What we've learned from 10 years of integrating biophysical and social research to improve outcomes of environmental flows in Australia

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Key Points

- Adaptive management , or 'learning from doing' is needed to address widespread environmental degradation of rivers
- Focusing on the learning aspect of 'learning from doing' reveals successes of adaptive management
- Research that integrates biophysical and social components is a practical model for addressing the challenges of the Anthropocene
- Benefits emerge when researchers from different disciplines inquire into systems together

Abstract

Adaptive management of environmental flows has both biophysical and social aspects. In this paper we share some lessons from over a decade of multi-disciplinary research on environmental flows, where we have sought to understand the process of learning and change practice.

Our first project focussed on river operators working within operating rules to achieve multiple outcomes in the Mitta Mitta River (Victoria). We integrated biophysical data with results from interviews with river operators, and contributed to the development of new guidelines for operation of Dartmouth Dam. Our recent research in the Edward-Kolety/Wakool system (NSW) is integrating results from biophysical monitoring and stakeholder surveys to document outcomes and perceptions of flow trials undertaken outside operational norms.

In both of these projects, learning (social, operational, ecological, physical) was occurring, but targeted social research was required to find and document evidence of it. Our multi-disciplinary research has helped broaden understanding of adaptive management and has influenced water management. It has led to social research being integrated into monitoring and evaluation of environmental flows in the Edward/Kolety-Wakool systems. River systems are under increasing pressure in the Anthropocene, and we consider this approach of integrating research is one model for meeting that challenge.

Keywords

Adaptive management, environmental water, Murray-Darling Basin, multi-disciplinary research, learning, flow trials

Introduction

The widespread environmental degradation of rivers requires water managers to implement actions despite imperfect knowledge about how systems will respond. In the context of 'wicked' problems, the practice of adaptive management enables managers to work in the presence of complexity and uncertainty (Pahl-Wostl et al., 2013). Variously defined as 'learning by doing' (Argent, 2009) and 'management under uncertainty' (Webb et al. 2017), adaptive management focuses on learning about and/or within a system to improve outcomes for all stakeholders.

Since the initial formulation of the concept of adaptive management in the 1970s (e.g. Holling, 1978), it has evolved differently through different research traditions (Allen et al. 2011). One approach is technically focused, often including the development of models to inform decisions and predict outcomes; evaluation of monitored data is used to update model parameters to improve the next round of management decisions (e.g. Nichols et al. 2007). In relation to the delivery of water for the environment, this technical approach is mostly focused on documenting the biophysical outcomes of the management decisions. A contrasting approach to adaptive management focuses attention on the process of learning, particularly how new information leads to changes in management practices. This more socially focused approach can enable participation in management and planning by a wide range of stakeholders (Ostrom, 2009; Wei et al., 2011). The technically and socially focused approaches are complementary, rather than contradictory (Lee, 1993). Indeed, adaptive management requires understanding of the biophysical implications of management to occur in tandem with flexibility and growth in the closely coupled social system (Gunderson, 1999). Since the Enlightenment there has been a gradual separation of researchers and practitioners into narrow fields of expertise, such that contemporary biophysical and social science fields have distinct ontologies, epistemologies and languages. Integrating, multi-disciplinary action-focused research provides a practical opportunity to bring these fields together to optimize adaptive management.

We are an ecologist and a social researcher; in this paper we share some of what we have learned from over a decade of research on environmental flows, where we have undertaken research linking biophysical and social research design and findings to improve our understanding of the process of learning and change practice.

Integrated research reveals adaptive management can evolve over time

Our first project together related to the management of Dartmouth Dam in north-east Victoria, which is managed as part of the River Murray System in the Murray-Darling Basin. In this system, river and dam operators were working within existing operating rules to achieve multiple outcomes. Biophysical monitoring of four variable flow trials between 2001 and 2008 evaluated the response of water column microbial activity, benthic and water column metabolism, the structure and composition of algal biofilms, and benthic macroinvertebrates to increased flow variability, created by varying the release from Dartmouth Reservoir (Watts et al. 2010). Each trial built upon lessons from previous trials, with collaboration among key stakeholders occurring before, during and after each trial. Results from interviews with river operators enabled us, and the river operators, to understand the factors influencing changed water management practices (Allan et al. 2009). Institutional conditions encouraged a shift to adaptive management over time that helped to achieve environmental, social and economic objectives downstream of Dartmouth Dam. We described this process as emergent adaptive management, acknowledging that the goal of adaptive management does not have to be specified *a priori,* but can emerge provided the stakeholders are willing and able to change their operational paradigm (Watts et al. 2010). Targeted research and collaboration among stakeholders assisted learning, and ultimately the development of interim operational guidelines for increased within-channel flow variability in the highly regulated Mitta Mitta River.

Through this multi-disciplinary and collaborative research we found that even this relatively simple example of adaptive management was more complex than the idealised cycling through phases of plan-do-monitor-learn. This in part reflects the multiple spatial and temporal scales in which planning occurs. Significant institutional review and planning tend to operate over long time cycles, whereas during the span of a management plan there is day-to-day learning that occurs through implementation of management decisions. We observed two distinct cycles of feedback and learning, with the implementation cycle ('inner loop learning') nested within the larger planning cycle ('outer loop learning') (Watts et al. 2010). Inner loop learning occurred through the discrete studies directly informing the planning and implementation of subsequent variable flow trials and refinement of monitoring (Figure 1). New knowledge was also shared with local property owners (learning loop moving out of the adaptive management cycle, Figure 1). We found, in fact, that when conditions are supportive there are opportunities for water managers to re-assess, and explore flexibility within existing river operating rules, resulting in improved environmental outcomes while simultaneously fulfilling or enhancing social and economic objectives and requirements.

We concluded that an incremental approach to adaptive management may be more feasible and more likely to succeed in the short term compared with larger-scale initiatives, and that it can be an enabling or complementary approach. The challenge for natural resource managers is to recognise when the conditions are supportive of change and act to enable adaptive management where it may be beneficial.

More than 10 years after the guidelines were developed they are still being used to inform the delivery of variable flows from Dartmouth Dam to the Mitta Mitta River (e.g. Murray-Darling Basin Authority 2021). The simplicity and non-prescriptive nature of the guidelines, means that dam operators have the opportunity to achieve multiple benefits for the ecosystem and community at the same time as fulfilling or enhancing the required social and economic objectives of dam operations.

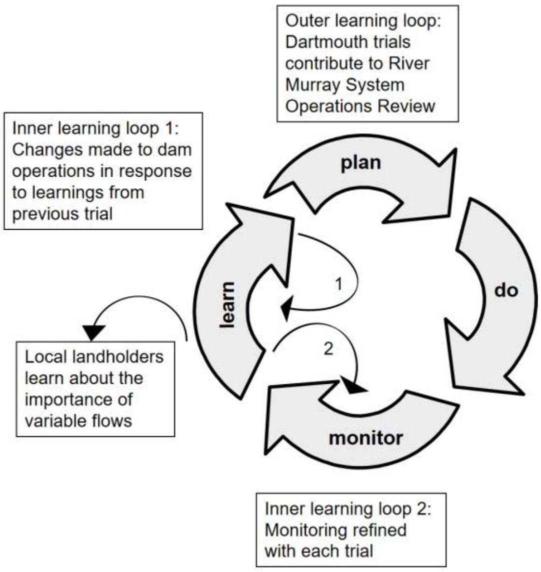

Figure 1. Adaptive management as it emerged in the Dartmouth Dam and Mitta Mitta River case study. Mini-adaptive management loops show how several small trials directly informed the planning and implementation of changes to operations. These lessons are now beginning to inform the larger planning framework of the River Murray System Operations review. Also, monitoring was refined, and local stakeholders informed. (Source Watts et al. 2010).

Integrated research reveals different ways in which stakeholders perceive management

Our more recent research is in the Edward-Kolety/Wakool system in southern NSW. This is a more complex river system with more complex governance and environmental water delivery than the Mitta Mitta case study. Water for the Environment is provided as part of the Murray-Darling Basin Plan that explicitly requires the use of adaptive management (Chen et al. 2020).

Our work in the Mitta Mitta River suggested that focusing on the learning side of 'learning from doing' helped to illuminate adaptive management. Transferring this to the Edward-Kolety/Wakool system we found more inner and outer learning loops than in the Mitta example. In fact, once we started looking it was clear that a number of different types of learning were occurring over time, and in different parts of the social-ecological system. Firstly the actions taken explicitly to enhance adaptive management of environmental water in the area were clearly driving learning from doing - the main learning cycle shown in Figure 2. Over time we have seen a shift from a general concept of adaptive management to an active learning cycle that has become embedded in management processes – the inner loops of Figure 2. Documentation of learning is also improving; for example in addition to flow recommendations being listed in annual reports, managers are asked to provide a statement of the adaptive management response to each of the recommendations (e.g. Watts et al. 2019). This ensures that the change in management is publicly shared and the learning process documented; and this transparency in turn enables stakeholders other than those directly involved in managing the water to learning about their river system, and about how to learn about it – the outer learning loops in Figure 2.

In the Edward/Kolety-Wakool system environmental watering actions have been undertaken since 2010, however, the size and duration of in-channel flows has been constrained due to operational constraints in the system (Gawne et al 2013). Watts et al. (2016; 2018) had recommended that water managers work with stakeholders to explore options to implement a flow trial that was outside the normal operational rules. The authors' recent joint research into adaptive management has focused on two of the small trials that were outside the operational norms in the system; a winter flow trial, and a small fresh called the '800 ML/day trial', each described briefly below.

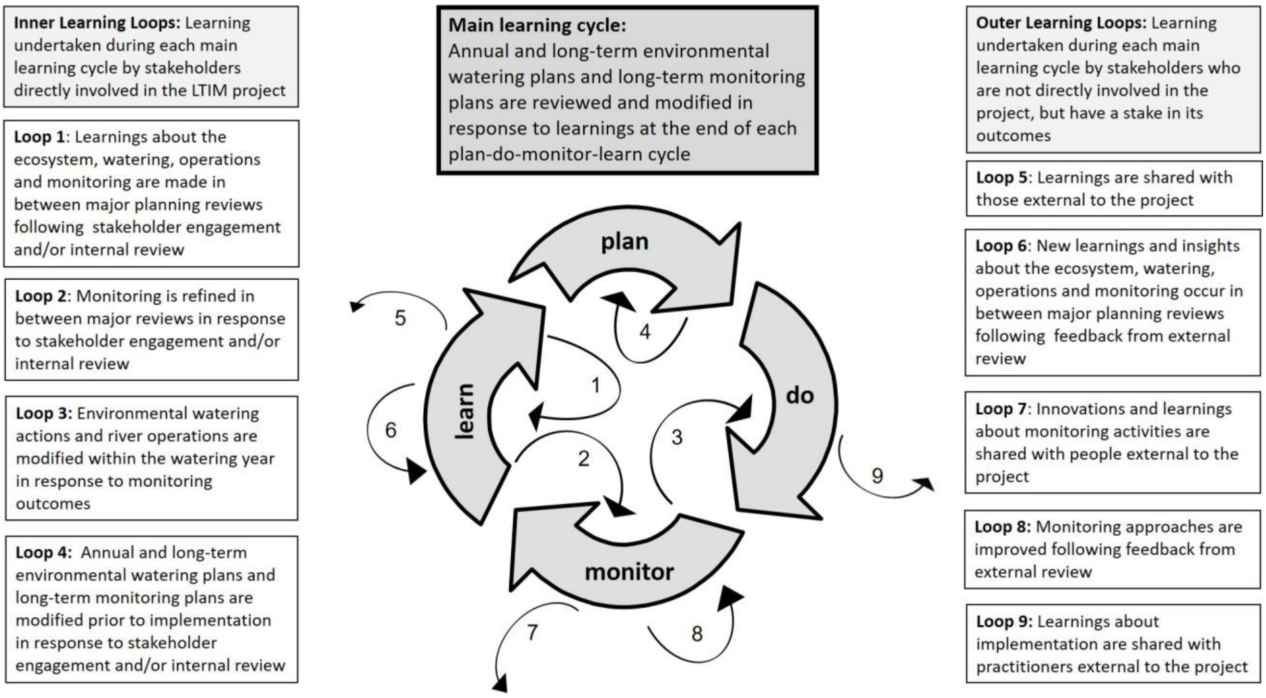

Figure 2. Main learning cycle and learning loops associated with environmental watering in the Edward/Kolety-Wakool River System. Large arrows indicate the main learning cycle representing adaptive management through annual or longer adjustments to practice. The smaller arrows inside the main cycle represent the inner learning loops, being learning by stakeholders directly involved in the LTIM project (Loops 1-4). The small arrows outside the main cycle represent outer learning loops, being learning by stakeholders not directly involved in the LTIM project, but who have a stake in its outcomes (Loops 5-9). (Source: Allan and Watts 2017).

The winter flow trial

A continuous base environmental flow was delivered in Yallakool Creek, the mid and lower Wakool River, and Colligen-Niemur system during winter from the end of May through to August 2017. The objective of this flow trial was to contribute to reinstatement of the natural hydrograph, improve connectivity, improve the condition of in-stream aquatic vegetation and fish recruitment. This watering action was in contrast to normal operating conditions in these river, whereby regulators to Yallakool Creek, Wakool River and Colligen Creek are usually closed during winter, resulting in extended periods of cease to flow in these systems. Planning for the watering action involved landholders, community members, water managers, river operators and scientists. Biophysical monitoring included 2-D hydraulic modelling to estimate extent of wetted in-channel riverbank, hydrological data, weekly water quality monitoring, estimation of gross primary productivity from dissolved oxygen data, and documentation of the movement of two species of fish using acoustic monitoring.

The 800 ML/day spring flow trial

The 800 ML/day spring flow trial tested some of the impacts of delivering water at a higher rate than the normal upper operational limit. Planning for the trial was undertaken over more than one year, with extensive engagement, consultation, discussions and planning involving landholders, community members, water managers, river operators and scientists. The planning led to the implementation of the 800 ML/day flow trial in the Yallakool-Wakool system from 22 August to 26 September 2018.

Biophysical monitoring was undertaken during the trial to examine the extent to which this flow trial could contribute to inform decision making and adaptive management of environmental water delivery in this system. The biophysical monitoring included 2-D hydraulic modelling to estimate extent of wetted in-channel riverbank, hydrological data and manual reading of staff gauges to estimate flow peaks and hydrology, photo points to document changes in river levels and to document the extent of inundation of infrastructure (e.g. low-lying private bridge crossings), weekly spot water quality monitoring and estimation of gross primary productivity.

In addition to the biophysical monitoring of the two flow trials, 13 semi- structured interviews were undertaken with 18 people with a 'stake' in the two trials - landholders, irrigators, Traditional Owners, agency staff, river operators, water managers and interested community members. The interviews encouraged relatively free flowing personal recollections of the implementation of the each of the flow trials, and reflection on experimenting with environmental water. Participants were invited to discuss their relationship with the Edward/Kolety-Wakool system, and to reflect on their experience of the trials (Allan and Watts, in preparation).

Outcomes of the flow trials

The winter flow trial maintained longitudinal connectivity in a part of the system that would usually experience cease to flow under normal river operations. In contrast, an adjacent tributary that did not receive this winter flow had a cease to flow of 72 days (Watts et al. 2018). The winter action improved water quality, especially in part of the river system that is often impacted by saline groundwater intrusion. The winter flow also increased gross primary productivity, improved the survival of submerged aquatic plants, and facilitated movement of tagged silver perch throughout the system over the winter months when fish would normally have restricted movement (Watts et al. 2018).

During the 800 ML/day spring flow trial only one private bridge and one low level crossing was inundated (Figure 3). The landholder managing one of the properties affected by the flow commented that 'the bridge only went a little bit under, and we could use it anyway'. Inundation modelling showed that the flow increased inundation of the riverbank and there were no adverse effects on water quality (Watts et al. 2019). No formal monitoring of biota responses to the watering action were undertaken. However, observations and photopoints showed that the watering action had inundated low lying benches and edge habitats, inundating amphibious vegetation (Figure 4). Frogs were heard calling from these recently inundated habitats and waterbirds were observed feeding in the shallow edges of inundated habitat.

Figure 3. One of the low level private bridges in the Yallakool-Wakool system. Left: Prior to the 800 ML/day spring flow trial. Right: During the peak of the flow trial.

Figure 4. Inundated backwaters during the peak of the 800 ML/day flow trial watering action.

The flow trials, and the idea of experimenting with environmental water more generally, were received positively by the most of the stakeholders we interviewed. Many saw undertaking trials as an opportunity to explore how to act in a complex socio-ecological system. For some the biophysical outcomes of the environmental water were important, for example, one landholder said:

> *Oh, I'm all for the 800; that worked really well, in my opinion…for the fish breeding and that. Because we get fisheries that come out here and do all the electric fishing and all the larvae counts … and to see the results that came out of this year compared to the last two years is, definitely things are going ahead.*

For others the trials showed what could be achieved despite the complexity and variance of needs in the area. For example, another landholder noted:

> *And I think that with the 800 meg a day, there was a lot of work done by [the State and Commonwealth agencies] and they have been congratulated in the e-water forums and those sorts of things, that they did a really good job of communicating with the community...The community knew what was happening. They knew when the pulse was going to arrive. What the expected duration was. They knew it was going to be short term. And so they could plan around it.*

The multiple opportunities for learning from flow trials is encapsulated in the following quote from an agency staff member:

> *But I think what it probably showed the community out there the opportunities of looking outside the square and maybe trialing different things, and the benefits by doing that. It is not only ecological outputs and outcomes that we achieved…..*

Through our integrated research in the Edward-Kolety/ Wakool River System we have learned that:

- There are multiple biophysical benefits from experimenting with environmental water, achieving better outcomes for both the environment and the community.
- That focusing too much on the 'doing' in learning from doing, risks missing many of the successes of adaptive management.
- A range of learning (social, operational, ecological, physical) is occurring through using environmental water in the area. However, as the learning occurred in many forms and across multiple years and organisations, a structured, co-ordinated effort was required to find and document it.
- Social research methods and approaches helped in the search for evidence of learning/ adaptive management, especially when used as part of an integrating research approach.

The success of this approach of integrating biophysical and social research is that water managers have a deeper understanding of landholder and community perceptions and concerns about the environmental watering actions, and landholders and community members have a closer understanding of the aim of the scientific experiments. This improved understanding enables water managers to incorporate appropriate planning for subsequent actions, and thus are more likely to succeed in the longer term in incorporating these types of actions into the operational flow regime. The benefits of a multi-disciplinary approach is evident in the success of planning and implementing a subsequent watering action. In spring 2020 a further flow trial was planned for the Wakool system, incorporating the new understanding developed from the previous two flow trials. The planning process in partnership with community was less protracted this time, because the community understood what the process and likely outcomes would be based on their experience of the previous trials. This subsequent environmental watering action had a higher and longer peak flow, and more gradual recession than the trial in 2018, resulting in additional benefits for the ecosystem, and the landholders did not have any concerns, and were able to continue their farming business without interruption. There were also enhanced social and economic outcomes through improved river bank condition resulting from the gradual recession of flow. We are now expanding our social research to gauge the wider community's perceptions of flow trials, and the results of this will contribute to future flow planning.

Conclusions

We believe the narrative above shows that our multi-disciplinary, integrating approach has influenced changes in water management practice. It has also led to funding for social research to be included as part of Flow- MER, Australia's program to evaluate the outcomes of the delivery of water for the environment. Ours is a somewhat rare story - regular review of the relevant literature suggests that adaptive management continues to be considered a purely technical activity, and often still a problematic one (see for example Nagarkar and Raulund-Rasmussen, 2016).

Reflecting on our positive experience we consider we are fortunate to have been based at the same university over a long time, and have developed mutual respect for each other's professional capacities and ontologies. Viewing our different knowledges as complementary, rather than in competition, has allowed new insight to emerge; insight that neither one of us alone could have developed. Facilitating this is our willingness to share funding and academic rewards; and these are important aspects of partnership. The social research was initially subsidised by the biophysical research, until the social results could prove the value of funding such work. The multi-disciplinary research has been published in journals that usually focus on biophysical sciences, giving the findings wider legitimacy. Finally, we are aligned in our goal of researching for the public good, seeking to combine our expertise to enhance the care of the social-ecological systems that we can influence. Such systems are coming under increasing pressure in the Anthropocene, and we believe our example of integrating research is one model for meeting that challenge.

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