SEVENTH FRAMEWORK PROGRAMME
THEME 6: Environment (including Climate Change)

Adaptive strategies to Mitigate the Impacts of Climate Change on European Freshwater Ecosystems

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 244121
Duration: February 1st, 2010 – January 31st, 2014

Deliverable 7.11: Proceedings of international stakeholder meeting in Australia

Lead contractor: **Griffith**

Due date of deliverable: **Month 44**
Actual submission date: **Month 48**

Work package: 7
Contributors: Samantha Capon (Griffith)
Estimated person months: 4

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013) Dissemination Level (add X to PU, PP. RE or CO)		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Abstract
Environmental water represents the cornerstone in Australia's approach to adapting freshwater ecosystems to climate change. As an adaptation tool, environmental water aim to minimise existing stressors, build resilience, protect refuges or enable triage during extreme events, e.g. drought. Over the next century, however, there are likely to be considerable changes in the climatic, cultural and institutional settings within which planning and management of environmental water occurs.

The allocation of environmental water and flows is the major policy response to meeting the needs of aquatic ecosystems, given the challenges of climate change and the development pressures facing Australian rivers. The challenge is to wisely deliver this environmental water (operational phase) given that institutional, legal, and environmental knowledge and frameworks are in their infancy relative to overall water resource development and management. Given our current knowledge and experience, and what we assume about the uncertainties about the future, what are the opportunities and challenges for the management of environmental water in 2030.

To meet this challenge the Water Resources and Freshwater Biodiversity Adaptation Network (National Climate Change Adaptation Research Facility) ran a national workshop from the 4th to 5th September 2012, with the support of the University of Canberra. This Deliverable comprises a report from the meeting, together with an article on the workshop that appeared in a magazine, RipRap.

NCCARF
National
Climate Change Adaptation
Research Facility
Adaptation Research Network
WATER RESOURCES AND FRESHWATER BIODIVERSITY

The Future of Environmental Water:

Identifying drivers, constraints and approaches to delivering water to Australia's freshwater ecosystems in the 21st Century

1. Background

Environmental water represents the cornerstone in Australia's approach to adapting freshwater ecosystems to climate change. As an adaptation tool, environmental water aim to minimise existing stressors, build resilience, protect refuges or enable triage during extreme events, e.g. drought. Over the next century, however, there are likely to be considerable changes in the climatic, cultural and institutional settings within which planning and management of environmental water occurs.

The allocation of environmental water and flows is the major policy response to meeting the needs of aquatic ecosystems, given the challenges of climate change and the development pressures facing Australian rivers. The challenge is to wisely deliver this environmental water (operational phase) given that institutional, legal, and environmental knowledge and frameworks are in their infancy relative to overall water resource development and management. Given our current knowledge and experience, and what we assume about the uncertainties about the future, what are the opportunities and challenges for the management of environmental water in 2030

To meet this challenge the Water Resources and Freshwater Biodiversity Adaptation Network (National Climate Change Adaptation Research Facility) ran a national workshop from the 4th to 5th September 2012, with the support of the University of Canberra.

2. Objectives

The workshop aimed to explore these potential changes so that priorities for research and institutional change can be identified. The key objectives were:

- to identify the likely biophysical, socio-economic, cultural and institutional constraints on the delivery of environmental water in the mid-future
- to identify possible drivers and opportunities for improving the delivery of environmental water into the 21st Century
- to identify technological, social and institutional changes that may influence planning and management in the mid-future
- to identify major knowledge gaps and priorities for science to provide knowledge to improve environmental water planning and management
- to build capacity by bringing together a diverse array of actors involved in environmental water planning and management and the science to support

3. Discussion

The workshop used a web based tool call iMeet, which is an interactive application that captures discussions within small groups working concurrently, and allows for the analysis, organisation and evaluation of ideas. The workshop involved a mixture of plenary sessions with keynote speakers, with participants working in small groups and capturing their discussions on iMeet. To facilitate discussions the workshop posed a number of questions to participants and speakers including:

- What will the objectives and targets for environmental water be in 2030?
- What institutional arrangements for managing environmental water will exist in 2030?
- How will environmental water be delivered and monitored in 2030?
- What knowledge will underpin environmental water planning and management in 2030?
- What would be different in a repeat of the 'Big Dry'?
- What technology and infrastructure will be used for delivering and monitoring environmental water?

The workshop also considered three future climate scenarios as outlined below as a way to focus the discussions.

Scenario	Antecedent flow conditions	Economic climate	Socio-political context
Big Dry Revisited	Drought (7 years of below average rainfall, 2 of which have been extreme dry years)	Strong national and international economies	Inertia (a reluctance to change)
Big Bad Dry	Drought (7 years of below average rainfall, 2 of which have been extreme dry years)	Weak national economic position and weak global economic outlook.	Transformative
Flip-flop	Cycling of floods and drought: a repeated cycle of 2-3 years of above average runoff, one of which has produced record floods, followed by 4-5 years that become increasingly dry.	Strong national economic position, but instability in the international economic position	Transformative

Participants identified challenges, opportunities and knowledge gaps, based on likely future scenarios and the questions that were posed. While more challenges than opportunities were identified a number of participants noted that by adopting a different point of view many challenges could also be seen as opportunities, and vice versa. Using on the large amount of material that was generated the following summary of outcomes has been prepared around the major topics of discussion. A post workshop working group of Brendan Edgar, Sam Capon,

Fiona Dyer, Jasmyn Lynch, Michael Peat, Sue Nichols, Evan Harrison and Robert Rolls met on the 22nd November in Canberra to review the outputs from the workshop and to develop a set of papers and reports.

3.1 Setting Goals and Objectives

Settings targets and developing a vision are critical and not always well done. Adapting thinking will be needed as societal values change over time. The triple bottom line approach (Social, economic, environment) is still a very important concept for management.

The drivers for protecting or using environmental water may need to evolve from ecological outcomes (i.e. threatened species) to multiple benefits e.g. water quality, tourism, biodiversity, spiritual and cultural values. Environmental watering will need to be able to respond to both wet and dry scenarios.

Perceptions of what constitutes a healthy aquatic system may also need to change, triage approaches may need further development and application in drought periods.

Development of agreed visions as opposed to bargaining and compromise will produce positive support for environmental watering decisions. Sharing the responsibility, risk and rewards rather than confronting ("us and them") will improve progress.

There is a risk that the concept of environmental water will be unable to make progress/ changes because not everyone will be satisfied and therefore willing to participate.

3.2 Climate Futures and Uncertainty

The range of possible futures and uncertainty associated with climate modelling was seen to be a challenge that was making planning and management difficult. The inability of our current climate models to provide reasonable estimates of changes in seasonality or extreme event occurrence was seen as an impediment for decision making.

There is uncertainty in climate scenarios/ projections, and potentially more uncertainty with freshwater ecosystems than other potential changes such as sea level rise. There is a need to develop policy that applies to a range of future scenarios, improve forecasting, and develop risk based approaches that consider scenario implications. Hindsight tools may be also a useful approach that could be utilised.

Natural variability is already very high, making it hard to identify management objectives. Longer term planning horizons are needed for environmental water, given long time lags and shorter political management timeframes. Monitoring and evaluation are often not treated seriously, there are long time lags in response which influence our understanding, management, funding, monitoring, political will etc.

There is uncertainty in planning, given socio-economic context. Decision making is needed in the face of incomplete knowledge and information. Adaptive management and science are very important under an uncertain future.

The variability across Basins and catchments is an opportunity to better mange for risk across different scenarios. Need to recognise Australia's different climate regimes. i.e. northern Australia may have a wetter future, MDB, Tasmania and SouthWest WA will all be different. The way in which environmental values are distributed across the landscape is also an important consideration.

It will be important to try and understand the way in which a different climate future might influence the types of ecological communities/functions present and the way they might be managed.

3.3 Legal issues

Legislation only ever provides the boundaries or framework within which we operate, alone it cannot provide solutions. Water legislation will need perpetual revision to align with emerging social drivers.

Water accounting across States/ regions distorts markets, different management and legislative regimes across borders is an impediment to change. Also multi layers of government make agreement reaching difficult. Significant reform achievements over recent decades provide a positive platform to build on.

Water systems set up for agriculture do not automatically suit environmental watering needs. Future opportunities could be explored for a water trust, with private/ business contributions, role for philanthropy.

Legal constraints to delivering environmental water will need to be addressed. Our legal framework needs to be adjusted to better accommodate environmental watering without adversely impacting irrigators. To be effective in 2030 the issue of third party impacts on floodplain landholders / infrastructure will need to have been resolved to able meet environmental demands. Compensation (land and water rights and trading) will need to be considered when exploring options to overcome constraints.

Trade of water from consumptive use to meet environmental needs may enable a more flexible and adaptive approach - without the need for more water recovery. Capturing indirect benefits of ecosystems in market and other instruments should also be considered.

Formalised regulations/standards on water quality should be included in legislation. This would help to address who is responsible for maintaining water quality as it is not current clear whether it is the land owner using the water, the water owner/trader, or the government through the Water Resource Plan (e.g. hypoxic or saline water deliveries) that is responsible.

3.4 Economic factors

Further work is needed on valuing water, using market and non-market measures that can contribute to policy and management. Identifying values is important for decision making. Metrics are needed to evaluate trade-offs across social, economic, environment.

Water use efficiency may not always be the best driver of resource allocation, and achieving a balance between economic tools and investment, there is a need to critically evaluate how government funds should be best spent.

Funding is reactive to the wet and dry context, research needs to be able to be reactive. Less funding is likely in a weaker economy for research and management. There may also be less competition for water, lower demand for irrigation and mining.

Water pricing will have an impact on future water use across sectors. Competition between all users (urban, industry, agriculture) will affect the price of water, urban use will likely predominate making further environmental water more difficult to achieve.

3.5 Social and Political Influence

Environmental management is currently considering the conservation of ecosystems in a cultural landscape. The challenge by 2030 is to ensure adequate consideration of social values during planning, deliberation and decisions regarding potential trade-offs. Equity between different social groups is rarely discussed as a water management objective, there needs to be greater consideration of social and cultural groups. Both indigenous and non-indigenous value of water is important. Social and economic benefits are also likely to be a consideration including: tourism, human health and vibrant regional communities.

Intergeneration equity also needs to be brought into the discussion. There is a nostalgia for past, current or idealised states. Attitudes towards corporate and foreign ownership will continue to be part of the discussion. We may need to consider what cultural aspects of our rural communities we want to retain.

Balancing water demands between growing populations (globally and domestically), food security and the environmental will be a consideration. One option proposed to help deal with this is to improve awareness of the water needed to produce products, so consumers can make educated choices (give food a water efficiency tick). This may lead to consumer driven preferences driving ecosystem stewardship.

If resources are going to be allocated to environmental water, the community has to see a value to it. Improved transparency, particularly demonstration of environmental outcomes will be important for maintaining security of environmental water. Better accountability/transparency/reporting would improve awareness and remove fear associated with watering actions.

The only way we have found to measure the social impact of water reform is to assess what would have happened without an action after having observed what it has done - we don't seem to be able to predict forward. We need to inspire feasible alternatives to business as usual.

We currently have an adversarial political system that leads to conflict between consumptive and environmental uses. We need to better manage this conflict. A move to an inquisitorial system may lead to better outcomes. Our political system is based on risk aversion, avoidance of controversy and incremental action, which may lead to reform exhaustion. Political processes rarely get things right the first time, so we may well have the same objectives as we have today and still be finishing the job in 2030.

Common political will: precipitated either by environmental crisis or education. Appease the masses in times of drought or other shortage/scarcity. Some competing interest groups have greater influence over the political process. Self-interest and the objective to retain power will continue to be a driver.

Future climate scenarios have a big impact on political will to act. Consensus building across sectors is important for action. Less justification for environmental watering in a series of wetter years. There will be pressure to return water for social-economic reasons. Management of carry over water will be important.

Indigenous values have a role in transforming social and economic systems and attitudes, with potential longer term perspectives. Incorporating indigenous values and management not currently well catered for, opportunities exist for better incorporation of Indigenous flow management.

Embedded cultural and institutional knowledge is important for future management, need to improve ways of sharing knowledge. Opportunities exist for more effective communication. Important to consider how to achieve fairness in decision making and outcomes. Who has legitimacy in making trade-offs between social and economic outcomes?

The capacity for people (both in the community and managers) to understand that the future ecosystem may look different from the past and that the priorities for environmental water may need to evolve as the climate changes. The capacity for people to change is critical to future management of water.

Institutional responses tend to be reactive, and reward busyness, rather than rewarding reflection and learning. This tends to bias actions, decisions and outcomes to short term and linear issues/processes. This approach doesn't allow for the time and resources required for social learning.

3.6 Governance

A key governance challenge identified by participants was the need for collaboration and integration amongst multiple, competing stakeholders representing a diverse range of sectors as well as encompassing numerous geographical regions and hierarchical levels. The major conflicts highlighted included those between:

- government and NGOs
- different jurisdictions
- Federal, State and local government bodies
- Geographical regions
- Different water users

Participants highlighted a range of issues associated with this multiplicity and diversity of actors including:

- Limits imposed by constitutional arrangements
- Inefficiencies, duplication
- High potential for conflict
- Long and mismatched decision-making time frames
- Difficulties in consistency and alignment of high level policy objectives with on-ground actions
- IP issues and barriers to sharing knowledge
- Differing requirements (for knowledge, tools etc) of different geographic regions
- Differences and inconsistencies in language, objectives, approaches etc
- Position of environment as a water user/provider or stakeholder and human representation of this

Criteria for future organisational arrangements suggested by participants included:

- A need for simplicity and flexibility
- A balance between centralised governance and local decision-making including alignment and integration of visions and objectives and greater consistency in language, objectives and approaches
- Transparency in knowledge sharing and decision-making
- Clearly defined roles and responsibilities of different decision-makers
- A need for an overarching strategic adaptive management framework
- Improved processes for stakeholder consultation, participation and communication
- Independent auditing by a federal body (NWC?)

The main points of discussion between participants involved overall governance models. In particular, some promoted a need for polycentric governance while others promoted a greater role for a federal water agency (e.g. an expanded CEWH).

A further constraint was the perceived silo mentality between all disciplines including data scientists, ecologists, hydrologists, evaluators, economists, policy analysts, sociologists, and elected officials. We are missing opportunities to achieve broader, more interdisciplinary solutions and outcomes. This issue cuts across all levels and related realms including political and social.

3.7 Setting Priorities and Adaptive Management

Priorities for environmental water will be determined by the values that broader human society places on the environment, also legal considerations such as international obligations (e.g. RAMSAR) and threatened species will be relevant.

Public health outcomes, economic values and societies other values will influence priorities and drive political agendas. Understanding the process of decision making and priority setting was seen as an important knowledge gap.

Currently, we make decisions about environmental water allocations based more on demand for water (i.e. ecosystems that require it to avoid decline in condition) rather than supply. Can we turn this around to what is available, e.g. CEWH, and how best to use it.

Investment in robust monitoring programs is needed to support adaptive management. We need to reduce our over-emphasis/ obsession with modelling and predicting consequences of water delivery decisions when the evidence base (i.e. monitoring) may be inadequate to produce meaningful predictions. Consider automated and/ or real time monitoring (water quality, webcams of wetlands/ rivers).

An improved knowledge base from now to 2030 will be the most informative aspect of determining our priorities. Trial of alternative approaches to assign priorities, such as a lottery system. Continued experimental use of water manipulations will improve confidence and refine priorities for use of environmental water, and the scenarios where environmental water is required or can be sacrificed (i.e. used for other purposes). Improved models (sophisticated and refined) will be a key outcome.

Improved links with land, riparian and floodplain management in setting priorities for environmental water. Thresholds and warning points of impending change if environmental watering does not occur and system stress or permanent change will result. Example: acceptance of floodplain transition from particular vegetation types/ species/ invasive species (e.g. Catford et al 2011).

Groundwater is a critical issue in overall water management. Understanding linkages between surface and groundwater is a key issue, contamination is a major threat to groundwater quality.

Rethinking appropriate indicators of ecosystem condition that can be directly manipulated by flow regime, and therefore are meaningful indicators of flow change. Use of both structural and functional indicators. Single species vs entire ecosystem consequences.

Also appropriate economic indicators that are strongly dependent on flow, including tourism and agriculture. What is a simple process to set and agree on targets for environmental, social and economic goals? This links with the goal of collaborative adaptive management.

Indicator species, ecological function, keystone species, iconic species, communities, vulnerable species, functional assets were terms used to describe the priorities for receipt of environmental water. Considerable debate exists around which are the most appropriate priorities but there was an emerging view that function and

a system focus will be more appropriate than a species approach. Single species were seen as still appropriate, more from the perspective of engaging the community. Associated with this is the selection of appropriate indicators that should be used.

Setting achievable (realistic) and measurable objectives for watering will be critical. Concepts of novel ecosystems and different future ecosystems (evolved) were raised.

Key ecological knowledge gaps identified included:

- Understanding the water requirements of species, communities and ecosystem to retain aspects of resilience and refugia
- Understanding what is achievable in a different climate future
- Understanding how to measure responses
- Understanding the range of possible climate changes and how this will affect species, communities and ecosystems

The use of ongoing adaptive management, and ability and willingness to take risks (where outcomes for some/all aspects of water management are unknown or uncertain), share responsibility, learn together and share knowledge, is critical to achieving progress in future decisions. Transparency of decisions and planning among all users will be important. Assessing the consequences of particular water management scenarios using combinations of environmental/ ecological, economic, social, agricultural and cultural criteria will mean that there will be more meaningful understanding of costs and benefits. There may be potential synergies and mutual benefits of particular flow scenarios. Government consortia setting priorities for water use. Current (and future) actions will be based on who screams loudest and has most (economically, socially, politically) to lose.

Coupling water management with both species/ ecosystem conservation and ecosystem services. Managing environmental water to maintain or enhance environmental assets we can use. Selecting criteria and identifying specific regions/ rivers/ ecosystems that have broad-scale significance (e.g. refugia). Identify priorities and scenarios of use for the volume of water available. Some discussion about iconic sites and species of conservation concern will continue to be priorities, maybe because the outcomes of altered flows will be readily understood.

3.8 Frameworks for Managing Environmental Water

Flexibility in water planning was seen as critical for managing into an uncertain future. Being allowed to try and learn from the management of water. This will require managing as an experiment and sometimes trialing watering events that may not achieve all of their objectives. Making trade-offs between competing priorities (for decision making) will be important.

People and organisations are at different levels of influence and willingness to participate in environmental water management. For example agriculture has 50+ yrs of experience, environment - 20+ yrs, Commonwealth government (ie CEWH) – around 5 years.

New management frameworks are needed for adaptive management. Droughts provide opportunities for change, systemic restructuring, transformation, governance arrangements, greater political focus. Science role in decision making, policy and management needs further consideration, it has an important role but what and how best to achieve this. Education and learning from past experience, global cooperation, optimising efficiencies.

Developing a framework to gain multiple benefits. The framework for water delivery and management should accommodate multiple objectives and forms of knowledge. In particular, indigenous knowledge and perspectives

should be incorporated with non-indigenous knowledge and perspectives into planning and decision making. This process should allow for common and differing objectives.

Allocations to meet objectives may be determined through optimisation, with others determined on the basis of perceived importance and acceptability. The allocations should take into account relative weightings for different benefits and values (e.g. cultural, environmental, agricultural/ industry, education, energy, tourism, health, aesthetic values) depending on context (e.g. socio-economic, geographic, environmental).

However, there should be a commonality and efficiency of delivery mechanisms where possible to maximise outcomes and benefits. An initial phase could be to recognise and identify overlapping benefits, or places where multiple benefits can be met from a water flow. In contrast, aquatic conservation requires a systematic approach.

A successful process requires equity in decision-making, achieved through improved coordination, communication, engagement and representation across all sectors including users and providers of environmental water. A dynamic process is necessary to identify and include existing and emergent stakeholder groups.

A better understanding of the needs of different water users is required to provide direction for delivering water to achieve multiple benefits and for specific needs. The focus should be on benefit sharing rather than water sharing, potentially reframed as integrated benefit flows. The current process of water accounting and multiple owners (or holders) of water tends to silo rather than overlap evaluation of 'types' and 'purposes' of water. It also is important to understand the interactions, connections and synergies between users and needs. Representatives from the irrigation industry may be especially effective as champions of environmental water needs.

Knowledge needs and opportunities for achieving multiple benefits. Various aspects need investigation to achieve a progressive, adaptive approach. Many of these may become opportunities for improved outcomes and multiple benefits.

The socio-economic aspects include the potential for:

- development of high value, seasonally appropriate agricultural or aquacultural systems in areas such as the lower lakes
- greater use of hydro-electric energy as a means of decreasing reliance on fossil fuel energy sources
- new, innovative agricultural systems in areas with conflicts in timing between environmental and consumptive water use
- usage of aquifers as storage systems to bank water, such as is happening with some managed aquifer recharge in S.A.

Environmental aspects include the potential:

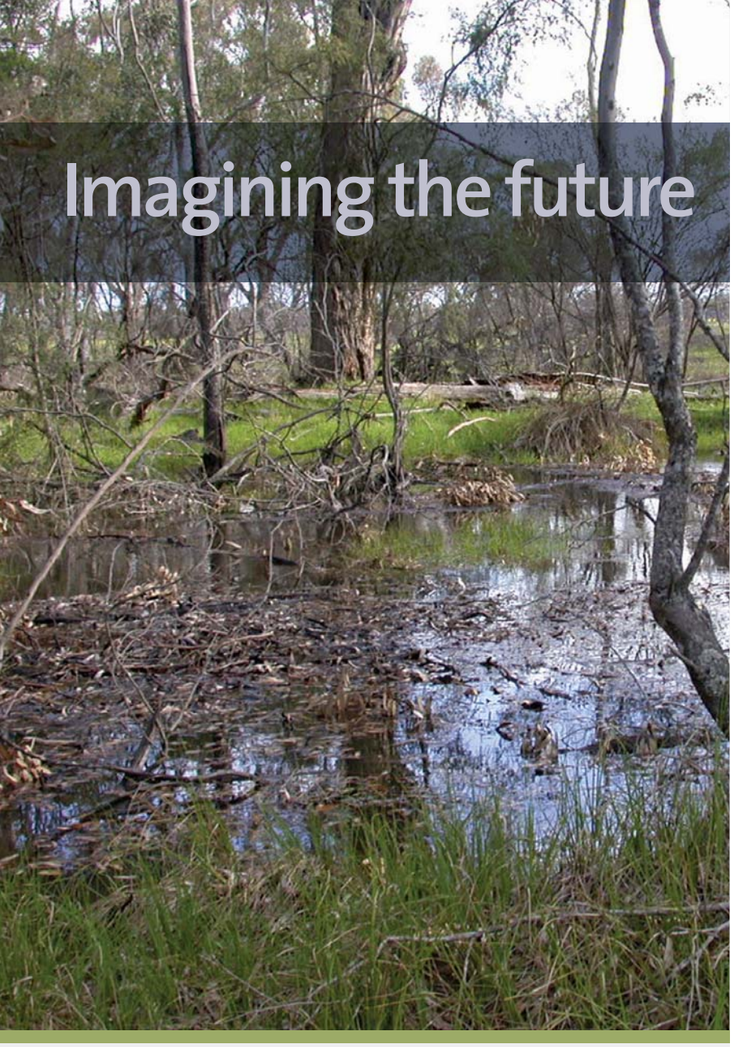
- use of environmental flows to augment regulated flows and vice versa i.e. irrigation releases managed to mimic the natural hydrograph
- for wetlands (e.g. RAMSAR sites) to contribute more to eco-tourism and conservation
- conservation prioritisation of different wetland areas based on ecological factors such as their relative importance as feeding and breeding sites for fauna.

Enhanced technology may facilitate some of these aspects by producing increased water efficiency and more options for water management, thereby making management more responsive and predictive. Increased investment may produce tools that better measure, forecast and track water use and availability. There are prospects for co-investment of water use efficiency technology between consumptive and environmental uses. Infrastructure constraints affect ability to deliver water. Recycling water is an opportunity.

There are also issues of accountability and system evaluation. Consideration needs to be given to whether all water including banks should be available for all purposes, and the implications of this for private water use. An integrated system has advantages for alignment and greater efficiency of effort in monitoring and evaluation, and for facilitating ongoing development of multiple trading options. Multiple benefits can be quantified for comparative purposes, although this is likely to require multiple indices rather than a single index. The system or framework could be incorporated into the water planning process.

The synthesis, integration and consolidation of existing knowledge and research was seen as an important step for managing into the future.

Imagining the future



PARTICIPANTS FROM THE **WATER RESOURCES AND FRESHWATER BIODIVERSTY ADAPTATION RESEARCH NETWORK** INCLUDING SAMANTHA CAPON, FIONA DYER, EVAN HARRISON, JASMYN LYNCH, SUE NICHOLLS, MICHAEL PEAT, ROB ROLLS AND BRENDAN EDGAR DETAIL THE KEY OUTCOMES FROM A RECENT WORKSHOP ON ENVIRONMENTAL WATER DELIVERY.

Mackenzie River, Victoria, 2006. Photo Fiona Dyer.

Environmental water delivery is a key strategy for restoring and maintaining the health of Australia's freshwater ecosystems, and is now a cornerstone in the policy approach for adapting freshwater ecosystems to climate change.

Planning and managing environmental water already poses a challenge to Australian institutions and communities, particularly in achieving fair outcomes for a diverse range of stakeholders and regions. During the next century, significant changes are likely in the climatic, cultural and institutional settings in which environmental water delivery occurs, and it is critical environmental water is managed adaptively to ensure effective use.

During September 2012, the Water Resources and Freshwater Biodiversity Adaptation Research Network (part of the National Climate Change Adaptation Research Network) held a workshop titled 'The Future of Environmental Water; identifying drivers, constraints and approaches to delivering water to Australia's freshwater ecosystems in the 21st century'.

Hosted by the Institute for Applied Ecology at the University of Canberra, the two day workshop was attended by more than 70 participants representing a diversity of disciplines, management agencies, research institutions and water users from around Australia.

Participants were challenged to expand their views through a range of invited presentations and associated discussion sessions framed around five key questions:

1. What will the objectives and targets for environmental water be in 2030?
2. What institutional arrangements for managing environmental water will exist in 2030?
3. How will environmental water be delivered and monitored in 2030?
4. What knowledge will underpin environmental water planning and management in 2030?
5. What would be different in a repeat of the 'Big Dry'?

A summary of the workshop's findings follows.

FOR FURTHER INFORMATION
Sam Capon—s.capon@griffith.edu.au
A detailed workshop report can be obtained by contacting—climate.water@griffith.edu.au

1. CLIMATE AND ECOLOGY

High levels of uncertainty are involved in modelling climate futures and their ecological impacts. In particular, the inability of current climate models to provide reasonable estimates of changes in flow seasonality, or the occurrence of extreme events, was identified as a specific impediment to decision making.

Participants highlighted freshwater ecosystems as facing higher levels of uncertainty than other ecosystems because of their complexity and variability. Regional variation in environmental values and climate futures was widely recognised as an important consideration for environmental water planning and management. The potential for change in the structure and function of freshwater ecosystems associated with climate and other environmental changes was also acknowledged, including the emergence of novel ecosystems. The future requires a focus on systems and on functions, rather than a species-based approach.

2. SOCIAL AND ECONOMIC FACTORS

Equity among different social and cultural groups in defining water management objectives was highlighted. Greater recognition of indigenous and non-indigenous water values was recognised as important, as well as consideration of intergenerational equity and attitudes towards corporate and foreign ownership. Global and domestic population growth, food security issues and the potential prioritisation of urban water demands were all identified as significant constraints on the future of environmental water delivery. The capacity of people to change, for example to overcome nostalgia for historic environments and communities, would also play a critical role in the future of environmental water management.

3. MULTIPLE BENEFITS

A wide range of social and economic benefits of environmental water, including tourism, human health and vibrant regional communities, were identified by participants as having the potential to influence future water planning and management. The need for the community to see the value in allocating water to the environment to provide these multiple benefits was crucial.

4. TOOLS AND TECHNIQUES

There is a need for improvements in valuing water, using market and non-market measures, to inform decision making. Metrics that evaluate trade-offs among social, economic and environmental objectives were highlighted as a gap. Greater opportunities for sharing cultural and institutional knowledge, and improving communication and transparency in decision making, were also highlighted. Raising awareness among consumers of water requirements for different production processes was suggested as an appropriate method for promoting consumer-driven environmental stewardship.

5. GOVERNANCE

The main governance challenges identified were the need for collaboration and integration among a range of stakeholders encompassing diverse geographical regions and scales. Legal constraints to environmental water delivery were also highlighted. A shift toward adaptive management approaches was identified as essential for effective environmental water management, including regular evaluation and revision of legislation. Participants expressed a need for a less reactive approach to environmental water delivery, and greater capacity to learn from past experiences. Incorporating indigenous and social values and management was raised as a key opportunity for achieving a longer-term perspective in environmental planning.

KNOWLEDGE NEEDS

Key knowledge gaps identified during the workshop included:

- greater understanding of links between surface water and groundwater,
- improved understanding of the water requirements of species, communities, ecosystems and ecosystem functions,
- greater understanding of ecological and socio-economic impacts of climate change and limits to adaptation,
- identification of appropriate responses for monitoring and evaluating ecological, social, economic and institutional change,
- greater understanding of the full range of water values and the needs of different water users as well as trade-offs amongst these,
- improved understanding of interactions, connections and synergies among water users and their needs, and a capacity to better integrate beneficial flows.

WORKSHOP PHOTOS COURTESY OF THE AUTHOR.