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Sharing Water with Nature: Insights on Environmental Water Allocation from a Case Study of the Murrumbidgee Catchment, Australia

Becky Swainson
Department of Geography, University of Guelph, Guelph, ON, Canada; becky.swainson@gmail.com

Rob de Loë
Department of Environment and Resource Studies, University of Waterloo, Waterloo, ON, Canada; rdeloe@uwaterloo.ca

Reid Kreutzwiser
Department of Geography, University of Guelph, Guelph, ON, Canada; reidk@uoguelph.ca

ABSTRACT: Human use of freshwater resources has placed enormous stress on aquatic ecosystems in many regions of the world. At one time, this was considered an acceptable price to pay for economic growth and development. Nowadays, however, many societies are seeking a better balance between healthy aquatic ecosystems and viable economies. Unfortunately, historically, water allocation systems have privileged human uses over the environment. Thus, jurisdictions seeking to ensure that adequate water is available for the environment must typically deal with the fact that economies and communities have become dependent on water. Additionally, they must often layer institutions for environmental water allocation (EWA) on top of already complex institutional systems. This paper explores EWA in a jurisdiction – New South Wales (NSW), Australia – where water scarcity has become a priority. Using an in-depth case study of EWA in the Murrumbidgee catchment, NSW, we characterise the NSW approach to EWA with the goal of highlighting the myriad challenges encountered in EWA planning and implementation. Sharing water between people and the environment, we conclude, is much more than just a scientific and technical challenge. EWA in water-scarce regions involves reshaping regional economies and societies. Thus, political and socio-economic considerations must be identified and accounted for from the outset of planning and decision-making processes.

KEYWORDS: water allocation; environmental water allocation; environmental flows; water governance; New South Wales; Australia; water sharing plans

INTRODUCTION

As economies have grown around the world, so too has exploitation of freshwater resources. The result has been not only severe but increasing environmental degradation in many of the world's major river basins (Postel, 2002; Dyson et al., 2003; Hirji and Panella, 2003; Wallace et al., 2003; Arthington et al., 2006; United Nations World Water Assessment Program, 2006). These impacts not only jeopardize ecosystem functions but also threaten the livelihoods and sustainability of communities and the people who depend on those ecosystems (Dyson et al., 2003). The need to maintain freshwater ecosystems and natural river flows is recognised globally; as a result, many jurisdictions have begun to explicitly set aside water for the environment (also known as environmental flows) through a process known as *environmental water allocation* (EWA).

Environmental flows refer to water provided within a river, wetland or coastal zone to maintain ecosystems and the benefits they provide to people and the environment (Dyson et al., 2003). A useful way of understanding environmental flows is with reference to 'ecological water demand': the environment demands water in the same way as do agriculture and industry. EWA typically involves providing specific quantities of water with a prescribed distribution in space and time. Water is purposely left in or released into rivers, streams and wetlands, with the goal (ideally) of mimicking a natural flow regime to maintain or restore particular ecological values (Hirji and Panella, 2003). While the concept may appear straightforward, actually achieving a balance between human and environmental needs for water can be exceptionally challenging. As a result, learning from the experiences of others who have attempted to implement EWA can be an important way to increase the likelihood of success.

An inventory completed in 2002 found that provisions for EWA exist in more than 30 countries (Hillman and Brierley, 2002). Australia is one of the countries currently grappling with significant water-related challenges. These include severe droughts induced by climate change and reductions in water availability (MDBC, 2007b; South Eastern Australian Climate Initiative, 2008); intense conflict over water use and allocation (Bowmer, 2007); and ecological degradation due to river regulation, diversion and flow modification (Kingsford, 2000; Arthington and Pusey, 2003). Within Australia, a number of policy measures, including EWA, have been developed to address these concerns. Australia is often identified as a pioneering jurisdiction in terms of advancing the theory and practice of EWA (e.g. Arthington and Pusey, 2003; Dyson et al., 2003; Poff et al., 2003; Schofield and Burt, 2003; United Nations World Water Assessment Program, 2006). Within Australia, the state of New South Wales (NSW) has adopted an approach to EWA that involves assigning the environment paramount rights to water and designing water-sharing plans with the goal of balancing water between human and environmental needs (NSW DLWC, 2001).

The purpose of this paper is to identify and evaluate the relative importance of factors that contribute to the success or failure of EWA. Drawing on an in-depth case study of the EWA process in the Murrumbidgee Catchment in NSW, we demonstrate that while EWA involves significant scientific and technical challenges, it is far from a solely technical exercise. Some of the difficulties presented by the ubiquitous – but less-commonly recognised – social and political dimensions of EWA are revealed. Interest in EWA as a tool for sustainable water management is increasing globally in response to the growing need to protect vulnerable water-dependent ecosystems. Thus, insights offered in this paper can inform future and continuing efforts to share water between humans and the natural environment in other jurisdictions.

SHARING WATER WHEN THE RIVERS RUN DRY

Rivers are a lifeline of prosperity and biodiversity in Australia, the driest inhabited continent on earth. Rainfall in many parts of Australia is inconsistent and unreliable. Hence, for over a century Australians have substantially altered the natural environment in order to secure reliable water supplies to sustain agriculture, industry and communities. Recently, however, Australians have recognised that they are nearing the limits of their water resources; access to water is uncertain and cannot be guaranteed to people who depend on it for livelihoods or for ecosystems that depend on it for life. This is exemplified by the severe drought which has affected most of southeastern Australia in recent years, with some areas being in the grip of the drought since 1997 (MDBC, 2007a). Considered one of the worst droughts observed in the region in the last 200 years (Bond et al., 2008), conditions reduced water supplies in Australia's iconic Murray-Darling basin to critical levels. In July 2009, active water storage in the Murray River system was only 17% of capacity and inflows into the system only about 30% of the long-term average, with a poor outlook for the near future (Murray-Darling Basin Authority, 2009).

Heralded as the first natural disaster driven by climate change to strike a developed nation (Marks, 2007; South Eastern Australian Climate Initiative, 2008), increasing drought conditions continue to have far-reaching consequences not only for local communities but also for ecosystems across southeastern Australia (see Bond et al., 2008). In this context, balancing the water needs of consumptive users and the environment is a national priority. These concerns are especially significant for New South Wales, Australia's most populated and water-consumptive state. Important institutional arrangements and mechanisms for environmental water allocation have been developed in NSW. However, implementation of these mechanisms has been extremely challenging, and only partly successful.

Institutional and policy context

National-level institutions

Water governance in Australia has been in a state of continuous change during the past two decades. Australia's national approach to water emerged in 1994 when, in response to growing environmental concerns and the need for economic restructuring of the water sector, the Council of Australian Governments (COAG), representing the Commonwealth Government and all states and territories, committed itself to national water reform (Schofield et al., 2003). The resulting COAG National Water Reforms acknowledged the need for a consistent national approach to water management. A core theme in the reform agenda was protection and maintenance of aquatic ecosystems (Shields and Good, 2002). The agreement states that "action needs to be taken to arrest widespread natural resource degradation in all jurisdictions occasioned, in part, by water use and that a package of measures is required to address the economic, environmental, and social implications of future water reform" (COAG, 1994). Specifically with respect to EWA, COAG signatories agreed to give priority to formally defining water allocations for the environment as a legitimate user of water, using the best available science, in order to enhance and restore the health of river systems (COAG, 1994).

The 1994 COAG reforms were followed in 2004 by the National Water Initiative (NWI) (COAG, 2004; National Water Commission, 2006b) that, building on the COAG reforms, sought to refresh and maintain the pace of national water reform by laying out a blueprint for water planning in Australia for a decade. The NWI required that environmental water be given statutory recognition with at least the same security as water for consumptive use; that all over-allocated systems be returned to environmentally sustainable levels of extraction; and that institutional arrangements specifically identify outcomes and establish environmental water managers with the authority and resources to achieve these outcomes (COAG, 2004).

In January 2007, in response to a worsening drought and conflict over transboundary water governance in the Murray-Darling basin, the then Prime Minister John Howard announced a National Plan for Water Security (NPWS). The NPWS set out a plan to invest AUD$10 billion over a decade in improving water management on a national scale, as well as for the Commonwealth government to take over management of the Murray-Darling basin. In parallel, the Commonwealth introduced the *Water Act 2007*, which was revised and implemented under Prime Minister Kevin Rudd's Water for the Future Plan (which succeeded the NPWS). The *Water Act 2007* created an independent Murray-Darling Basin Authority; although the States retain their constitutional rights and duties relating to water, they ceded primacy to the Commonwealth in matters of basin management. Public consultations on a proposed plan for the basin were launched in November, 2010, with the adoption of the first Basin Plan expected in 2011 (Murray-Darling Basin Authority, 2010). The Act also creates a Commonwealth Environmental Water Holder. This officer's duties include securing and then managing the water assets of the Commonwealth inside and outside of the Murray-Darling basin (Prasad, 2008).

State-level institutions

In response to the ambitious goals set out in these national reforms, State governments (which still hold primary jurisdiction over water management in Australia) have been required to adjust their policies and institutions for managing water. In particular, they are required to implement legally recognised EWA based on the best available science (COAG, 1994). NSW began its reforms in 1995, when the State began delivering water to important wetland areas, created the Healthy Rivers Commission, and launched a process for developing River Flow and Water Quality Objectives for the State's rivers (NSW DLWC, 1998). In 1997, local River Management Committees (RMCs) were formed to develop River Management Plans for the regulated rivers in the State. RMCs were to be the key community-based mechanism for providing advice to the government regarding its implementation of the water reforms (NSW DLWC, 1998). As part of creating River Management Plans, RMCs were required to review a set of interim environmental flow rules provided by the government, and then either accept them or propose alternative flow rules (NSW DLWC, 1998).

The current NSW *Water Management Act* (2000) replaced all other legislation governing water in the state (NSW DLWC, 2001; NSW DIPNR, 2004b). The *Act* has three main objectives: 1) improved environmental health for the State's waters; 2) greater economic benefits for individuals and communities; and 3) shared government and community responsibility for water management (NSW DLWC, 2001). This represents an innovative approach to water management in that, first, it requires the involvement of the community in planning and decision making. Second, it aims to undertake water resource management at the catchment scale. Third, it gives the natural environment priority for receiving water allocations and aims to limit the volume of water taken from each water source to within environmental requirements (Hillman and Brierley, 2002; Australian Productivity Commission, 2003). The Act also set out a multi-tiered planning structure for water management (NSW DLWC, 2001). Elements include a State Water Management Outcomes Plan, which sets the overarching goals and policy context for management of the State's water resources, and locally based water sharing plans (WSPs) for each water sharing area.

WSPs were prepared for each region of the State by independently chaired local Water Management Committees that included water users, local councils, the Aboriginal community, environmental groups, catchment management interests, State environment and agriculture ministries, and the Department of Infrastructure, Planning and Natural Resources, which has since been replaced twice, first by the Department of Natural Resources and most recently by the Department of Water and Energy (NSW DLWC, 2001; NSW DWE, 2007d). Local members were to be appointed whenever possible, and all members of the committee were considered equal partners in decision making (NSW DLWC, 2001).

The goals of WSPs are to allocate water for the environmental needs of rivers and groundwater sources and to direct how the remaining water is to be shared among water users in each area, including water for towns, domestic and stock watering, industry, and irrigation. They provide the legal framework for water rights and the conditions of water licences. Provisions in the WSPs are designed to limit extractions in order to protect the total volume of water in the rivers, and to attempt to replicate the natural variability of flows by specifying releases of water for specific environmental purposes (NSW DNR, 2006).

This approach to water governance, in general, and to EWA, in particular, is ambitious. Implementation has been problematic and contested. As a result of the severe drought experienced in the region, and due to the consequent reductions in water availability, WSPs in NSW were suspended under Ministerial discretion starting in November 2006 (Inland Rivers Network, 2007; NSW DWE, 2009). Also in 2006, water designated for the environment was 'borrowed' by the State in a number of catchments to provide water for high-security entitlements and town water supplies (NSW DNR, 2006). Environmental flow rules and provisions under the affected WSPs were therefore suspended. These actions put into question the robustness of this system. By examining the NSW experience with EWA implementation, and the significant obstacles faced throughout the process, we reveal important dimensions of EWA that must be addressed in order to achieve an acceptable balance between human and environmental needs for water.

Environmental water allocation in NSW, Australia

Within the institutional framework provided by the complex system of laws, policies and guidelines for water management that exists in NSW, how water is actually provided to the environment can take many forms. The first mechanism for EWA is the *rules-based* water provided through a WSP, which is meant to be delivered to the environment by prior right before water is allocated to consumptive uses within a water management area. As noted above, these rules are currently suspended across much of NSW.

In addition to this statutory environmental water, water can also be provided through emerging *market-based* methods (MDBC, 2006). This is accomplished primarily through a representative for the environment participating directly in the water market by purchasing access licences and putting that water towards environmental rather than consumptive use (*buy-back* strategy), or by minimising losses due to infrastructural inefficiency and using or trading the gains in the market for environmental outcomes (*efficiency-gains* strategy). More complex market mechanisms such as lease-backs, covenants, and options arrangements are being developed in some locations (NSW DIPNR, 2004c). In any one catchment or water source in NSW, the suite of arrangements for providing EWA will include a combination of these diverse mechanisms, which together are meant to provide for environmental water needs.

Despite requirements for the allocation of water for the environment in NSW, and statutory provisions for EWA in WSPs along with a host of other mechanisms, actual environmental outcomes have so far been limited. For example, one assessment of the water reform progress found that NSW was not meeting its commitment to providing appropriate environmental water allocations in stressed and/or over-allocated rivers (National Competition Council, 2005). This suggests that on-the-ground implementation of EWA in NSW continues to present a challenge. A case study of the Murrumbidgee catchment is used in this paper to identify and evaluate the factors that have facilitated and constrained environmental water allocation in NSW, especially the social and political dimensions of EWA that can be as important as, or more important than, commonly cited scientific and technical challenges. Importantly, implications for the theory and practice of EWA and water management are more broadly drawn from this analysis.

THEORETICAL FRAMEWORK

Factors that contribute to the success or failure of EWA can be identified from a variety of theoretical perspectives. In this study, we drew on the extensive literature pertaining to institutions. This literature includes a host factors that can be used to analyse the 'fit' of institutions for EWA, and thus reveal factors that contribute to the success or failure of this approach to providing water for the environment. With respect to EWA, relevant institutions include the formal and informal rules, practices, norms, etc. that structure how water is allocated for environmental purposes in specific places. These include the legislative and regulatory requirements for EWA, the interactions among agencies and between agencies and water users, the influence of the market on EWA, and the actual 'rules in use', or implementation of these policies and arrangements as they are carried out on the ground. As with any institution, a range of external and internal factors determine the extent to which institutions for water management are appropriate at specific times and in particular places (Shah et al., 2005). We focus on four: political/economic context, socio-cultural context; administrative context; and biophysical context.

In order to be appropriate in a jurisdiction, institutions for environmental water allocation should be compatible with the existing *political* and *institutional context* in which they are to be used. In particular, institutions for EWA should fit with the prevailing political and legal structures and values of a jurisdiction (Knill, 1998; Page, 2000; Zarkin, 2005). Additionally, institutions fit best in situations where they have strong political support from relevant levels of government (Schofield et al., 2003), and where they are compatible with existing institutions in a jurisdiction (Mossberger and Wolman, 2003).

The appropriateness of institutions also depends on the extent to which they fit with the *socio-cultural norms* and *values* of a jurisdiction (Roland, 2004). The fit of institutions is reduced when they conflict with cultural beliefs or public opinion (Mossberger and Wolman, 2003). In turn, fit is better where there is local appreciation and support for the underlying objectives of institutions, and where local ownership of processes and outcomes exist (Hirji and Panella, 2003). Institutions for EWA will also be more likely to succeed when public input has been sought and incorporated into the process of designing and implementing them, and when they explicitly address agreed-upon goals that incorporate local context, including environmental, economic, social, and cultural values, which can vary widely from river to river (Ladson and Finlayson, 2002; Dyson et al., 2003; Schofield et al., 2003). Finally in this context, institutions for EWA will also fit best when the socio-economic costs and benefits have been considered in a local context (Jayasuriya, 2003; Schofield et al., 2003).

Institutions for EWA should be compatible with the *capacity of the jurisdiction for administration and implementation*. The capacity of the agencies responsible for implementing and administering EWA arrangements, as well as their resources (financial, technical, administrative, etc), influences how appropriate a set of institutions is in a particular place (Knill, 1998; Zarkin, 2005). The technical and local knowledge of staff are also critical for institutional fit. Policies often depend on people with specific characteristics for their effective implementation (Page, 2000). EWA is included in this category, as it requires people with technical expertise and knowledge of local conditions in order to effectively determine and implement flow rules. Agencies must also possess adequate resources for compliance monitoring and enforcement of allocations (Ladson and Finlayson, 2002).

The fourth and final component of institutional fit used in this study relates to the *biophysical and hydrological context* of the jurisdiction. Institutions for water management are most appropriate when they suit the hydrological, ecological, and biophysical conditions of an area (Malano et al., 1999; Saleth and Dinar, 1999; Bandaragoda, 2000; Brown, 2003). Additionally, institutions for environmental water allocation will be more appropriate if they are based on high-quality data on the river system in question; on good understanding of local ecosystem components (Ladson and Finlayson, 2002; Schofield et al., 2003; Arthington et al., 2006); and if they are determined using a flow assessment methodology appropriate for the biophysical and hydrological context in which they are being used (Dyson et al., 2003; Tharme, 2003; Arthington et al., 2006). Finally, institutions for EWA should be compatible with existing infrastructure (such as dams and weirs) (Dyson et al., 2003). In many cases, the physical capacity of a regulating structure limits possible flow manipulations (Schofield et al., 2003).

METHODS

In this research, a qualitative, in-depth case study approach (Gerring, 2007) was used to explore EWA in the Murrumbidgee catchment, NSW (figure 1, below). Field work in NSW took place during June and July of 2007. This period pre-dated implementation of the *Water Act 2007* and the most severe drought conditions in the region (experienced subsequently). As a result, this study should be treated as a snapshot taken during a period where the water governance system was evolving rapidly in NSW, in general, and in the Murrumbidgee catchment, in particular.

Data collection and analysis

Data were collected through key informant interviews, analysis of documents and personal observations. In-depth, active interviews provided critical insights. Twenty key informant interviews were conducted with individuals, chosen because of their involvement with EWA in NSW and the Murrumbidgee catchment. Interview subjects were drawn from the following groups: Commonwealth government (1 informant), the Murray-Darling Basin Commission (1), NSW DWE staff at state (3) and local levels (2), local government officials (2), Catchment Management Authority staff (1), relevant research and academic communities (5), representatives of the irrigation industry (3), and environmental non-governmental organisations (2). Every attempt was made to interview an Aboriginal representative from the Murrumbidgee River Management Committee (MRMC). Unfortunately, this was not possible due to availability conflicts with potential informants.

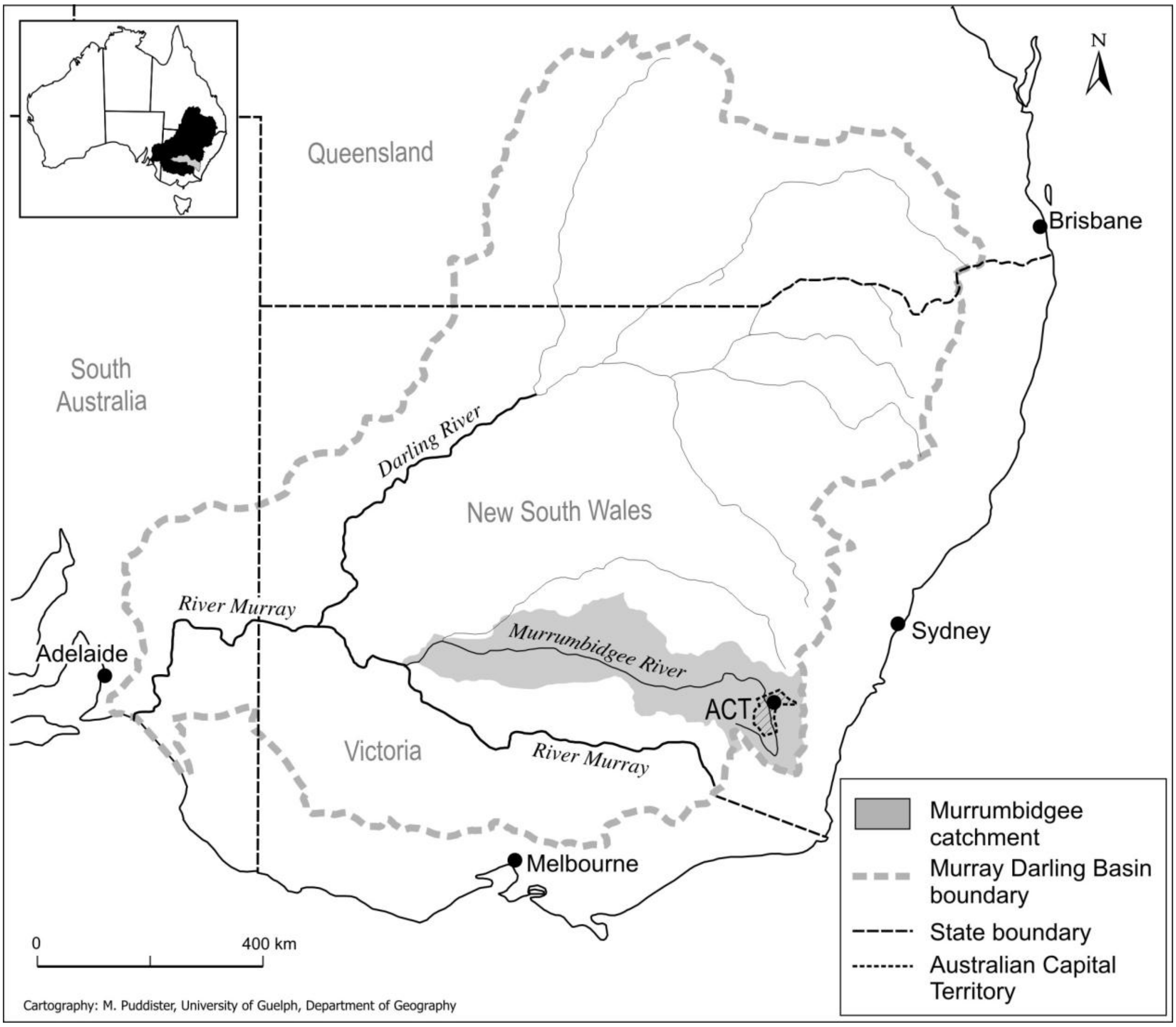
The interviews were organised around a detailed interview guide that was created following a literature review of factors that influence the design and implementation of environmental water allocation and water-sharing mechanisms. Questions in the guide were open-ended, and related to the four types of factors discussed above. For example, to explore issues relating to biophysical context, interviewees were asked "How was local ecological knowledge incorporated into the development of environmental flow rules for the Murrumbidgee"? Most of the interviews were conducted in-person, with a few completed by telephone. Interviews lasted between 30 minutes and 3 hours, and were digitally recorded. All interviews were transcribed verbatim by the lead researcher. Additional data were collected through analysis of pertinent documents. Sixty-one documents were analysed to gather information pertinent to the research questions, and to support triangulation. Documents included water management legislation, policies and documents; catchment planning documents; NGO and industry publications; and relevant media releases.

Analysis of interview transcripts and documents was guided by the theoretical framework outlined above. The goal of the analysis was to reveal factors that facilitate and/or constrain EWA development and implementation. Interview data were coded according to the four broad themes that emerged from the literature review that produced the theoretical framework discussed above. This resulted in a set of political/institutional, socio-economic, administrative, and biophysical factors identified by interviewees as influencing EWA policies and implementation in NSW. Open coding was used within each of these broad themes to examine the data for similarities and differences and to develop sub-categories that distinguished concepts and factors from one another (Strauss and Corbin, 1998). For example, within the many political/institutional factors identified by interviewees, the data were examined to identify and categorise specific concepts such as political will, existing institutions, and economic considerations. Supporting documents were organised and coded in the same way as interview transcripts. Documents were particularly important in the context of triangulation (Stake, 1995) because they permitted clarification and substantiation of information and insights collected from interview subjects. The combined analysis of interview transcripts ad documents revealed factors relating to each of the broad themes identified in the theoretical framework. These were then compared against the theoretical framework; this process permitted an assessment of the relative importance of the various factors in the case study. During this process, the researchers continually cross-checked and reviewed the themes and factors that emerged to ensure validity.

Case study: Murrumbidgee catchment, NSW

The Murrumbidgee is a large lowland river located in southeastern Australia (Page et al., 2005). It is approximately 1600 km in length, of which almost 1200 km are regulated by 26 dams and weirs (Kingsford, 2003). The Murrumbidgee, a major tributary of the interstate Murray-Darling basin (NSW DIPNR, 2004a), drains an area of 84,000 km^2 west of the Great Dividing Range in southern inland NSW (figure 1) (Murrumbidgee Catchment Management Authority, 2006).

Figure 1. Case study region: the Murrumbidgee catchment, NSW, Australia.



The Murrumbidgee catchment is home to approximately 545,000 people. This includes the populations of Canberra, Australia's capital city (2006 population: 324,000), and Wagga Wagga, NSW's largest inland city (2006 population: 59,908) (Murrumbidgee Catchment Management Authority, 2006; ABS, 2007). However, even with recent urban growth, the Murrumbidgee remains primarily an agricultural catchment. The river supplies water to NSW's well-known Riverina agricultural region, which is considered a significant part of Australia's 'food-bowl'. Agricultural production in the catchment is worth in excess of AUD$1.9 billion annually. The irrigation industry in the catchment produces 25% of NSW's fruit and vegetables, 42% of the State's wine grapes, and half of Australia's rice production (Murrumbidgee Catchment Management Authority, 2006). Other major industries in the catchment include dryland agriculture, beef production, intensive poultry production, and merino sheep and wool (Murrumbidgee Catchment Management Authority, 2006). Agriculture, specifically the irrigation industry, contributes significantly to the social and economic well-being of numerous villages and towns in much of the Murrumbidgee catchment (Shields and Good, 2002).

Water-sharing in the Murrumbidgee is especially challenging and contentious because of the conflicting demands of the environment and agriculture (Bowmer, 2003). Competition between these two sectors was heightened during the study period because the drought that was affecting the region had reduced water availability to critically low levels (NSW DWE, 2007a; MDBC, 2007a; CSIRO, 2008). The Murrumbidgee has one of the longest histories of water resource development in the Murray-Darling basin, with the first diversions occurring in 1855 and regulation of the main stem beginning in 1910 (Kingsford, 2003). Irrigation agriculture is by far the greatest water user in the catchment (Shields and Good, 2002; Cooperative Research Centre for Irrigation Futures, 2005). Diversions for irrigation in the catchment account for more than 22% of all annual flows diverted from the Murray-Darling basin (CSIRO, 2008). In the lower, regulated section of the Murrumbidgee river, where the majority of diversions occur, approximately 50% of the available surface water is diverted for irrigation in a typical year (Shields and Good, 2002).

Flow regulation is widely acknowledged to be a major cause of deteriorating conditions in many Australian river and floodplain ecosystems (Cullen and Lake, 1995; Kingsford, 2000; Bunn and Arthington, 2001; Arthington and Pusey, 2003). In the case of the Murrumbidgee river, the volume and natural pattern of flows have been significantly altered by river regulation and diversion for irrigation, resulting in considerable ecological stress for the river and its ecosystems. Correspondingly, Norris et al. (2001) found the Murrumbidgee to be the most disturbed river in the southern Murray Darling Basin. Such intense hydrological modification has negatively affected the environmental health of the river, its wetlands, and associated ecosystems, as well as contributed to water quality problems in the catchment (Hillman, 2004; Kingsford and Thomas, 2004; NSW DIPNR, 2004a).

In recognition of these concerns, and in line with national and State water reforms, environmental flow rules have been in place for the Murrumbidgee river since 1998. Statutory EWA rules have been implemented via the *Water Sharing Plan for the Murrumbidgee Regulated River Water Source* (the Murrumbidgee WSP) (NSW DIPNR, 2004c) under the *Water Management Act*. Environmental water rules in the Murrumbidgee WSP were designed to provide for both *planned* and *adaptive* environmental water – although only one release of environmental water was ever made prior to suspension of the WSP (NSW DWE, 2009). Planned environmental water provisions include rules that are designed to reserve all water above the extraction limit for the environment; protect low flows in the upper reaches of the Murrumbidgee; provide winter flow variability by releasing a percentage of inflows to Burrinjuck dam in the winter months; specify minimum end of system flows; provide environmental water allowances; and water to be stored in dams and released strategically for environmental outcomes such as wetland inundation or bird breeding events (NSW DIPNR, 2004a). Along with the rules-based EWA provisions in the WSP, which are currently suspended due to drought contingency measures (NSW DNR, 2006), a number of other EWA mechanisms existed in the Murrumbidgee catchment in 2007 (table 1).

RESULTS: THE MULTIPLE DIMENSIONS OF ENVIRONMENTAL WATER ALLOCATION

It is widely acknowledged that there are inherent uncertainties in the science surrounding environmental flows, and aquatic ecosystems in general (Bunn and Arthington, 2001). Hence, EWA planning and implementation can be severely constrained by a lack of appropriate scientific information. This concern is considered particularly significant relative to the impacts of climate change on hydrology and aquatic ecosystems (Hillman and Brierley, 2002; Arthington et al., 2006).

During the period in which the research was conducted, scientific information was incorporated as a major component of EWA planning in the Murrumbidgee catchment. For example, the MRMC commissioned studies and reports on ecosystem flow needs, and sought expert advice on ecosystem needs for water in the catchment. However, knowledge of ecosystem dynamics in relation to environmental flows, in general and within the Murrumbidgee system specifically, was considered by interview subjects to be rudimentary at best. Numerous interviewees, many of whom are experts in the field of EWA, acknowledged that the relationship between environmental flows, ecological benefit, and water quality is poorly understood, a fact which is similarly recognised in EWA literature (e.g. Arthington et al., 1998; Gippel, 2001; Schofield and Burt, 2003). In general, EWA decisions in the

Murrumbidgee were made in a data- and knowledge-poor environment; as noted by the chair of the MRMC, "[w]e had almost no information. They don't realise how little information there was. We had nothing". Bowmer (2003) identified this poor knowledge base as one of the critical issues that contributed to implementation problems in the Murrumbidgee's water-sharing process. This finding is echoed by a national assessment of water reform progress, which found that NSW did not employ the best available science in preparing WSPs. The study's authors concluded that information was often generic and insufficiently detailed to enable planning committees to determine the flow requirements needed to maintain ecosystem health (National Water Commission, 2006a).

Table 1. Mechanisms for EWA in the Murrumbidgee catchment, NSW (as of 2007).

Environmental water provision	Type of EWA*	Lead agency	Description	Reference
Water Sharing Plan	RB	NSW DWE	Planned and adaptive environmental flows specified in the Murrumbidgee WSP	NSW DIPNR (2004c)
RiverReach	EG	Murrumbidgee Irrigation Ltd. (private irrigation corporation)	Water exchange allows private irrigation water in the Murrumbidgee Irrigation Area to be traded to the environment in wet years and used for irrigation in dry years	Murrumbidgee Irrigation, 2007
RiverBank	BB	NSW Department of Environment and Climate Change	RiverBank is spending $105 million over 5 years to buy water for the environment from willing sellers, including in the Murrumbidgee catchment	NSW DEC, 2006
CMA Environmental Water Trust	RB/BB	Murrumbidgee Catchment Management Authority	Murrumbidgee Catchment Management Authority has jurisdiction to manage an environmental water trust of water bought on the market (BB), which will fill the adaptive environmental water in the WSP (RB)	Murrumbidgee Catchment Management Authority, 2006
National Plan for Water Security	BB	Commonwealth	NPWS commits AUD$10 billion for water management in the Murray-Darling basin, including funds for buying water licences for EWA	DEWR, 2007
Water for Rivers	EG	NSW, Victoria, Commonwealth	Delivering water for environmental flows in the Snowy and Murray rivers by finding efficiency gains, some work in the Murrumbidgee	Water for Rivers, 2008
The Living Murray	EG/BB	Murray-Darling Basin Commission	Designed to recover environmental water for sites along the Murray using infrastructural improvement and market-based methods, some water from the Murrumbidgee	MDBC, 2007c

*RB=rules-based; EG=efficiency gains; BB=buy-backs.

Due to the lack of adequate scientific information in the Murrumbidgee catchment, a number of management decisions were made in an *ad hoc* manner. For example, the EWA rules initially specified that 65% of inflows would be released from the Burrinjuck dam, but, as one MRMC member explained: "that was just a figure they thought was a good figure; they thought it sounded about right, and that's about it. Ecologically there was no science behind it". Developing science-based EWA rules designed to have positive outcomes for river health without adequate knowledge of the river and ecosystems in question clearly presents a significant challenge.

Coupled with the overall dearth of scientific information, another challenge faced in the Murrumbidgee catchment was the (lack of) consideration of climate change in EWA decision making. Environmental flow assessments in the Murrumbidgee, whereby the ecological needs of the river system are determined based on historical flows and ecosystem needs, were based on what was believed to be high quality hydrological data. Hydrologic records have been kept for the Murrumbidgee since 1880 (Hardwick, 2007), and more than 100 years of flow records were used in hydrologic modelling to investigate the impacts of different environmental flow rules on the river system (MRMC, 1998; NSW DIPNR, 2004c). However, many interviewees indicated that the last 100 or so years of flow records are in fact misleading because this period is not representative of current climatic conditions or those that will be experienced in the future as a result of climate change. Indeed, a recent review commissioned by the Commonwealth government suggests that a 1 ºC increase in temperature is expected to produce a 15% decrease in streamflow in the basin (Garnaut, 2008), and a recent analysis specifically suggests that water sharing and EWA strategies in NSW based on historical data may be flawed due to a climatic shift since 1950, with an increase in rainfall but greater variability (Khan et al., 2003). As for how this has impacted EWA in the Murrumbidgee, the chair of the MRMC put it simply: "[e]verything we did was based on 108 years of historical data, and now it's drier than that".

Clearly, the resulting WSP and EWA rules did not adequately incorporate scientific knowledge or consider the potential impacts of climate change on water availability. Less than 2 years after implementation of these rules – while supposedly based upon the 'best available science' – they have been rendered unable to function and suspended due to drought. As a result, the WSP and EWA rules in NSW are not sufficiently robust for a range of climatic conditions, a conclusion similarly drawn by the Nature Conservation Council of NSW and others (2007).

However, while undoubtedly significant, scientific and technical problems alone do not explain the full extent of the challenges and ultimate failure of the institutions for environmental water allocation in NSW. Findings from the research conducted for this study show that, in addition to issues with inadequate scientific information, many of the significant obstacles faced in the Murrumbidgee catchment were institutional, political and social in nature.

Determining an appropriate balance between the needs of people and the environment for water lies at the heart of the EWA challenge. As a result, trade-offs among a suite of interests are an inescapable part of the process (Hirji and Panella, 2003). How NSW addressed the concerns of irrigators to develop contextually appropriate EWA arrangements demonstrates the importance of incorporating economic factors into environmental decision making. However, given that river modification driven by economic imperatives is largely the reason for EWA to be necessary in the first place, it is clear that focusing primarily on economic concerns in water planning has the potential to be detrimental to achieving environmental outcomes. Evidence suggested that this occurred in NSW.

The values driving broad planning policy for water management in the Murray-Darling basin were summarised by a senior basin management professional interviewed for this research as follows: "the priority has been irrigators, and the environment's got to fit around that". Supporting this view, an employee of a Commonwealth water planning agency readily acknowledged that, "in planning policy they may say that the environment is our priority, but in reality it's not. It's always the last one in the basket". This *de facto* policy of prioritising economic and political concerns over environmental water needs was evident in EWA implementation during the study.

The continuing suspension of the NSW WSPs and subsequent drought contingency measures provided further evidence of the weight given to economic concerns relative to environmental considerations within EWA institutions in NSW. In 2006, due to extreme drought conditions (and despite allocation priorities legislated in the *Water Management Act*), the State 'borrowed' water from the Murrumbidgee environmental water account to supplement consumptive licences and town water supplies in the catchment (NSW DNR, 2006; NSW DWE, 2009). Not long after, the Murrumbidgee WSP, along with a number of other WSPs in NSW, was suspended under Ministerial discretion; these WSPs remain suspended since November 10, 2006 (Inland Rivers Network, 2007; NSW DWE, 2009). The DWE has stated that the borrowed environmental water will be reallocated to the environmental accounts as soon as conditions improve, and that the environment will be the first to be re-credited from inflows into the Murrumbidgee (NSW DWE, 2007b, c). However, while consumptive allocations in the Murrumbidgee were subsequently increased a number of times due to increases in water availability (NSW DWE, 2007a; Inland Rivers Network, 2007), the environmental water that was taken to top up other licences had not been fully repaid as of May 2009 (NSW DWE, 2008; NSW DWE, 2009) and the WSP remains suspended even at the time of writing.

In addition to the suspension of the WSPs, EWA outcomes have been undermined for political and economic reasons in other ways. For instance, despite the presence of legislation requiring the provision of environmental water, interviews indicated that it is considered politically undesirable to deliver environmental flows during droughts. One interviewee, an employee of a Commonwealth water management agency, provided an example:

> We've had situations where there are wetlands that are dying and needing some sort of flow, but the government has made an overriding call to keep that water in the dam, because it looks bad to release it. So you'll have water not doing anything when it could be put to good use, and so in that respect the security of the environmental water can be compromised.

For reasons such as these, we argue that much of the potential environmental benefit of EWA has been compromised for economic considerations in NSW, a fact noted by other commentators. For instance, Millar (2004) has observed that on many occasions, the NSW government has made compromises about measures to protect environmental health when pressed by irrigators, claiming that those measures would adversely affect the economic viability of their industry. Indeed, across the Murray-Darling basin even when considerable pressure and financial commitments have driven new mechanisms for EWA, the resulting policies have been so diluted by agricultural pressure groups that they have often failed to achieve their goals (Hussey and Dovers, 2006). As one MRMC member stated with respect to EWA in the Murrumbidgee, "It [EWA] is working here because it isn't doing anything too hard". Findings from the research suggest that economic imperatives and the viewpoints of a politically powerful group – irrigators – have been so heavily weighted in the process that, even though EWA rules exist, the political will to implement and maintain them has not been strong enough to provide ecologically meaningful environmental flows.

Local decision-making dynamics also posed significant challenges for the EWA process in the Murrumbidgee catchment. The MRMC, the multi-stakeholder group tasked with developing the draft WSP for the Murrumbidgee river, represented most of the local stakeholders involved in water sharing. Though consensus was the original goal, the high degree of conflict among the values of committee members resulted in fractured and weakened EWA provisions in the catchment. Thirteen interviewees, including each of the ten informants who were MRMC members, identified a great deal of conflict during EWA planning within the MRMC, particularly between the irrigation representatives and the environmental community. This ongoing tension between irrigators and environmentalists in the Murrumbidgee is consistent with general trends across NSW with respect to EWA (Bowmer, 2003; Millar, 2004). Even though a diverse range of local stakeholders was represented in the water-sharing process, interviewees felt that "they hardly figure in. It really comes down to irrigation versus environment". Accordingly, many interviewees described the situation within the MRMC as polarised:

the 'city greenies' and 'environmental antagonists' against the irrigation community. One interviewee described the conflict in terms of incompatible values:

> Value systems are in conflict, so if you've got one group of people thinking that water is a public good and that environment needs its full share for healthy rivers, whatever that is, and irrigators have businesses in which they've invested a lot of money… it's a conflict that's extremely difficult to overcome.

Interviewees acknowledged that negotiations within the MRMC were at times openly hostile, and the water-sharing process in the Murrumbidgee has been described as "nasty", "messy", and even that there was metaphorical "blood on the floor". For instance, one interviewee recalled the time when a local farmer who owned an 'environmentally-conscious' operation was forced to step down from the Committee due to sabotage by people who thought that this person was "an absolute bastard for speaking up for the environment". The interviewee was 'sworn to secrecy' regarding the exact nature of the sabotage to this individual, but believed it to be the deliberate result of others disagreeing with this member's stance on the MRMC.

Serious problems arose when it came to incorporating public input into EWA decision making at the State level. The role of community input and the MRMC was not clear, which caused confusion and anger among members of the Committee and the broader community (Bowmer, 2003; Millar, 2004). While the final WSP was always intended to be a 'Minister's plan' (as stated in the *Water Management Act*), there was a lack of clarity as to the role of the Committee and its authority in final decision making. After years of work by the MRMC to negotiate and recommend a draft WSP, the Minister made a number of changes against the recommendations of the Committee. While these changes occurred within legislated Ministerial discretion, it caused confusion and concern about transparency and the purpose of community consultation.

Many interviewees expressed resentment and frustration with respect to the outcome of the EWA and WSP planning process in the Murrumbidgee, and felt that the public consultation that had taken so much effort was wasted. One MRMC member echoed this disappointment:

> [The Ministry] reviewed our report after five years, and it had all this red writing through it. They just really dismissed stuff that we'd already resolved; that was disappointing. They talk about consulting with people; I mean you've got to be fair dinkum about it. You've got to be honest and transparent about when you say you'll consult with someone, you've got to listen and take notice of them, not just sort of consult with them and if it doesn't suit your case you go and write it up how you want it. Yeah, that was disappointing.

Other groups such as the Ricegrowers' Association of Australia (based in the Murrumbidgee catchment) also spoke out about the perceived lack of meaningful involvement in water planning, stating that community involvement cannot be based simply on provision of information and tokenistic consultation, and that, "isolating communities from decision making about natural resources causes angst, breaks down the potential for constructive and cooperative solutions and destroys local ownership and trust" (RGA, 2005).

One of the main objectives of the NSW *Water Management Act* (Part 1, 1(3d)) is "to recognize the role of the community, as a partner with government, in resolving issues relating to the management of water sources". However, in trying to achieve this objective, it appears that the government of NSW had unrealistic expectations. It asked community members to negotiate a consensus agreement on water sharing wherein one group of stakeholders – irrigators – faced significant financial and cultural losses (e.g. having to give up their rural farm lifestyle) for every drop of water given up to the environment through the process. Though committee members were supposed to be considered equal partners in decision making, there were clear power dynamics and politics at play within the committee, which in turn compromised effective EWA planning and resulted in the committee finally agreeing to a 'watered-down' water sharing plan. Dissatisfied with this draft plan, the State government altered it to better suit government objectives, thereby angering and disillusioning the very communities it sought to engage.

DISCUSSION AND CONCLUSIONS

In the Murrumbidgee catchment, a variety of issues contributed to the problems faced in developing and implementing EWA. These included significant scientific and technical challenges that are characteristic of EWA in most jurisdictions. However, profound social and political challenges also existed – and these too are commonplace. Scientific and technical challenges revealed in this study included the high degree of scientific uncertainty that undermined decision making, and a widespread failure to adequately consider the implications of climate change. This produced EWA arrangements that, experience has shown, were not sufficiently robust to cope with increasingly severe water scarcity. Social and political challenges included difficulties reconciling deep-seated value conflicts between economic development and environmental sustainability, and the challenging social and political dynamics of local involvement in water management processes. We argue that while much attention is being directed towards the scientific and technical challenge of EWA, less is paid to the social and political challenges that are no less integral to developing effective, robust institutions for sharing water. Successful EWA clearly demands that attention be paid to both kinds of considerations.

For the most part, literature on EWA theory and practice focuses on overcoming the scientific and technical challenges of environmental flows. To illustrate, numerous publications highlight improvements and innovations in scientific methods for determining the environmental water requirements of ecosystems (e.g. Jowett, 1997; Hughes and Rood, 2003; Tharme, 2003). Significantly less attention has been paid to strategies for addressing the complex – yet no less important – social and political challenges of environmental water allocation. These include how to gain stakeholder participation and public support for EWA, and how to integrate a new environmental imperative into an institutional context that has historically privileged economic uses of water. Some recent literature has begun to consider the social and political factors involved in EWA. For example, Graham (2009) found that in the Murrumbidgee catchment, irrigators' perceptions of EWA effectiveness affected their support for the EWA process; this acknowledges the significance of stakeholder perception and public support as integral components of EWA. Recognising the social dimension of EWA, Howard (2008) argues that restoring environmental flows in Australia's River Murray is more than a debate between agriculture and environment, but that amenity values – the qualities of a region that make it an attractive place to live, work and play – also are critical. Similarly, King and Brown (2006) are advocates of holistic flow assessment methods that explicitly consider socioeconomic factors – how flow changes will impact people and livelihoods along the river – alongside biophysical considerations.

The findings from our study of EWA in NSW are consistent with the conclusion drawn by Wallace et al. (2003). These authors argued that scientific principles can be used to determine ecosystem water requirements, but whether these requirements can be achieved depends on complex interactions among social, economic and political considerations. Ultimately, it is important to remember that EWA is a political activity because the need to share water with the environment only exists when insufficient water is available to meet both human and environmental needs. How then can we most effectively provide water for the environment in a scientifically valid fashion that recognises the profound social and political dimensions that are at play when water is scarce?

Catchment-based integrated water resources management (IWRM) has been put forth as a framework that can be used to better incorporate diverse societal values into EWA decision making through achieving better stakeholder representation and, therefore, incorporating a wider range of views (Wallace et al., 2003). IWRM is accepted internationally as an appropriate way to address a diverse range of water and related resource concerns. However, as shown in this case study, catchment-based planning for EWA is no guarantee that conflicting values will be reconciled and equitably considered in the EWA process. Similar findings emerge from studies of IWRM in other parts of the world where competition for water between economic uses and the environment is severe, e.g. southern Africa (Swatuk, 2008). As Conca (2006) concludes, "The most common form of water conflict today is not the interstate water wars foreseen by so many international relations prognosticators, but rather the societally based conflicts between the proponents and opponents of controversial ways of manipulating water or the rules controlling it". In the context of EWA, deeply entrenched economic interests often hold sway, and local decision-making processes can open up a whole new set of problematic social dynamics, further complicating EWA development and implementation. Thus, while we accept that IWRM is an appropriate overarching framework and tool kit for addressing water management problems at the catchment scale, it is not a panacea. There are no easy 'technical fixes' for the kinds of socio-economic and political challenges experienced in the case evaluated in this study. As a result, we emphasise the importance of identifying and addressing the socio-economic and political implications of EWA from the outset in planning and decision-making processes.

In the context of the Murrumbidgee, specifically, and NSW more generally, economic factors – particularly the dependence of the irrigation industry on scarce water resources – have largely determined the course of water reforms (Haisman, 2005). Our case demonstrates that privileging economic factors can significantly constrain development of effective EWA arrangements. At the same time, however, the case demonstrates that it is too simplistic to suggest that these interests can be ignored, or that resistance to change is simply a reflection of deeply entrenched interests exercising their power. Irrigators in the Murrumbidgee catchment have resisted efforts to reduce their water entitlements because their livelihoods and communities are at stake. Thus, across the state environmental objectives have been compromised to sustain water-dependent rural communities. The importance of water for these communities cannot be overemphasised. As has been demonstrated by other researchers, the impacts of insufficient water for irrigators in rural communities include failed businesses and profound social trauma (Kuehne and Bjornlund, 2006).

While the EWA challenge lies in balancing multiple demands for water, experiences in the Murrumbidgee catchment suggest that it may not always be possible to find a balance that adequately protects the environment in a place where water is exceptionally scarce and plays such an integral role in the local economy. Circumstances in the Murray-Darling basin in Australia are especially dire, but the problems associated with sharing water between people and the environment exist wherever EWA has become a priority. Solutions to this dilemma are not straightforward, and are never guaranteed. Nonetheless, the case examined in this paper, along with growing evidence from other research, points towards several viable strategies.

To begin with, we in no way suggest that EWA should be based solely on political or economic considerations. A sound scientific basis and an ability to clearly understand the ecological implications of trade-offs between water for the environment and water for the economy are required to support effective decision making. Thus, efforts to improve the science of EWA should clearly be a priority. We do suggest, however, that EWA processes must begin by recognising the fact that trade-offs will be required, and thus that EWA is a *political* as well as a *scientific* problem. This conclusion is entirely consistent with growing global awareness of the extent to which water problems are not simply technical problems, and cannot be solved through technical processes alone (Aylward et al., 2005; Conca, 2006). In practical terms, this means that from the outset, EWA processes must acknowledge and account for the political and socio-economic contexts that exist.

Achievement of this goal is more likely when two conditions exist. First, it is vital that institutions exist that mandate collaborative, multi-stakeholder planning and decision making. As argued above, these approaches are not a panacea. However, experiences around the world support the importance of mechanisms for collaborative governance that permit integration of differing viewpoints, types of knowledge, and interests (Innes and Booher, 2010). As noted in the case study examined in this paper, implementation of collaborative water governance in NSW was problematic. However, it is important to emphasise that unlike many other jurisdictions, NSW has established institutional arrangements that provide a legal mandate for collaborative planning for water allocation and that situate the resulting plans clearly within the larger water allocation system. That the plans resulting from this process in NSW were suspended in large part reflects the sheer magnitude of the drought, and does not diminish the importance of multi-stakeholder approaches to watershed governance. Second, an interdisciplinary orientation is essential. Several contributors to the literature on EWA have called for greater interdisciplinary collaboration (e.g. Dyson et al., 2003; Schofield et al., 2003; Richter et al., 2006). However, 'interdisciplinary' in this context is commonly defined in terms of the natural sciences and engineering, i.e. hydrologists, biologists, aquatic ecologists, and water resource engineers working together. Often missing in these discussions are the social scientists, who bring knowledge of the socio-economic and political challenges identified in this article, insights that improve the prospects of developing effective EWA arrangements. Defining 'interdisciplinary' in terms of collaboration among social sciences and natural sciences/engineering, we suggest, is needed to ensure that the socio-economic and political considerations that are inescapable in water-short regions are prioritised *in advance* of a crisis. We recognise that this degree of interdisciplinarity is difficult to achieve – a concern that has been raised in other contexts (e.g. Petts et al., 2008). Nonetheless, we suggest that development of a genuine interdisciplinary orientation to EWA is essential so that social as well as ecological concerns can be identified, analysed and balanced before conditions aggravate during a crisis.

Beyond these relatively straightforward measures, we argue that recognising and accounting for socio-economic and political considerations in EWA must be viewed as a *fundamental* challenge that transcends individual catchments. In situations where water scarcity is not yet severe, and where the dependence of economic interests on water is not overwhelming, it may be possible to meet environmental water needs with incremental adjustments. However, in cases such as the one examined in this paper, where scarcity is severe and where water underpins entire regional economies, incremental adjustments will not be effective. As the Australian example illustrates, extensive changes to water allocation systems typically are needed to deal with the kinds of systemic problems revealed by the country's ongoing drought. These kinds of changes are simply not within the mandate or capability of local actors at the catchment scale. Even more fundamentally, where meeting environmental objectives has significant implications for regional economies, and where the cooperation of multiple jurisdictions is required, political leadership grounded in a society-wide consensus will be required to institute the profound social and economic transformation that will be needed. Clearly, this fact alone moves EWA well beyond the scientific and technical realms.

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