncertainty

Robustness is rarely free. [178] Trade-offs often need to be made between least-cost options that perform well under ideal conditions often reflecting the status quo and options that are robust to a wide range of plausible futures. Decision-makers need to value robustness and understand how much it is worth to their key stakeholders.[178] This is yet to be done effectively in Australia. Urban water investment and management decisions are subject to evaluation by independent economic regulators who use more narrowly defined measures of performance like least-cost metrics subject to service level requirements that contain considerable status quo bias. [168] RDM techniques are usually more expensive and demanding to apply than standard cost-benefit approaches and require more highly-skilled practitioners. However, the cost of RDM analysis is small in comparison to the sunk costs incurred if major investments underperform or fail because of future climate change or population growth outcomes not considered during investment appraisal. [168], [178] RDM techniques also provide more rigorous analysis of innovative solutions because a wider range of evaluation criteria and objectives can be more easily incorporated into the evaluation process. Development, planning and delivery of innovative urban water portfolios that build cost-effective and robust responses to uncertainty will be unlikely to be able to be properly evaluated on their merits until (a) changes are made to relatively inflexible economic and environmental regulations, and (b) governments develop regulatory criteria for evaluating the cost-effectiveness of robustness. [42], [168], [180], [181]

Smaller-scale, decentralised, district IWCM approaches offer a robust solution to climate change and population growth pressures and uncertainties at a precinct level. They are particularly well-suited to greenfield developments where they offer considerable financial and environmental benefits. [181] IWCM approaches deliver water management solutions that integrate water supply, wastewater and stormwater management, rather than managing them as separate activities in the way conventionally done by large, centralised urban water utilities. [182] From an IWCM perspective, stormwater is a water source to be harvested, not a flood risk to be managed. It can be integrated into the urban landscape to increase amenity or treated for potable use. Wastewater is also a water source and recycling it can reduce wastewater transport and infrastructure costs. [42], [180]-[182] Decentralised IWCM approaches are also useful for promoting competition in the water sector. In the right locations and under the right regulatory settings they can be cost-competitive with conventional, centralised approaches to water services provision. [180], [181] However, independent economic regulation frameworks in some states may constrain water utilities from regularly working in collaboration with local government to deliver integrated portfolios of water management solutions for large urban areas alongside smaller, niche providers of innovative solutions like IWCM. [42], [172], [180], [181]

4.c. *Current approaches to urban water pricing impair good decision-making about the timing of supply augmentation investments*

Depending on the jurisdiction, urban water prices in Australia are set by state governments, local governments or independent economic regulators. [183] Urban water prices influence the allocation of resources across the urban water supply chain and provide signals that influence demand- and supply-side decisions and investment patterns. [42] [36] Existing price regulation based on a fixed rate of return for a weighted average cost of capital may distort demand-side decisions and also may provide incentives for utilities to invest in new sources of supply before they are actually required. [184] [36], [185], [186] As a consequence, existing price structures and regulatory approaches to price-setting for retail tariffs as well as bulk water, stormwater and wastewater services all have the potential to constrain effective and efficient decision-making in the face of uncertainties from climate change and population growth. [36] [186], [187] [188]

Urban water pricing methodologies could be significantly improved in all jurisdictions to provide better signals to consumers about the costs of providing urban water services and improve supply augmentation decisions. [36] [42], [184], [188] For example, dynamic or "scarcity" pricing that allows prices to vary depending on existing water supplies would provide a more economically efficient method of: (a) managing demand by increasing prices when supplies are low; and (b) identifying when supply augmentation decisions may be economically justified (i.e. if very large increases in price are required to reduce demand). [36], [184] [186] [188] Ensuring that developer changes reflect the full costs of adding new users to existing networks is also crucial to allowing alternative, decentralised IWCM approaches to be evaluated on an equivalent basis to the expansion of existing centralised water services provision. Full cost comparisons should include environmental externalities and risk-adjusted user costs that take account of future water supply uncertainties. [188] [42]

4.d. *Crisis-driven political interference in major infrastructure and water management decisions remains a serious problem with long-term consequences for climate resilience of urban water services*

Major urban water infrastructure investments were made during the Millennium drought without appropriate evaluation of alternative options. [189] Ten billion dollars was spent on desalination plants in capital cities alone. [190] In Canberra, a decision was made to augment the Cotter Dam and the Victorian government also funded the construction of the north-south pipeline to make rural water available for urban supply augmentation (the use of which was then curtailed by political considerations[191]). In NSW and Victoria, these investment decisions were not subject to regulatory scrutiny and ministerial directions and regulatory orders prevent economic regulators from evaluating whether these investments were efficient—although Auditors-General not subject to the same restraints have been highly critical of these investments. [35], [42] Even Sydney Water's more considered "real options" approach to evaluating any decision to adopt desalination was disregarded when a political decision was made to fast track a plant. [164]

Crisis-driven political decisions such as these have provided major cities with rainfall independent water sources and increased their short- to medium-term water security. However, they have done so at considerable financial cost and with a number of potentially negative long-term consequences, which may eventually decrease resilience to climate change and population growth pressures. [171], [189] For example, desalination plants are now sunk costs and incorporated into consumer prices. Expenditure on the plants has crowded out other options like IWCM except in greenfield sites not yet connected to centralised water and wastewater transport systems or flagship brownfields sites like Sydney's Barangaroo. [171], [172] By introducing rainfall-independent water sources, desalination has reduced the need for cities to diversify their water supply options in the short- to medium-term and is likely to increase the risk of the "reservoir effect" where supply augmentation increases demand and increases cities' long-term vulnerability to future climate change and population growth induced water "shocks". [169] Perth provides an excellent example of this—a focus on supply augmentation, some of it very innovative, is accompanied by higher household water use than other Australian capital cities despite the fact that Perth has been dealing with a step change in rainfall since the 1970s and faces major climate change risks to its rain-fed water supplies. [171]

What can be done

Urban water managers and regulators require outcomes-focussed and flexible economic regulatory frameworks and more robust investment decision-making tools to drive innovation and better prepare Australian cities and towns for uncertain climate change and population futures. Examples of the changes required include:

- Improving competition in the provision of urban water services and the integration of IWCM. The *NSW Water Industry Competition Act 2006* provides an excellent model for other states and has created new markets for water innovation. Progress in other states lags behind NSW and world's best practice. [42], [180], [181]
- Enacting objective-focussed rather than prescriptive regulatory frameworks to enable better integration of planning decisions across geographic scales, between responsible agencies and across multiple objectives (e.g. innovation, economic efficiency, improved water quality). [42] See for example the development of options for Seqwater and the Port of Brisbane to reduce their input costs by managing upstream catchments, options that have been constrained by existing economic regulatory frameworks. [192]
- Better use of robust decision-making techniques to evaluate urban water services investment options. See for example planning done for London, California's Inland Empire Utilities Agency, and four interconnected regional water utilities in North Carolina's "research triangle" region. [168], [170], [174], [178]
- Making changes to regulation to ensure consideration of options like IWCM and demand-side responses occurs on an equal footing to standard, centralised options. [42]

Philanthropic organisations can consider:

- supporting independent research and civil society organisations capable of holding governments to account and demanding a commitment to rigorous assessment of investment options and long-term planning to ensure that political expediency does not dominate urban water investment decision-making
- supporting research and the development of a strong evidence-base to contribute to changing regulations that constrain the full development of a broad portfolio of urban water management solutions for Australian cities and towns
- working with urban water utilities, civil society organisations and universities to develop and trial RDM approaches to long-term planning for climate change and population growth resilient water services development in Australian cities.

Again, these three options for philanthropic action suggest that there is likely to be an important role for philanthropy in supporting the establishment of an independent **national freshwater resources think tank** tasked with promoting independent research and generating evidence-based and innovative urban water policy and investment options.

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