Submission to the Productivity Commission's Inquiry into National Water Reform

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CSIRO welcomes the opportunity to provide input into the Productivity Commission National Water Reform Inquiry. Our submission contains:

A) Preamble: a summary of CSIRO contributions to national water reform

B) CSIRO response to the inquiry terms of reference: we provide comments pertaining to "The interaction of water policy with other policy areas such as energy, agriculture, planning, urban supply"

C) CSIRO response to the specific questions posed in the Issues Paper: input in response to a number of the Information Requests described in the Issues Paper.

CSIRO is happy to elaborate on our submission should the Commission consider that valuable.

A) Preamble

KEY POINTS:

- *CSIRO has contributed to National Water Initiative actions through the delivery of a framework for water resource assessments, which has been applied across Australia.*
- *CSIRO's partnership with the Bureau of Meteorology on water information has delivered tools and data that underpin a range of cutting edge water information services.*

National Water Initiative – Knowledge and Capacity Building

Over the last decade, CSIRO has contributed significantly to National Water Initiative actions under Element 7 – Knowledge and Capacity Building. As a consequence, Australia has a nationally consistent integrated water resource assessment framework to assess historical characteristics of water availability (and hydroclimate variability over temporal and spatial scales) and water use (irrigation and environment) and predict future outcomes under climate change and development. This framework has been applied to the Murray-Darling Basin, Northern Australia, south-west Western Australia, Tasmania and the Great Artesian Basin. The framework has been extended to water and agricultural resource assessments in northern Australia that identify and evaluate water capture and storage options, identify and test the commercial viability of irrigated agricultural opportunities, and assess potential environmental, social, cultural and economic impacts and risks.

Commonwealth Water Act 2007 – Improving Water Information Program

CSIRO's research partnership with the Bureau of Meteorology on water information has, for the first time, delivered:

i) streamflow forecasting services used by regional water managers for water scheduling to water allocation decisions;
ii) water data transfer formats embedded in commercial water industry software and used by water agencies across Australia as a repeatable and reliable means to exchange water information;
iii) landscape water balance models to underpin national water accounting, on-going regional water availability assessments (the impacts of coal seam gas and coal development on water assets; water resource development potential in northern Australia); and
iv) foundation data sets including: digital elevation model for the continent; improved rainfall and evapotranspiration estimates especially in areas with sparse measurement.

B) CSIRO response to the inquiry terms of reference

CSIRO offers the following comments and published references to the following part of the inquiry terms of reference: ***"the interaction of water policy with other policy areas such as energy, agriculture, planning, urban supply"***.

KEY POINTS:

- *CSIRO encourages the Commission to take a whole-of-economy and systems view of water management to ensure Australia has the foresighting capacity to ensure informed choices as policies and actions are adapted to long-run change (for example, climate change, food and energy security), and account for feedbacks across society and the economy (avoiding inadvertent maladaptation).*

The role of science and access to the best available information has been a core underpinning to the National Water Initiative to support water reform outcomes. Climate and water resource projections when coupled with foresighting provides a powerful analytical underpinning for future policy formulation and evaluation.

Water management in a foresighting context

CSIRO draws the Commission's attention to the **Australian National Outlook 2015** (Hatfield Dodds *et al.* 2015). In 2015 CSIRO released the Australian National Outlook (ANO). The ANO is a first attempt to understand and analyse the connections in Australia's physical economy many decades into the future – economic activity, resource use, environmental performance and living standards, 1970-2050.

The ANO:

- seeks to provide a better understanding of Australia's physical economy. It has a particular focus on understanding two aspects: The 'water-energy-food' nexus and the prospects for Australia's materials- and energy-intensive industries.
- explores over 20 possible futures for Australia out to 2050 against the backdrop of the past 40 years to identify key future global drivers and assess how these may impact our country.
- integrates these global perspectives into a uniquely Australian context in relation to plausible technological and policy settings we might consider as a nation to secure our future prosperity.

The key insights summary addressing food & agriculture, water & environment, and energy can be found at: https://www.csiro.au/en/Research/Major-initiatives/Australian-National-Outlook/National-Outlook-publications/Main-reports

Avoiding maladaptation

Responding to climate change in a way that avoids maladaptation (inadvertently taking actions that seem adaptive but which end up resulting in an overall loss of benefit to society) requires cross-sectoral policy as well as action. Maladaptation may result from cross-sectoral effects, where benefit seems to be obtained in one sector but at the expense of another (Barnett and O'Neill 2010). In essence, different policy areas such as water, energy, agriculture and planning are all part of a larger water value chain. CSIRO has been developing integrated systems approaches to understanding and effectively responding to climate risks for complex value chains. Currently these are being applied internationally in the agriculture sector and in the mining sector (Hodgkinson *et al.* 2013, Lim-Camacho *et al.* 2017, see https://adaptivevaluechains.com/), but they could be applied to the water value chain in Australia to reveal how much and in what ways policy areas should intersect to avoid maladaptation.

References

Barnett, J. and S. O'Neill. 2010. Maladaptation. *Global Environmental Change* 20: 211-213.

Hatfield-Dodds, S., H. Schandl, P.D. Adams, T.M. Baynes, T.S. Brinsmead, B.A. Bryan, F.H.S. Chiew, P.W. Graham, M. Grundy, T. Harwood, R. McCallum, R. McCrea, L.E. McKellar, D. Newth, M. Nolan, I. Prosser, A. Wonhas. 2015. *Nature* 527: 49-52.

Hodgkinson, J. H., B. Loechel, S. Crimp. 2013. Informing the future of Australian mining through climate change scenarios. *Proceedings of the 20th International Congress on Modelling and Simulation* (MODSIM2013): 2221-2227.

Lim-Camacho, L., A. Ariyawardana, G. K. Lewis, S. J. Crimp, S. Somogyi, B. Ridoutt, S. M. Howden. 2017. Climate adaptation of food value chains: the implications of varying consumer acceptance. *Regional Environmental Change* 17: 93-103.

C) CSIRO response to the specific questions posed in the Issues Paper

CSIRO offers the following comments and published references to a subset of the Information Requests described in the Issues Paper.

Page 7: Data and information sources that might be useful for assessing progress

KEY POINTS:

- *CSIRO draws to the Commission's attention an independent review of the impact (benefits) of water resource assessments commissioned by the National Water Commission.*

In 2014 CSIRO undertook an independent review of the impact of the water resource assessments undertaken by CSIRO on behalf of the Commonwealth. The headline finding of the ACIL Allen review included an economic assessment of two of many major water management decisions informed by CSIRO research (Murray-Darling Basin and the construction of irrigation schemes across Tasmania) estimated benefits of between $685–795 million and $1.24 billion, respectively. The link to download this report can be found at: https://www.csiro.au/en/About/Our-impact/Our-impact-in-action/Natural-environment/Water-assessment

Page 10: Feedback on the preliminary framework (table 1)

KEY POINTS:

- *CSIRO supports the preliminary framework for National Water Reform priorities.*

The role of best available information and managing uncertainty are explicitly recognised. However, effectively addressing climate change (see below) may require a slightly different approach to 'cost-benefit' as recommended in the National Water Commission's 2014 assessment (Recommendation 8). This is because cost-benefit analysis is only one of multiple types of strategic decision-making processes based on economic theory and is arguably the one least suited to making effective decisions under conditions of uncertainty (UNFCCC 2009, Watkiss and Hunt 2013). There are a range of other approaches (see Watkiss and Hunt 2013) and CSIRO has been developing tools and approaches to make them practicable in the Australian context (e.g. Wise *et al.* 2014, see also https://research.csiro.au/eap/). Beyond 'cost-benefit analysis' a broader 'strategic decision-making analyses and processes (e.g. real options analysis, portfolio analysis, cost-benefit analysis)' approach could be considered.

References

UNFCCC. 2009. Potential costs and benefits of adaptation options: a review of existing literature. UNFCCC Technical Paper, Markandya, A. and Watkiss P. F. Available at: http://unfccc.int/resource/docs/2009/tp/02.pdf.

Watkiss, P. and A. Hunt. 2013. Method Overview: Decision Support Methods for Adaptation, Briefing Note 1. Summary of Methods and Case Study Examples from the MEDIATION Project. Available at: http://www.mediation-project.eu/platform/pbs/pdf/Briefing-Note-1-LR.pdf.

Wise R.M., I. Fazey, M. Stafford Smith, S.E. Park, H.C. Eakin, E.R.M. Archer Van Gardenen, B. Campbell. 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. *Global Environmental Change* 28: 325-336.

Page 10: Key contemporary and future drivers of water reform

KEY POINTS:

- *Evolving climate change mitigation and adaptation strategies within the reform and water planning processes will be critical to Australia's water security.*
- *Adaptation will fundamentally require new objectives and a different strategic approach to making decisions– adaptation at the socio-institutional level.*
- *Australia has been at the forefront of new global thinking on adaptation. We suggest these 'second-generation' approaches to adaptation are worth evaluating as Australian governments revise water policy and planning to adapt to projected change.*

As recognised in the terms of reference for the Inquiry, climate change must be considered a key driver of water reform. This is not just a future driver but a contemporary one as well given significant changes in water availability and seasonality already being experienced (Chiew *et al.* 2011, CSIRO 2012, Commonwealth of Australia 2015). Reform is also needed now in order to have many solutions in place by the time they are needed, as there may be significant lead times involved in developing and implementing new approaches (Stafford Smith *et al.* 2011, Wise *et al.* 2014).

Adaptation will fundamentally require new objectives and a different strategic approach to making decisions – adaptation at the socio-institutional level (Stafford Smith *et al.* 2011, Cartwright *et al.* 2013, Gorddard *et al.* 2016). The current system of allocating water assumes that all goals can be achieved through careful control of allocation decisions. Under climate change, the total amount available is highly likely to decrease in most parts of Australia while demand is likely to increase due to a drier climate and population growth. Thus, status quo goals will become less achievable and controllable and decisions are likely to become ever more contentious, more polarised (Colloff *et al.* 2016, Restemeyer *et al.* 2017). In this context, the opportunities for adaptation often appear limited.

Climate adaptation as a discipline has become increasingly focused on how governments and other organisations can set more achievable objectives, broker common ground between different interests based on values, make better decisions in the context of uncertainty, and stage adaptation over time to ensure groundwork is laid now for future solutions. This fundamentally involves institution, governance, and strategy reform and broadens the opportunities for addressing climate change in a proactive way (Stafford Smith *et al.* 2011, Colloff *et al.* 2016, Gorddard *et al.* 2016).

Australia has been at the forefront of this new global thinking on adaptation, building tools and approaches that we can use to help governments and other organisations transform the way they make decisions to ensure better outcomes under climate change – approaches like foresighting, adaptation pathways, partnership brokering with diverse stakeholders, better distributed governance, and more flexible adaptive planning processes (Wise *et al.* 2014, Rissik *et al.* 2014, Abel *et al.* 2016). These more strategic, 'second-generation' approaches to adaptation have not yet been applied in a domestic water policy or management context but we suggest are worth evaluating as Australian governments revise water policy and planning to adapt to projected change.

References

Abel, N., Wise, R.M., Colloff, M.J., Walker, B.H., Butler, J.R.A., Ryan, P., Norman, C., Langston, A., Anderies, J.M., Gorddard, R., Dunlop, M. and O'Connell, D. 2016. Building a resilient pathway towards transformation when "no-one is in charge": insights from Australia's Murray-Darling Basin. *Ecology and Society* 21: 23.

Cartwright, A., J. Blignaut, M. De Wit, K. Goldberg, M. Mander, S. O'Donoghue, and D. Roberts. 2013. Economics of climate change adaptation at the local scale under conditions of uncertainty and resource constraints: the case of Durban, South Africa. *Environment and Urbanization* 25: 139-156.

Chiew FHS, Young WJ, Cai W and Teng J (2011) Current drought and future hydroclimate projections in southeast Australia and implications for water resources management. *Stochastic Environmental Research and Risk Assessment*, 25, 601–612, doi:10.1007/s00477-010-0424-x.

Colloff M. J., Lavorel S., Wise R. M., Dunlop M., Overton I. C., Williams K. J. 2016. Adaptation services of floodplains and wetlands under transformational climate change. *Ecological Applications* 26: 1003-1017.

Commonwealth of Australia. 2015. National Climate Resilience and Adaptation Strategy. Australian Government, Canberra. Available at: www.environment.gov.au.

CSIRO (2012) Climate and water availability in south-eastern Australia – A synthesis of findings from Phase 2 of the South Eastern Australian Climate Initiative (SEACI). CSIRO, Australia, 41 pp.

Gorddard R, Colloff MJ, Wise RM, Ware D and Dunlop M (2016) Values, rules and knowledge: adaptation as change in the decision context. *Environmental Science and Policy*, 57, 60–69.

Restemeyer, B. M. van den Brink, and J. Woltjer. 2017. Between adaptability and the urge to control: making long-term water policies in the Netherlands. *Journal of Environmental Planning and Management* 60: 920-940.

Rissik D., S. Boulter, V. Doerr, N. Marshall, A. Hobday and L. Lim-Camacho. 2014. The NRM Adaptation Checklist: supporting climate adaptation planning and decision-making for regional NRM. CSIRO and NCCARF, Australia. Available at: www.AdaptNRM.org.

Stafford Smith, M., L. Horrocks, A. Harvey and C. Hamilton. 2011. Rethinking adaptation for a 4oC world. *Philosophical Transactions of the Royal Society* 369: 196-216.

Page 14: Are processes for reviewing water plans sufficiently robust, transparent, open, and timely?

KEY POINTS:

- *CSIRO encourages the Commission to review the robustness of monitoring and evaluation to ensure that local and basin wide benefits can be demonstrated and quantified.*

Localism is central to environmental water management and reform in the Murray-Darling Basin. These principles can be summarized as follows:

1. Local perspectives are understood and translated into water allocations for environmental use
2. Local groups are supported through nominated state, regional and local engagement structures
3. Local values and priorities are evident in community engagement, information provision and monitoring and evaluation activities and functions (Australian Government 2011)

Contrary to expectations that local and basin-scale interests and outcomes may diverge, case-study analysis has revealed the ability for local groups to collaboratively manage both land and water resources to achieve locally important outcomes, and contribute to basin-scale outcomes (Robinson *et al.* 2015). Yet localism does require robust monitoring and evaluation reporting frameworks that can account for local and basin wide benefits of environmental water allocations at multiple (local, regional and basin-wide) scales. In regions that are significant for Indigenous communities, annual cross-cultural evaluation, planning and delivery of water cross-scales may be needed to inform flow planning at the site and the basin scale for the next year.

References

Australian Government. 2011. A Framework for Determining Commonwealth Environmental Water Use. Canberra: Australian Government Publishing Services. http://www.environment.gov.au/resource/framework-determining-commonwealth-environmental-water-use.

Robinson CJ, Bark RH, Garrick D, Pollino CA. 2015.Sustaining local values through river basin governance: community-based initiatives in Australia's Murray–Darling Basin 58 (12), 2212-2227. *Journal of Environmental Planning and Management*, 58(12), 2212-2227.DOI: 10.1080/09640568.2014.976699

Page 14: Is there scope to improve how water plans deal with long-term shifts in climate affecting resource availability? Are there recent examples of leading practice?

KEY POINTS:

- *In comparison to a decade ago, Australia has a much stronger technical basis (climate projections and water forecasting) for developing the next generation of water plans to account for hydrologic non-stationarity.*
- *There is an opportunity for Australia to embed 'second-generation' adaptation into water planning – this may require shifts in stakeholder brokering, decision-making, and governance.*

Hydroclimate projections

The latest national hydroclimate projections for Australia are provided at www.climatechangeinaustralia.gov.au[1,2]. Projections with finer spatial detail are available for Victoria[3] and New South Wales[4]. Far south-east Australia and far south-west Australia are likely to be drier in the future with more frequent prolonged dry periods (particularly in winter when most of the runoff occurs)[5,6], and eastern Australia may experience heavier summer rainfall with potential consequences for water availability and flood risk[7]. These sources of information provide guidance on climate change for planning in the water and related sectors.

The past is no guide to the future – uncertainty needs to be addressed systemically

Hydrologic non-stationarity and changes to ecohydrology must also be accounted for when models are extrapolated to predict water futures not seen in the past (higher temperature and potential evaporation, higher CO_2 and changed rainfall patterns)[8]. It is not sufficient for water plans to include a quantification of uncertainty. There is also a need to develop an uncertainty framework at the management/regulator level. Casting groundwater impact metrics in a probabilistic framework will have greatest benefits to groundwater management if management rules (currently deterministic) are also expressed in a probabilistic sense.

Water planning and climate change

Some impacts of climate change can be mitigated through actions such as the refinement of water plans, establishing water trade, buffering the system from stress through water buybacks for the environment, maximising the benefits of environmental watering, and establishing plans to cope with long dry periods[9]. With risks of large shifts in future hydroclimates, however, climate adaptation requires more fundamental reform to planning and decision-making processes and governance with a foundation based on shared values to establish desirable long-term outcomes under alternative plausible futures (see comments above under ***p10 Key contemporary and future drivers of water reform***). Currently, water resources adaptation is dominated by a more restricted predict-then-act-approach[10,11], which is not well suited to planning under conditions of uncertainty or large change.

Second-generation adaptation

Attractive alternatives involve 'second-generation' adaptation (also see above) which include fundamental shifts in stakeholder brokering, decision-making, and governance. At the risk assessment level, they can also involve the 'bottom-up' or 'scenario-neutral' approach[12,13], which focuses on a systems model and key system drivers to determine the system's exposures to climate variability and then assess what this means in terms of the projected climate futures. This method reduces the reliance on detailed predictive climate information and grounds the assessment in an understanding of the system itself. Increasingly the system

definition includes the socio-economic-institutional context, which broadens the areas in which effective adaptation options can be found[14].

These second-generation approaches and adaptation at the strategic level are likely to be critical to developing plans that can continue to be successful given future operational demands and practices, and that perform satisfactorily under a range of alternative climate pathways. However, taking advantage of new approaches may require significant reform in the fundamental model of water allocations and trading (see comments above under ***Key contemporary and future drivers of water reform***).

At a technical level water management planning needs to actively challenge the consensus understanding of a system and seek out different system conceptualisations that agree with the available data and knowledge or at least identify those assumptions that have the greatest potential to fundamentally alter water resource management[15]. This is a first step in recognising deep uncertainty and developing management strategies that are robust, i.e. that lead to acceptable water resource status despite incomplete knowledge[16]. Participatory modelling tools[17] have been shown to be useful tools to engage with stakeholders to develop and communicate such strategies.

References

[1]CSIRO and Bureau of Meteorology (2015) Climate change in Australia Information for Australia's Natural Resource Management Regions. Technical Report, CSIRO and Bureau of Meteorology, Australia, 216 pp.

[2]Chiew F and Prosser I (2011) Water and climate. In: *Water – Science and Solutions for Australia* (Editor: I Prosser), CSIRO Publishing, (ISBN 9780643100527), pp. 29–46.

[3]Potter NJ, Chiew FHS, Zheng H, Ekstrom M and Zhang L (2016) Hydroclimate projections for Victoria at 2040 and 2065. CSIRO, Australia, http://publications.csiro.au/rpr/pub?pid=csiro:EP161427.

[4]Evans JP, Ji F, Lee CP, Argüeso D and Fita L (2014) Design of a regional climate modelling projection ensemble experiment, NARCliM, *Geoscience Model Development*, 7, 621–629.

[5]Chiew FHS, Young WJ, Cai W and Teng J (2011) Current drought and future hydroclimate projections in southeast Australia and implications for water resources management. *Stochastic Environmental Research and Risk Assessment*, 25, 601–612, doi:10.1007/s00477-010-0424-x.

[6]CSIRO (2012) Climate and water availability in south-eastern Australia – A synthesis of findings from Phase 2 of the South Eastern Australian Climate Initiative (SEACI). CSIRO, Australia, 41 pp.

[7]Johnson F, White CJ, van Dijk A, Ekström M, Evans JP, Jakob D, Kiem AS, Leonard M, Rouillard A and Westra S (2016) Natural hazards in Australia: floods, *Climatic Change*, 139, 21–35.

[8]Chiew FHS, Potter NJ, Vaze J, Petheram C, Zhang L, Teng J and Post DA (2014) Observed hydrologic non-stationarity in far south-eastern Australia: implications and future modelling predictions. *Stochastic Environmental Research and Risk Assessment*, 28, 3–15, doi:10.1007/s00477-013-0755-5.

[9]Neave I, McLeod A, Raisin G and Swirepik J (2015) Managing water in the Murray-Darling Basin under a variable and changing climate. Water, April 2015, pp. 102–107.

[10]Ekström M, Kuruppu N, Wilby RL, Fowler HJ, Chiew FHS, Dessai S and Young WJ (2013) Examination of climate risk using a modified uncertainty matrix framework—Applications in the water sector, *Global Environmental Change*, 23, 115-129

[11]Reisinger A, Kitching RL, Chiew F, Hughes L, Newton PCD, Schuster SS, Tait A and Whetton P (2014) Australasia. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the *Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Editors: VR Barros, CB Field *et al.*). Cambridge University Press, pp. 1371–1438.

[12]Prudhomme C, Wilby R, Crooks S, Kay A and Reynard N (2010) Scenario-neutral approach to climate change impact studies: application to flood risk. *Journal of Hydrology,* 390**,** 198–209.

[13]Whateley S, Steinschneider S and Brown C (2014) A climate change range-based method for estimating robustness for water resources supply. *Water Resources Research,* 50**,** 8944–8961.

[14]Gorddard R, Colloff MJ, Wise RM, Ware D and Dunlop M (2016) Values, rules and knowledge: adaptation as change in the decision context. *Environmental Science and Policy*, 57, 60–69.

[15]Peeters L J M, Pagendam D, Crosbie R S, Viney N R, Rachakonda P K, Dawes W R, Gao L, Marvanek. S, Zhang Y Q and McVicar T R (2017) Building confidence in environmental impact models through quantitative and qualitative uncertainty analysis. In preparation for *Environmental Modelling and Software*.

[16]Gao L, Bryan BA, Nolan M, Connor JD, Song X, Zhao G (2016). Robust global sensitivity analysis under deep uncertainty via scenario analysis. *Environmental Modelling and Software*, Volume 76: 154–166.

[17]Castilla-Rho JC, Mariethoz G, Rojas R, Andersen MS, Kelly BFJ. (2015) An agent-based platform for simulating complex human–aquifer interactions in managed groundwater systems. *Environmental Modelling & Software* 73, 305-323.

Page 14: Are current water entitlement and planning frameworks conducive to investor confidence, facilitating investment in major new infrastructure (such as in northern Australia), while managing risks to the supply security of existing water users?

KEY POINTS:

- *In the presence of adequate information decisions on water resource development and investor confidence can be significantly enhanced.*

Ongoing interest in developing the water resources of northern Australia has not met with commensurate on-ground investment. On-ground investment in northern Australia requires both the investor and the regulator to have confidence in both opportunities and risks. In the absence of adequate information regulators tend to make conservative decisions that restrict resource allocation and, hence, opportunities for investment. One way to improve the confidence of regulators and investors is to provide information at a finer spatial and temporal scale than is currently available.

In 2012 the Australian Government commissioned CSIRO to undertake the Flinders and Gilbert Agricultural Resource Assessment, a large multi-disciplinary assessment of the soil, land and water resources of these two catchments. https://www.csiro.au/en/Research/LWF/Areas/Water-resources/Assessing-water-resources/Flinders-Gilbert. The Assessment provided baseline information on a wide range of parameters including soil, surface and groundwater resources, water storage options, irrigated cropping, Indigenous aspirations and water values, the economics of existing and potential industries and information on the risks that may attend different forms of water resource development. The information and products generated by Assessment provided numbers that public and private investors could trust and resulted in both public and private outcomes. For example, the work provided clarity over the nature and scale of the opportunity of irrigation and water resource development in these two catchments, focusing attention where it was most warranted. It resulted in a revision of water resource plans with regulators having sufficient confidence to allocate more than a four-fold increase in water, and the work informed projects of state significance. In terms of private outcomes it provided investors with confidence to attract external capital and spend their internal capital; it reduced enterprise start-up costs. CSIRO is currently undertaking a similar assessment in three more regions in northern Australia, the Fitzroy (WA), four catchments near Darwin (NT) and the Mitchell (Qld). This work will be completed in June 2018.

Page 14: How can the interests and needs of Indigenous people be better accommodated and represented in water planning processes?

KEY POINTS:

- *Recent studies show how collaborative and adaptive governance approaches and the application of cultural ecosystem services could offer useful planning and evaluation frameworks to negotiate and track progress of water planning reforms for Indigenous people.*

Indigenous water values, water rights, and cultural flows

CSIRO has undertaken an extensive series of studies of Indigenous water values, rights and interests across northern and southern Australia. These include water planning analyses and syntheses (Jackson 2009, Jackson and Altman 2009, Jackson and Robinson 2010, Jackson 2011, Jackson and Langton 2012, Jackson *et al.* 2012b) and regional studies in the Murray Darling Basin (Maclean *et al.* 2012, Bark *et al.* 2015) Robinson *et al.* 2015, the Pilbara (Barber and Jackson 2011a, 2012b), the Kimberley (Jackson *et al.* 2012a, Woodward *et al.* 2012), multiple catchments in the Northern Territory (Jackson 2005, Barber and Jackson 2011b, Jackson and Barber 2013), and key rivers in North Queensland (Barber *et al.* 2012, Barber 2013) (Maclean and Bana Yaralji Bubu Inc. 2011). Indigenous water values, rights and interests is a component of the CSIRO Northern Australia Water Resource Assessment.

In 2010 CSIRO assessed the effects of changes in water availability on Indigenous people in the Murray Darling Basin. Mechanisms to increase benefits to Indigenous groups from increased access to environmental water and management decisions were identified and shown how collaborative and adaptive governance approaches and the application of cultural ecosystem services could offer useful planning and evaluation frameworks to negotiate and track progress of water planning reforms for Indigenous people in the Basin (Bark *et al.* 2015; 2016; Robinson *et al.* 2015). The report can be found at: https://www.mdba.gov.au/sites/default/files/archived/basinplan/833-MDBA-Indigenous-SIA-Final-Oct-071010.pdf.

References

Barber, M. 2013. Indigenous water values, rights and interests in the Flinders and Gilbert catchments. A technical report to the Australian Government from the CSIRO Flinders and Gilbert Agricultural Resource Assessment, part of the North Queensland Irrigated Agriculture Strategy CSIRO Water for a Healthy Country and Sustainable Agriculture flagships, Australia, Canberra.

Barber, M., S. Jackson, J. Shellberg, and V. Sinnamon. 2014. Working knowledge: local ecological and hydrological knowledge about the flooded forest country of Oriners Station, Cape York. *The Rangeland Journal* 36:53-66.

Barber, M., J. Shellberg, S. Jackson, and V. Sinnamon. 2012. Working knowledge: local ecological and hydrological knowledge about the flooded forest country of Oriners Station, Cape York. CSIRO, Darwin.

Bark, R. H., M. Barber, S. Jackson, K. Maclean, C. Pollino, and B. Moggridge. 2015. Operationalising the ecosystem services approach in water planning: a case study of indigenous cultural values from the Murray–Darling Basin, Australia. *International Journal of Biodiversity Science, Ecosystem Services & Management*:1-11.

Jackson, S. 2005. Indigenous values and water resource management: a case study from the Northern Territory. *Australasian Journal of Environmental Management* 12:136-146.

Jackson, S. 2009. National indigenous water planning forum: background paper on indigenous participation in water planning and access to water. CSIRO, Darwin.

Jackson, S. 2011. Aboriginal access to water in Australia: opportunities and constraints. Pages 601-628 in Q. Grafton and K. Hussey, editors. *Water resources, planning and management*. Cambridge, Cambridge University Press.

Jackson, S., and J. Altman. 2009. Indigenous rights and water policy: perspectives from tropical northern Australia. *Australian Indigenous Law Review* 13:27-48.

Jackson, S., and M. Barber. 2013. Recognition of Indigenous water values in Australia's Northern Territory: current progress and ongoing challenges for social justice in water planning. *Journal of Planning Theory and Practice* 14:435-454.

Jackson, S., M. Finn, and P. Featherston. 2012a. Aquatic resource use by indigenous Australians in two tropical river catchments: the Fitzroy River and Daly River. *Human Ecology* 40:893-908.

Jackson, S., and M. Langton. 2012. Trends in the recognition of indigenous water needs in Australian water reform: the limitations of 'cultural' entitlements in achieving water equity. *Journal of Water Law* 22:109-123.

Jackson, S., and C. Robinson. 2010. Indigenous participation in water planning and governance. Report to the Northern Land and Water Taskforce: Chapter 30. Brisbane.
Jackson, S., P. Tan, C. Mooney, S. Hoverman, and I. White. 2012b. Principles and guidelines for good practice in Indigenous engagement in water planning. *Journal of Hydrology* 474:57-65.
Maclean, K., and Bana Yaralji Bubu Inc. 2011. Water Dreaming: Kuku Nyungkal people, water and country in the Wet Tropics. CSIRO, Brisbane.
Maclean, K., R. Bark, B. Moggridge, S. Jackson, and C. Pollino. 2012. Ngemba water values and interests Ngemba Old Mission Billabong and Brewarrina Aboriginal fish traps (Baiame's Nguunhu). CSIRO, Brisbane.
Woodward, E. 2010. Creating the Ngan'gi Seasons calendar: reflections on engaging Indigenous knowledge authorities in research. Learning Communities: *International Journal of Learning in Social Contexts* 2:125-137.
Woodward, E., S. Jackson, M. Finn, and P. Marfurra McTaggart. 2012. Utilising Indigenous seasonal knowledge to understand indigenous aquatic resource use and inform water resource management. *Ecological Management and Restoration* 13.

Page 14: What steps have been taken — or should be taken — to integrate water quality objectives into water planning arrangements?

KEY POINTS:

- *Broadening of water quality objectives and integrating them into both urban and rural development planning can improve both public health and environmental health outcomes.*

Broadly speaking, water quality is considered in relation to the impact on receiving environments such as for discharge of wastewaters to the marine environment or recharge/discharge of water to an aquifer. Currently the EPA regulates wastewater discharge to the marine environment, but not stormwater – despite the fact this can also be high in phosphorus. Greater incorporation of water quality objectives in water planning arrangements may provide greater impetus for stormwater harvesting and use (and reuse in general).

In relation to water recycling, water quality is addressed through the suite of Australian Guidelines for Water Recycling within the National Water Quality Management Standards. One of these, the Managed Aquifer Recharge (MAR) Guidelines, addresses both water quantity and quality issues relevant to managed aquifer recharge (with any water source) and water recycling. While aimed at focusing efforts to the greatest risks, these guidelines require considerable data that can add to the cost of establishing schemes, and more so if novel schemes (especially if microbial or organic chemical hazards are involved). These guidelines could be revised to incorporate new knowledge and improve their practicality.

According to the 2015/16 national performance, water recycling in Australia continues to increase. However there remains a tendency for recycling via third pipe systems, which is unlikely to be an economical use option. Third pipe options were shown to be uneconomical for stormwater use within the MARSUO project (Dandy G *et al*. 2013; Dillon *et al.* 2014).

References

Dandy, G., Ganji, A., Kandulu, J., Hatton MacDonald, D., Marchi, A., Maier, H., Mankad, A. and Schmidt, C.E.2013, Managed Aquifer Recharge and Stormwater Use Options: Net Benefits Report*,* Goyder Institute for Water Research. *Goyder Institute for Water Research*. Technical Report Series No. 14/1
Dillon P., Page, D., Dandy, G., Leonard, R., Tjandraatmadja, G., Vanderzalm, J., Rouse, K., Barry, K., Gonzalez, D. and Myers, B. (2014). Managed Aquifer Recharge Stormwater Use Options: Summary of Research Findings, *Goyder Institute for Water Research*, Technical Report 14/13.

Page 16: To what extent has the NWI goal of open water trading markets been achieved?

KEY POINTS:

- *The utility of water trading markets has been demonstrated using hydro-economic modelling, particularly in the case of using trading to sustaining irrigated agriculture and provision of environmental water flows.*

The utility of water trading markets has been demonstrated using hydro-economic modelling (O'Connor *et al.* 2013, Mainuddin *et al.* 2007), particularly in the Murray-Darling Basin (Queshri *et al.* 2007, 2011). This is particularly in the case of using trading to sustaining irrigated agriculture (Kirby *et al.* 2014) and provision of environmental water flows.

Key outcomes are that:

- adaptation strategies (including trading) provide a range of flow and economic outcomes in the Murray-Darling Basin.
- several strategies offer significant scope to enhance flows without large adverse impacts on the gross income of irrigation overall.
- should a projected dry extreme climate change be realized, no strategy can prevent a large reduction in flows and also in gross income, particularly of low value irrigation industries.
- in all scenarios considered, net revenue gains from freeing trade are estimated to outweigh the negative revenue effects of reallocating water for environmental flows.

References

Kirby, M., Bark, R., Connor, J., Qureshi, M.E., and Keyworth, S., 2014. Sustainable irrigation: how did irrigated agriculture in the Murray-Darling Basin, Australia, adapt in the Millennium Drought. *Agricultural Water Management special issue on Sustainable Irrigation*, 145, 154-162.

Connor, J.D., Franklin, B., Loch, A., Kirby, M. and Wheeler, S.A., 2013. Trading water to improve environmental outcomes. *Water Resources Research*, 49-12. doi:10.1002/wrcr.20323.

Mohammed Mainuddin, Mac Kirby and Ejaz Qureshi, 2007. Integrated Hydrologic-Economic Modelling for Analyzing Water Acquisition Strategies of the Murray River Basin. *Agricultural Water Management*, 93, 123-135.

Qureshi, E., Connor, J., Kirby, M. and Mainuddin, M., 2007. Economic Assessment of Environmental Flows in the Murray Basin. Australian *Journal of Agricultural and Resource Economics*, 51, 283-303.

Qureshi, ME, Grafton, RQ, Kirby, M, and Hanjra, MA, 2011. Understanding irrigation water use efficiency at different scales for better policy reform: a case study if the Murray-Darling Basin, Australia. *Water Policy* 13, 1-17.

Page 16: Are there worthwhile opportunities to expand trade to new regions and water resources?

KEY POINTS:

- *With recent technical developments in real time sensing in catchments and seasonal streamflow forecast we believe there is a stronger technical basis that could support expanded trade into new regions and water resources.*

Real-time water resources management

For the first time in Tasmania, federated real-time water resources data are being used by a community of irrigators for managing water availability for irrigation and environmental requirements, i.e. in the Ringarooma River catchment, north-east Tasmania (Smethurst *et al.* 2016). Irrigators cooperate through a water users group, and aim to avoid flows decreasing below an environmental threshold that would trigger a 'cease-to-take' regulation that may occur during the dry season when irrigation demands are high. At times when there is high risk of a cease-to-take declaration occurring, irrigators coordinate within and

outside the group, and with the regulator, to reduce extractions of water from the river and coordinate releases of stored water. Adopting data-driven real-time management has contributed to the avoidance of cease-to-take declarations during the past two years, despite increased irrigation. Several novel aspects of this project include: federating irrigator-relevant data from multiple agencies, daily stream flow forecasts (from the eWater 'Source' model), localised weather forecasts (from a national meteorological model), and a strong community spirit of cooperation in managing water resources and environmental values. This sets a basis for more sophisticated water management, including: sub-catchment water management, and flow predictions that potentially include daily extractions and releases (http://www.sense-t.org.au/projects-and-research/agriculture)

Seasonal streamflow forecasting

Seasonal forecast of streamflow and water system inflows can help moderate the volatility of water trading and enhance the effectiveness of water markets. A national streamflow forecasting product, developed by CSIRO and Bureau of Meteorology research, is now delivered routinely by the Bureau of Meteorology (http://www.bom.gov.au/water/ssf/; Wang *et al.* 2015; Bennett *et al.* 2016), yet allocation outlooks are issued based on long term averages or scenarios. The seasonal forecast will need to be tailored and communicated specifically for water trading, providing timely 'outlook' information for everyone in the water market.

References

Bennett JC, Wang QJ, Li M, Robertson DE and Schepen A (2016) Reliable long-range ensemble streamflow forecasts: combining calibrated climate forecasts with a conceptual runoff model and a staged error model. *Water Resources Research*, 52, 8238–8259, doi:10.1002/2016WR019193

Smethurst, Philip; Morrison, Brigid; Almeida, Auro; Carins, Jeremy; Davenport, Alan; Edeson, Greg; *et al.* Real-time water resources information used for water sharing in a Tasmanian irrigation community. In: *HWRS2015*; Dec 2015; Hobart. Engineers Australia; 2016. 8 p

Wang QJ, Robertson DE, Bennett JC, Schepen A, Li M, Song Y, Tuteja NK, Shin DH, Zhou S, Lerat J and Feikema PM (2015) Scientific progress on seasonal streamflow forecasting. Proceedings of the *36th Hydrology and Water Resources Symposium – The art and science of water*, Engineers Australia, Dec 2015, pp 601–608, http://search.informit.com.au/documentSummary;dn=823115635281055;res=IELENG> ISBN: 9781922107497.

Page 19: What are the guiding principles for 'best practice' management of environmental water?

KEY POINTS:

- *One of the key guiding principles for best practice management of environmental water is the capacity to monitor and support adaptive management.*
- *There remains a gap in the use of monitoring and predictive tools to guide and inform the management of environmental water, specifically as it relates to outcomes at a basin-scale for ecological assets and function, the prioritisation of use of environmental water and exploring the multiple benefits of environmental water.*

In exploring ecological responses to environmental watering CSIRO and university partners developed basin-scale approaches to monitoring, evaluation and prioritisation of decisions for environmental flows (Bunn *et al.* 2014) through the Environmental Flows Research Cluster. CSIRO also developed a method that underpins the Sustainable Diversion Limit (SDL) Adjustment mechanism in the Basin Plan (Overton *et al.* 2014, Overton *et al.* 2015). Being a temporal and spatial method, this has the potential to be extended to prediction of environmental watering of assets and functions on an annual and strategic basis, to assist prioritisation of decisions. The use of Earth Observation for monitoring ecological asset and functional responses to environmental watering remains limited, however, these approaches have been demonstrated to be effective (Sims and Colloff 2012, Doody *et al.* 2014).

In exploring multiple benefits of environmental water, CSIRO has undertaken an evaluation of ecosystem services for the Basin Plan (MDBA 2010). This remains the most comprehensive assessment of the benefits of environmental watering at a basin scale, and has the potential to underpin management of environmental water and 'best practice' beyond ecological parts of a system.

References

Bunn, S. E., N. R. Bond, J. Davis, B. Gawne, M. Kennard, A. J. King, R. T. Kingsford, J. D. Koehn, S. Linke, J. Olley, E. Peterson, C. Pollino, F. Sheldon, N. Sims, R. S. Thompson, D. P. Ward, and R. Watts. 2014. Ecological responses to altered flow regimes. Synthesis Report., CSIRO Water for a Healthy Country, Clayton, Melbourne.

Doody, T. M., S. N. Benger, J. L. Pritchard, and I. C. Overton. 2014. Ecological response of *Eucalyptus camaldulensis* (river red gum) to extended drought and flooding along the River Murray, South Australia (1997–2011) and implications for environmental flow management. *Marine and Freshwater Research* 65:1082-1093.

MDBA. 2010. Assessing environmental water needs of the Basin (April 2010). MDBA, Canberra.

Overton, I., C. Pollino, N. Grigg, J. Roberts, J. Reid, N. Bond, D. Barma, A. Freebairn, D. Stratford, and K. Evans. 2015. The Ecological Elements Method for adjusting the Murray–Darling Basin Plan Sustainable Diversion Limit. Development of the Murray–Darling Basin Plan SDL Adjustment Ecological Elements Method, Report prepared by CSIRO for the Murray-Darling Basin Authority, Canberra

Overton, I. C., C. Pollino, J. Roberts, J. R. W. Reid, N. R. Bond, H. M. McGinness, B. Gawne, Stratford D.S., L. E. Merrin, D. Barma, S. M. Cuddy, D. L. Nielsen, T. Smith, B. L. Henderson, D. S. Baldwin, G. S. Chiu, and T. M. Doody. 2014. Development of the Murray-Darling Basin Plan SDL Adjustment Ecological Elements Method. . Report prepared for the Murray-Darling Basin Authority. CSIRO, Canberra.

Sims, N. C., and M. J. Colloff. 2012. Remote sensing of vegetation responses to flooding of a semi-arid floodplain: Implications for monitoring ecological effects of environmental flows. *Ecological Indicators* 18:387-391.

Page 25: What policy and institutional arrangements are needed in the urban water sector to improve the efficiency of service provision?

KEY POINTS:

- *There are opportunities to integrate non-potable use water services within the urban water sector.*

Current urban water policy and institutional arrangements focus primarily on potable water use and much less to the application of alternative water and application for non-potable uses. The market for non-potable water is limited or absent and consequently uptake of these sources is poor. Drawing on valid scientific data to develop policy and institutional arrangements for encouraging alternative water uses, particularly for non-potable uses, would improve this.

Page 25: Is there a case to increase the involvement of customers in regulatory decision making, as is commencing in Victoria? If so, what is the best way to do this?

KEY POINTS:

- *Community engagement in the decisions involving recycled water has been critical to their acceptance.*

Lessons from the millennium drought demonstrated that community and customer engagement from the commencement of any water based supply decisions or processes significantly increased the acceptance and subsequent success of changes to water policy and new water schemes (particularly relating to water recycling and alternative water use). Community and stakeholder involvement, especially during the

planning of new green field areas, will help in improving transparency about water security, safety, and sustainability of water and wastewater services.

Page 25: How can the level of competition in the provision of urban water services be increased?

KEY POINTS:

- *There are options that may facilitate greater competition leading to increased provision of urban water services.*

The level of competition in the provision of urban water services can be increased by:

i) improving the ability of water suppliers (including new companies) to access and utilise alternative water sources such as urban stormwater and recycled water could increase completion in the water market;
ii) diversification of supplies e.g., use of captured stormwater and treatment to class A level may be a more economically viable option than centralised supply which requires long distance pumping; and
iii) new innovative technology and local community-based alternatives water supply options could increase competition and cut water costs.

Page 25: Do water and wastewater services delivered to regional and remote communities, including Indigenous communities, comply with relevant public health, safety, and environmental regulations? If not, what policy remedies might improve performance?

KEY POINTS:

- *Recent studies reveal that adequate understanding of water resources (in particular groundwater), and training in the operation/maintenance of water supply systems are key factors for water security and safeguarding health outcomes in remote regional communities.*

There are significant challenges in delivering drinking water and sewage services in rural and remote communities. Both drinking water quality and wastewater management are significant issues in northern part of the country. There is evidence that many small communities are currently challenged to provide adequate water treatment systems through a lack of support and local operational knowledge. Many small councils are also attracted to installing complex water treatment schemes that they have neither the operating resources nor appropriately trained staff to operate, resulting in treatment failures.

Simple decentralised systems for water recycling can be cheaper to run due to the capture and use of alternative water at the site, but are difficult to manage if not operated appropriately. Development of design, operation and maintenance of systems is required to ensure they work properly and do not pose a public health risk in the event of system failure.

Guidelines to validate decentralised systems, both engineered and natural systems which could be implemented at national scale, can improve confidence in operation and ability to meet set water quality parameters. Examples are available at: http://www.australianwaterrecycling.com.au/

CSIRO, in collaboration with Goyder Institute for Water Research partners, has developed a novel hydrogeophysical approach through the Facilitating Long-term Outback Water Solutions (FLOWS) initiative, that has been effective in exploring and evaluating groundwater resources in the APY lands, SA (Parsekian *et al.* 2014). The Aboriginal population of the APY lands in South Australia is dependent on groundwater for nearly all water needs. In that region, placement of wells in productive aquifers of appropriate water quality is challenging because of lack of hydrologic data and variable aquifer properties. A combined geophysical approach with airborne and ground-based data sets was successful in locating a potential aquifer, confirm water content, and estimate the subsurface extent of the water-bearing zone. Systematic application of such methodologies would facilitate better targeting of areas for on-ground drilling

investigations. The main advantages of these surveys are that they are able to cover very wide areas in a short time, and thus avoid lengthy prospecting campaigns on the ground. Drilling can then be targeted, increasing the success rate of bores drilled into significant aquifers which directly reduces the upfront costs.

References

Parsekian A, Grombacher D, Davis A, Flinchum B, Munday T, and Cahill K (2014). Near-surface geophysics for informed water-management decisions in the Anangu Pitjantjatjara Yankunytjatjara (APY) lands of South Australia. *THE LEADING EDGE*, December, pp. 1342-1347. http://dx.doi.org/10.1190/tle33121342.1.