



# Exploring the Multiple Meanings of Adaptive Management: A Case Study of the Lachlan Catchment in the Murray–Darling Basin

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## Abstract

Managing rivers and sharing their benefits is largely dependent on stakeholder values and knowledge, expressed through policy, governance and institutions. Adaptive management is essentially a social learning process, which can provide a tool to navigate the ‘wickedness’ of contemporary social-ecological challenges. This research applied an interpretive, qualitative approach to examine government intentions for adaptive management, as expressed in water policy documents, and practitioner experiences of learning through adaptive management in a case study of water management in the Lachlan catchment, Murray–Darling Basin, Australia. Data were created from content analysis of government water policy documents and interviews with key water managing and policy stakeholders. Interview participants attached divergent meanings to the concept of adaptive management. Five different ‘styles’ of adaptive management were found to coexist in the Lachlan catchment, which were associated with different levels of learning. While some learning was ad hoc, there was also promising evidence of more active adaptive management of environmental flows, which was resulting in higher-level learning. The findings highlight a disconnect between how adaptive management is understood in the academic literature, by practitioners, and how it is portrayed in Australian water policy, which is restricting opportunities for higher-level learning. Transformative learning was found to occur in response to crisis, rather than being linked to an intentional learning process.

**Keywords** Learning · Adaptive management · Stakeholder participation · Environmental flows · Murray–Darling Basin

## Introduction

The highly variable flow regimes of Australia’s Murray–Darling Basin (the Basin) are essential for supporting ecosystem processes and species that have adapted to a ‘boom-bust’ ecology (Overton et al. 2009). Regulation of river flows to enable European settlement and agriculture has led to increasing degradation of the diverse and iconic wetlands of the Basin (Davies et al. 2008, 2012; Pittock and Finlayson 2011).

The people of the Basin have multiple and sometimes divergent perspectives on how water should be allocated and managed, and how numerous interests should be represented in decision-making (Bischoff-Mattson and Lynch 2016). Confronted by increasing risk of extreme droughts and floods under climate change, and intensified competition among water users, policy makers are struggling to develop effective institutions to manage uncertainties and share water fairly in the Basin (Connell and Grafton 2011; Garrick et al. 2013). Managing and governing water in the Basin can be framed as a ‘wicked’ planning issue, as it is characterised by multiple drivers of change; high levels of uncertainty and ambiguity; multiple perspectives, values and objectives; complex social–ecological interactions; interconnectedness with other issues; and shifting understandings of the problem over time (Wallis and Ison 2011).

The framing of river basins as complex social-ecological systems recognises that knowledge is provisional and incomplete, and continuous learning is needed to enable management to respond to rapid and unpredictable changes (Folke et al. 2005). The concepts of adaptive management

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and adaptive governance have resonated with researchers and practitioners of river and catchment management as the best available approach to navigate the ‘wickedness’ of contemporary environmental challenges (Allen et al. 2011; Dietz et al. 2003). Adaptive management is an iterative process of structured learning and decision-making, comprising cycles of issue definition, setting management objectives, developing system models and planning scenarios, framing management actions and policies as hypotheses, monitoring, evaluating and adjusting practice (Allen et al. 2011; Rist et al. 2013). Adaptive management recognises people and environments as inherently complex, unpredictable and difficult to control, and encourages continuous learning, rather than reduction, as the key to coping with complexity and uncertainty (Allan et al. 2008). Adaptive governance refers to the social and institutional environment that enables adaptive management (Dietz et al. 2003) and is therefore also closely associated with learning. Adaptive management, while theoretically desirable, has often fallen short of its promise in practice (Allan and Stankey 2009). This has led to increasing interest in contributions from the social sciences that provide insight into the experiences of practitioners using and learning from adaptive management, the meanings they attach to the term, and how practitioner logics and epistemologies can be reconciled with scientific logic to narrow the theory–practice gap (West et al. 2016).

This paper explores the types of learning associated with multiple understandings of adaptive management in the Lachlan catchment, a sub-catchment of the Murray–Darling Basin, Australia. The paper examines different portrayals of adaptive management in the literature, water policy documents and the perceptions of stakeholders (local community and government practitioners). The discussion explores how different understandings of adaptive management influence the experience of learning, and opportunities for higher-level learning. Such understanding is essential if adaptive management is to fulfil its promise of enabling informed action in the face of complexity.

## Literature Review

To better understand practical applications of adaptive management, it is useful to explore the dominant theories of social learning and how they apply to adaptive management.

### Theories of Social Learning

Sociocultural theories understand learning to be embedded in social interaction, and thus deeply connected to the construction of culture, identity, knowledge and values

(McInerney et al. 2011), such that knowledge is seen to emerge from social practices (Hickey 2011). These ‘situative’ theories of learning do not deny the existence of individual knowledge, but consider it a secondary representation of knowledge that is constructed in broader social contexts. Therefore, knowledge and meaning are embedded in the collective experiences people have in the world. Sociocultural frameworks suggest learning is facilitated through a focus on social dynamics; individual and group identities; and broader political, cultural and historical contexts.

Argyris and Schon (1974) describe a theory of single and double-loop learning in the field of organisational learning and change. Other researchers have expanded the theory to include a third loop of learning (e.g. Hargrove 2008), which has then been applied to understanding change in water governance regimes (Pahl-Wostl 2009). In this conception, single-loop learning refers to incremental improvements in action strategies to achieve goals, without questioning underlying assumptions or objectives. Double-loop learning refers to a revisiting of assumptions, such as cause-effect relationships and reframing ideas and system boundaries. Triple-loop learning reconsiders underlying values, beliefs and worldviews that may be impeding management practices (Pahl-Wostl 2009).

The concept of ‘social learning’ encompasses a spectrum of ideas; from those that explain how social interactions contribute to individual learning, to those that focus on collective learning, or a combination of both (Bandura 1977; Blackmore 2007; Steyaert and Jiggins 2007; Wenger 1998). Social learning occurs as people interact to construct knowledge that is relational and collectively oriented (Ison et al. 2013). Blackmore (2007) characterises social learning with stakeholders as the convergence of goals, understanding and expectations; co-creation of knowledge; shared understanding of issues is developed through shared actions such as physical experiments, joint fact-finding and participatory interpretation, which contributes to change in behaviours and norms. The participatory and constructivist nature of social learning encourages double and triple-loop learning.

### Adaptive Management as a Social Learning Process

While the ultimate goal of management may be for biophysical improvements, such as improved outcomes from environmental water use, adaptive management and adaptive governance are essentially social learning processes (Koontz et al. 2015). Effective social learning can facilitate the development of new skills, roles and responsibilities at the individual level; and new institutional arrangements, capacities, norms and values at the social level, which may enhance adaptive management practice (Steyaert and Jiggins 2007).

Gunderson (2015) emphasises adaptive management as addressing three ‘gaps’ in management; firstly it is a process to bridge diverging mental models of systems, and assumptions about resource dynamics. Secondly, adaptive management bridges different perspectives amongst scientific disciplines; and thirdly, adaptive management seeks to close the gap between knowledge and action. The growing emphasis on participatory learning through adaptive management in the literature reflects a shift away from expert-based teaching, which characterises traditional environmental management and agricultural extension activities, toward community-based transformative learning (Cundill and Fabricius 2009). Transformative learning occurs when values that underpin institutions and decision-making are questioned (Keen et al. 2005).

As effective adaptive management depends on social learning, it is not surprising that the major factors constraining it relate to social, governance and institutional dimensions, especially related to knowledge and action (Allan and Curtis 2005; Allen and Garmestani 2015). Adaptive management is difficult to implement within the scope of current social norms and policy settings (Ruhl and Fischman 2010), which support the status-quo and single-loop knowledge acquisition, rather than encouraging transformational learning and change. Perhaps the most significant challenge for implementing adaptive management is finding harmony between the sometimes-conflicting epistemologies and logics of practice, and the scientific logic underpinning adaptive management theory (West et al. 2016). Peat et al. (2017) note that river experiments can bring various stakeholders together to learn, contributing to adaptive management. Understanding the differing perceptions of stakeholders practicing adaptive management, and how this influences their experiences of learning, can help guide more effective adaptive management practice. Such understanding requires empirical studies, such as the one presented here, into how different practitioners understand and apply adaptive management, and how different sociocultural settings influence stakeholders learning as a group.

### Implementation of Adaptive Management in the Basin

While the body of scientific knowledge on the relationship between stream flow and ecosystem function is growing rapidly, predicting ecological responses to different water management rules and limits remains a complex task (Poff et al. 2017). As a result, State and Commonwealth Governments in Australia have invested in adaptive management of environmental flows to improve their understanding of how ecosystems respond to flow. This investment includes legal mandates for adaptive management in key

water legislation and policy and Commonwealth funding over 5 years for the Long Term Intervention Monitoring project (Gawne et al. 2013), which will be extended through the Monitoring, Evaluation and Research Project from 2019.

Despite the significant impediments to adaptive management described in the previous section, there are emerging examples of the concept being successfully applied in the delivery of environmental flows at smaller scales, such as river reach, or sub-catchment level within the Basin, with strong stakeholder participation (Allan and Watts 2017; Conallin et al. 2017). Webb et al. (2017) argue that successful adaptive management of environmental flows is occurring more often than is perceived, but successes are rarely reported, meaning learning often does not extend beyond the project where it takes place. This research contributes to further understanding the social dimensions of learning associated with different applications of adaptive management, which is important for enhancing adaptive management practice in the Basin.

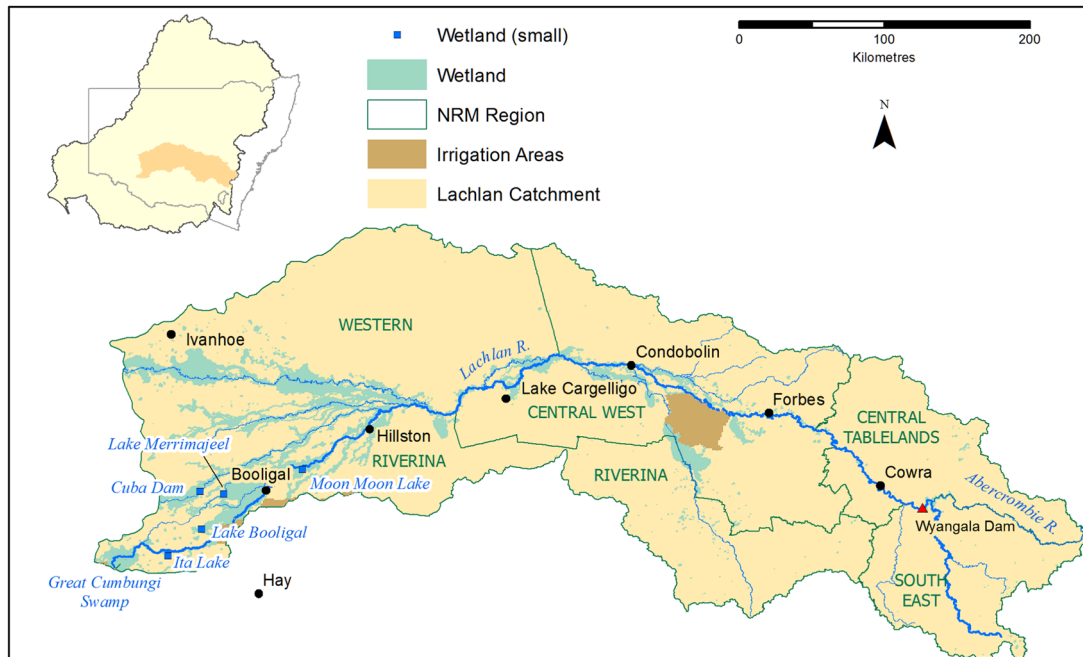
## Methods

### Case Study Area

The Lachlan catchment is a highly regulated, semi-arid river system (Lukasiewicz et al. 2013) within the New South Wales (NSW) part of the Basin, which supports extensive agriculture, rural communities and significant wetlands and rivers (see Fig. 1). Wyangala Dam is the major storage regulating the Lachlan River, which supplies an irrigation industry stretching almost the full length of the river. The Lachlan is unique within the Basin, in that it terminates in a 1600 ha series of wetlands (the Cumbung Swamp), only connecting to the Murrumbidgee when both rivers are in flood. The ecological condition of the Lachlan has been consistently rated as ‘very poor’ based on a range of ecological indices of hydrology, fish and macroinvertebrate condition (Davies et al. 2012).

The Lachlan, like all catchments in the Basin, has undergone sweeping water reforms to address over-allocation of water, environmental degradation and economic inefficiencies in the delivery and use of water; problems that were exacerbated by the Millennium Drought 1996–2010 (Kendall 2013). These reforms began with the Council of Australian Government (COAG) water reforms in 1994, followed by the National Water Initiative in 2004, the *Commonwealth Water Act* in 2007, water ‘buy backs’ in 2007–2009 and the *Basin Plan* in 2012.

Water reforms have resulted in more adaptive and sustainable water management in the Lachlan, amidst socio-political stress resulting from drought and changes in water



**Fig. 1** Map of the Lachlan, a sub-catchment of the Murray–Darling Basin, New South Wales, Australia. Map produced by the Spatial Data Analysis Network at Charles Sturt University

policy (Schoeman 2017). The ‘Lachlan catchment environment’ now has significant entitlements to water, which are delivered by government agencies through adaptive management (Dyer et al. 2017). ‘Environmental flows’, the main delivery mechanism, are described as the ‘quantity, timing and quality of freshwater flows and levels necessary to sustain aquatic ecosystems, which, in turn, support human cultures, economies, sustainable livelihoods and well-being’ (Arthington et al. 2018).

The Commonwealth Environmental Water Holder (CEWH) is the agency responsible for managing water acquired by the Australian Government as part of water reforms. The CEWH now owns the majority of environmental water entitlements in the Lachlan, with the remainder owned by the New South Wales State Government. Various stakeholders work together to advise on how the Lachlan River is managed, though committees such as the Lachlan Riverine Working Group (LRWG), which is the environmental water advisory group for the Lachlan, and the Customer Services Committee, which provides advice on water management activities. The relatively small group of stakeholders active in these committees have been consulted extensively for a range of government initiatives, resulting in consultation fatigue within the catchment. The key legal instrument for managing water in the Lachlan catchment is the *Lachlan Regulated Water Sharing Plan 2004*, which outlines the rules governing how water is managed (Department of Infrastructure 2004).

## Data Collection

This research is part of a larger project that sought to understand the social, governance and institutional dimensions of adaptive water management in the context of the Anthropocene. (Schoeman 2017). The aspect presented here explored the multiple meanings of adaptive management in the Lachlan catchment, and how these affect learning. The intentions of government, and broad themes in their language use relating to adaptive management, are written and published. A content analysis of 190 water policy documents was therefore possible. The lived reality of stakeholders practicing adaptive management is rarely documented, so selected interviews were undertaken. The interviews (following Kvale 1996) sought to understand the meaning practitioners ascribed to the term adaptive management, and how this meaning shaped their perceptions and experience of learning (Wagenaar 2011). The Lachlan case study incorporated an embedded design, as per Yin (2009), including multiple levels of water governance within Australia’s federal system: local/regional, State and Commonwealth agencies.

Institutional documents represent shared understandings of policy challenges and agreed strategies to solve those challenges. Content analysis is a research technique aiming to semi-objectively and systematically quantify and describe the content of institutional statements (Weber 1990). Keyword searches and coding of content were included to explore the intentions of government, as

expressed by the relative importance of different concepts in public documents (Lukasiewicz et al. 2013).

Institutional documents were sourced from three agencies at Commonwealth, State and catchment levels that have key roles in water governance and management. The public websites of these agencies list ‘key policies’ that drive their strategic direction and actions in water management. Complete lists of key water policies were systematically downloaded from the Australian Department of Sustainability, Environment, Water, Populations and Communities (now Department of the Environment and Energy), New South Wales Office of Water (now within the Department of Industry) and the Lachlan Catchment Management Authority (now multiple Local Land Services). These key water policies included publications from the (then) National Water Commission and the Murray–Darling Basin Authority.

The document analysis sought evidence of ‘if’ and ‘how’ water policy promotes adaptive management as a learning process. Semi-quantitative methods were used to compare the prevalence of different management concepts in the set of 190 documents. To reduce researcher bias, simple word counts of search terms were used to describe the content of documents (Payne and Payne 2004). The word frequencies were expressed as a percentage of the total sample of documents where the word or phrase is present. This presence/absence measure was chosen to avoid overestimating the importance of a concept that may be discussed at length in a single document. Thus, the findings presented here give an indication of how prevalent the keywords were across the set of water policy documents.

Weber (1990) notes, it is generally true that the most frequently appearing words reflect the greatest concerns in institutional statements, but urges caution when making inferences. A single word may be used in a variety of contexts or may have more than one meaning. Keyword in Context (KWIC) searches were therefore used to provide context and check for divergent word meanings. KWIC searches involve reading the sentence or paragraph

surrounding the word to establish the context (Stemler 2001). Stakeholder interviews were needed to investigate how adaptive management policy is perceived and applied by practitioners, and how the broader policy setting either enables or restricts learning in practice.

Specific individuals who were perceived to be influential community leaders and were likely to have rich experiences in various water governance and management initiatives, were recommended for interview by informants in a local catchment organisation. These participants were invited by telephone for an interview and asked to recommend other key actors who should be involved. This ‘snow-ball’ sampling method (Biernacki and Waldorf 1981) identified further water stakeholders outside of the list provided by informants. The sampling method was purposive, focused on current governance, and so attracted participants who were generally powerful players with high levels of influence in the water governance process. As a result, there is an absence of minority or disenfranchised voices in this data set.

The 19 purposefully selected interview participants included government and non-government actors involved in various aspects of water use and management in the Lachlan, including irrigation, dry-land farming, environmental water management, land management, water planning, policy and river operation (Table 1). Many interview participants had experience across several levels, roles and committees and held multiple affiliations. A few participants were early career, but the majority were late career, some with decades of experience working in the Lachlan catchment. Eight participants were female; eleven were male. Eight held, or were working towards, PhDs.

Interviews were conducted face-to-face in 2013–2014 in the Lachlan catchment, and in and around Canberra, where State and Basin/Commonwealth government offices are located (and where policy is formulated). Interview durations ranged from 45 to 190 min, with most lasting for around 60 min. Interviews were recorded and later transcribed verbatim into word documents and thematically

**Table 1** Interview participants

Interview participants	Number of participants
Actors from Commonwealth Government agencies: Commonwealth Environmental Water Office (CEWO), Murray Darling Basin Authority (MDBA), National Water Commission (NWC)	5
Actors from State Government agencies: Water New South Wales and Department of Industry, Office of Environment and Heritage (OEH)	7
Regional actors: Researchers with experience on various regional committees, actors employed by the Catchment Management Authority (CMA) and/or Local Land Services (LLS) (replaced the CMAs in 2013)	4
Landholders, irrigation representatives	3

coded. The initial round of coding used both inductive and deductive elements in that transcripts were coded and categorised into themes that came from the data but arrangement and naming of the themes were influenced by theory (Bazeley 2012). Distinct themes emerged related to how participants perceived adaptive management, particularly its learning aspects. As these themes had some congruence with themes of learning, they were labelled as adaptive management ‘styles’.

## Results

### Government (Documented) Intentions for Adaptive Management

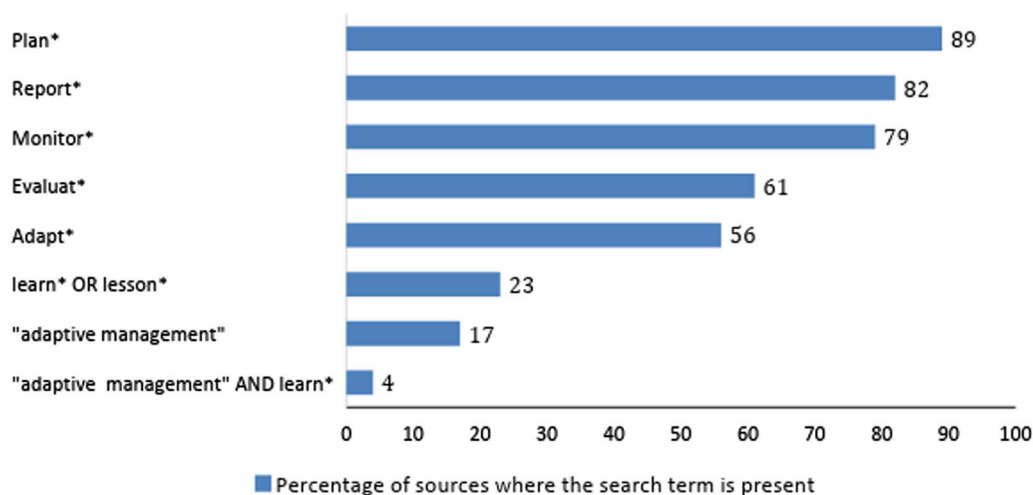
Adaptive management is legally required for natural resource management in NSW through the statutory document ‘Standard for Quality Natural Resource Management’. In addition, the Commonwealth *Water Act 2007* and NSW *Water Management Act 2000* legislate that adaptive management principles should be applied in water management. While there is clear statutory support, some ambiguity remains around the definition and process of adaptive management.

Of the policy and strategy documents covering all aspects of water management, 33 documents (17%;  $n = 190$ ) refer directly to adaptive management (Fig. 2). An additional five documents refer to MER or MERI (Monitoring, Evaluation, Reporting and Improvement), the latter being a potential version of adaptive management appearing in water planning and catchment management documents. The cross-section of documents shows strong government intentions for planning (mentioned in 89% of the

documents); reporting (82%); and monitoring (79%), while evaluation (61%), adapting (56%) and learning (23%) are less prominent concepts in the water policy discourse. The major activities of planning, monitoring and evaluation are not always tied together as components of an adaptive management cycle. The content analysis suggests government agencies have stronger intentions for ‘front end’ planning than ‘back end’ evaluation and learning.

KWIC searches revealed that of the 33 documents referring to adaptive management, around half include only vague allusions, where ‘adaptive management’ is mentioned with no definition or explanation. For example, the NSW *Water Management Act 2000* and the Commonwealth *Water Act 2007* both advocate applying the principles of adaptive management, without defining what those principles are, or how they should be applied. The National Water Initiative also states that planning frameworks should provide for adaptive management, with no further guidance (COAG 2004, pg. 5, para. 25 (iv)).

The NSW Monitoring, Evaluation and Reporting (MER) approach provides a definition that describes a passive version of adaptive management, where historical data are used to estimate best practice, which is refined through further review and learning (Walters and Holling 1990). The Basin Plan provides a more active definition of adaptive management, and removes some ambiguity by detailing the steps involved, “(a) setting clear objectives; (b) linking knowledge (including local knowledge), management, evaluation and feedback over a period of time; (c) identifying and testing uncertainties; (d) using management as a tool to learn about the relevant system and change its management; (e) improving knowledge” (MDBA 2012, pg. 4). In addition, the transitional Catchment Action Plans (Central Tablelands, Central West and South East) describe



**Fig. 2** References to adaptive management and related concepts in the key water documents of the Department of Environment and Energy, New South Wales Office of Water and Lachlan Catchment Management Authority ( $n = 190$ ; Asterisk indicates inclusion of stemmed words)

an active learning process incorporating feedbacks for triple-loop learning into their implementation plans.

### **Stakeholder (Practical) Perceptions of Learning**

The policy documents provide context for water management practice in the Lachlan. While adaptive management is encouraged, mostly in a vague, generic way, different adaptive practices were apparent. The five styles of adaptive management identified in the interview data are presented in Table 2, with some brief explanations for each and sample evidence from the interviews. The main actors associated with these styles are also indicated. A brief explanation of each of the styles is provided below.

#### **Adaptive Management as ‘No Rules’**

A number of participants spoke of adaptive management that involved making decisions that did not strictly follow the rules outlined in the formal Water Sharing Plan (WSP). Adaptive management as ‘managing with no rules’ was not described as an iterative learning process, but rather a strategy to make quick, flexible decisions. An example of this flexibility occurred during the Millennium Drought 1996–2010. After the Lachlan WSP was suspended in 2004 due to drought, the Water Minister took responsibility for distributing scarce water among users. Water was managed on a month-by-month basis through the Critical Water Panel, a group of local stakeholders who advised on river operations up until 2011, with final decision-making power resting with the Water Minister.

The Critical Water Panel was viewed, by those involved, as a successful model for adaptive water management during drought, as the group used local knowledge to make quick decisions in the absence of water sharing rules. This version of flexible management enabled water supply to be sustained for most of the river almost to the end of the drought. Criticisms of the Critical Water Panel expressed during interviews were that decisions were made by ‘the seat of everyone’s pants’, and subject to political considerations rather than being based on knowledge and learning.

#### **Adaptive Management as ‘Streamlining’ Management**

One example of learning offered by government agency staff during interviews was an adjustment to how stakeholders are engaged in water planning, that is, learning about process. In this case, interview participants perceived that a small group of highly experienced water stakeholders

was more effective at achieving the desired outcome than very broad stakeholder participation in complex water planning situations. The evidence provided was that the River Management Committees of the early 2000s, tasked with developing the Regulated Water Sharing Plans, were too big and too unruly and the task too complex. The recent trend in water planning involves relying on fewer highly experienced stakeholders to draft initial plans, and seeking broad community input in the later stages of planning.

#### **Adaptive Management as ‘Questioning Assumptions’ about the System**

Another example of adaptive management offered by interview participants was learning by revisiting hydrological assumptions about how water moves through regulated river systems. Monitoring and evaluation following water releases from Wyangala Dam during and after the Millennium Drought showed that assumptions about hydrology made during the drought, particularly where the flow was expected to go, no longer applied. In this example, adaptive management was described as a tool to build knowledge about the system during different climatic conditions and to navigate uncertainty. Rather than being highly experimental, or project based, this example reflects a view of adaptive management as an accumulation of monitoring and evaluation information that causes managers to revisit previously held assumptions about the system.

#### **Adaptive Management as ‘Reacting’ and ‘Experimenting’ with Environmental Flows**

Environmental water managers describe a style of adaptive management that is flexible, with rapid, within the rules, decision-making in response to changes in the ecosystem. Environmental watering events involve releasing licenced or rules-based environmental water allocations from the dam to mimic ‘natural’ flow events. For example, augmenting natural flows following a rainfall event, with a specific objective, such as watering river red gums or supporting a bird-breeding event. In these situations, environmental water managers need to coordinate government agencies and landholders to respond quickly to environmental cues, and to work with trade-offs between different environmental values related to, for example, frogs, birds, vegetation and fish. An environmental water advisory group with broad stakeholder participation, including landholders, has enabled trust building and experiential social learning through presentations, site visits and sustained social interaction.

**Table 2** Different styles of adaptive management described by water stakeholders in the Lachlan case study

Styles of adaptive management	Description	Sample evidence	Learning type	Main actors associated with this construction
No rules	Managing water in the absence of rules (laws, guidelines) through a highly uncertain situation	The Critical Water Panel made water allocation decisions month-to-month during the Millennium Drought in the absence of water sharing rules “decisions were made by the seat of everyone’s pants... they were making it up as they went along”	‘Muddle through’ crisis; high level of flexibility, low accountability; ad hoc learning	River operators, natural resource managers, irrigators
Streamlining	Redesign of management processes to improve effectiveness based on the accumulation of experience	Government adapted stakeholder engagement to be more streamlined, and involve fewer stakeholders “they learned in terms of adaptive management... they actually looked at a different process for the unregulated Water Sharing Plans, which worked very well. It was a much better process”	Achieve objectives more efficiently; learning about process; <i>single-loop learning</i>	Water planners and natural resource managers
Questioning assumptions	Consistent monitoring and evaluation reinforces or disproves assumptions about system behaviour	Monitoring over time disproved assumptions about hydrology “Some of the assumptions made after the drought are being disproven using adaptive management... in terms of where they can expect the flow to go”	Improve knowledge about the system; <i>double-loop learning</i>	River operators, water policy developers
Reacting and experimenting	Defining environmental objectives; modelling different scenarios; planning and executing actions towards objectives; monitoring and evaluating outcomes; and mechanisms to respond quickly to environmental feedbacks	Environmental water managers plan water releases as large-scale experiments and monitor ecosystem responses “We’re not sure what will happen, but we’ll give it a go, we’ll monitor it and if we get good outcomes then we know to give it another go... It’s a little bit experimental”	Test hypotheses; learn about the system to improve management outcomes; flexible, with rapid, within the rules, decision-making in response to changes in the ecosystem; <i>double-loop learning</i>	Environmental water managers
Transforming	Adjusting underlying beliefs and norms that drive everyday actions, institutional change based on new understanding of the system and/or crisis such as drought	Irrigators changed their water use behaviour and diversified their enterprises following the Millennium Drought “The drought has changed probably the behaviour of the water users... [Instead of] the normal boom and bust operation, they tend to keep [water allocations] for a number of years now”	Changing social norms to adapt to change; questioning objectives; <i>triple-loop and social learning</i>	Irrigators, agricultural industry representatives



## Adaptive Management as ‘Transforming’ Understanding

In this perception of adaptive management, participants described the transformation of behaviour and institutions based on new understandings. Some participants suggested that irrigators in the Lachlan have applied adaptive management and learnt to diversify their farming practices following the Millennium Drought, with a trend towards irrigating smaller areas of land with higher reliability. This example portrays adaptive management as a social learning process, where farmers in the Lachlan have responded to information feedbacks from the system (drought) and water policy changes, in order to adapt their farming practices. This is understood as transformative learning, as participants described a process of re-evaluating the foundational values and beliefs that had previously driven their decision-making.

## Discussion

This study highlights variability in the range of understandings and practices associated with adaptive water management in the Lachlan catchment. Firstly, there are disconnects in how adaptive management is portrayed in academic literature and water policy documents, and even greater disconnects among these portrayals and how they are enacted by stakeholders in practice. Academic literature advocates for ‘active’ adaptive management and transformative learning, water policy documents emphasise front-end planning, reporting and passive adaptive management, while practitioners, including government practitioners, are constructing various ‘styles’ of adaptive management, resulting in different levels of learning. As a phrase and a concept adaptive management is thriving in the Lachlan, given the numerous and diverse examples offered by practitioners. However, very little of what people describe as adaptive management is aiding the type of higher level, transformative learning promoted in the literature.

## The Role of Water Policy Documents in Enabling Learning

The content analysis of water policy documents revealed stronger intentions for ‘front end’ planning and doing, rather than ‘back end’ evaluating, learning and adapting, a finding that was also reflected in interviews. The concept of ‘learning’ is not a strong, explicit intention of government or is not common in their water policy lexicon. Nevertheless, management objectives may include activities connected to learning, such as monitoring and improving the knowledge base for decision-making. The role of new

knowledge in the review and replacement of management objectives is certainly not straightforward to follow or document (see Allan and Watts 2017).

The logic of policy documents is aligned with public and corporate drivers for accountability and efficiency, in contrast to the scientific logic behind adaptive management, which values experimentation. An active understanding of adaptive management as a social learning process has not been fully realised in Australian water policy cycles, notwithstanding its rhetorical emphasis in keystone legislation and policy. Lee (1993) argues that an adaptive policy should be designed to test hypotheses about the behaviour of an ecosystem under human influence, so policy is an active question, not a prescription. This is clearly not the norm in Australian water policy. The single loop, passive learning advocated in the policy documents may be enough for a narrow set of activities where streamlining management or improving process is the goal. However, where there are deep uncertainties about ecological relationships and how a system will respond to management intervention, double and triple-loop learning that includes actions to probe the system is needed.

Therefore, while learning was occurring in practice through different styles of adaptive management, the water policy context with its corporate and public logics emphasising planning, accountability and efficiency, while masking complexity and uncertainty, constrains more active and reflexive forms of adaptive management where underlying worldviews, beliefs and values that may be hindering management can be called into question (Pahl-Wostl 2009).

The research presented in this paper links transformative learning to crisis response. While based on only one case study at a single point in time, this particular finding suggests caution is required with the accepted narrative of managers undertaking adaptive management with an eventual goal of transforming practice. Crisis has been identified as a trigger for rapid learning for management (for example, Bormann and Stankey 2009), but it is yet to be well incorporated into adaptive water management thinking. A policy emphasis on front end planning suggests that crises are to be avoided.

As demonstrated in the interview findings (Table 2), the various styles of adaptive management are related to the level of learning with which the actor is willing or able to engage. Although proffered by some participants as an example of adaptive management, the ‘no rules’ style of adaptive management does not have an explicit focus on learning and is more akin to ‘muddling through’ (Lindblom 1959), with decisions based on limited analysis and bounded rationality. There is little emphasis on learning, and any that occurs is first order and single loop.

The version of adaptive management described as ‘streamlining’ was learning to conduct management more

efficiently: while learning was clearly occurring, this is, at a stretch, a very passive form of adaptive management where learning is valued to the degree that it improves institutional management outcomes. The ‘questioning assumptions’ style of adaptive management may encourage double-loop learning, where cause-effect relationships and assumptions are reconsidered, but ‘streamlining’ is mostly a form of single-loop learning.

More strongly related to double-loop learning is the ‘reacting and experimenting’ style of adaptive management being used for delivering environmental flows. This style most closely resembled academic definitions of adaptive management in that there was a focus on learning as well as ‘doing’; monitoring and evaluation to inform management and policy reviews; sub-catchment or ecosystem scale experiments to explore hypotheses; complexity was acknowledged if not embraced; and there were mechanisms for multi-stakeholder involvement and learning through the LRWG. These more active learning activities provided opportunities for single and double-loop learning, but the focus was still on how to achieve quite narrowly defined objectives most efficiently.

Modelling different scenarios is one planning tool highlighted by participants as a way to explore different management options and aid learning. Decisions must be made with incomplete knowledge and some participants viewed environmental watering events as highly experimental. However, other environmental water managers noted that the ‘experimenting’ aspect has been constrained by pressure to demonstrate the value of the significant public investment in environmental water. As a result, there is a strong disincentive for environmental water managers to experiment with watering events that are risky, in terms of having unpredictable responses in the ecosystem, but may also provide greater learning opportunities.

The ‘transforming’ style of adaptive management describes a process of triple-loop social learning in the agricultural industry. Water users in the Lachlan, as a group, have shifted their water use behaviour following the drought (this is also evidenced in Burrell et al. 2015). This behaviour change indicates a majority of farmers have modified their underlying beliefs, realised they cannot rely on irrigation water and changed their behaviour and farming enterprises accordingly. This has, in turn, led to a transformation of the agricultural industry in the Lachlan to become more resilient to drought, a phenomenon that is not as pronounced in neighbouring catchments. This ‘style’ of adaptive management is arguably more driven by crisis than any intentional learning process.

The adaptive management styles were not exclusively associated with particular actors. Of note, however, is that while the reacting and experimenting style was most closely associated with environmental water managers,

transformative learning was most associated with irrigators and agricultural end users and was aligned with crisis. These various findings reinforce the current understanding of adaptive management as an ambiguous, poorly understood management approach, with significant gaps between theory, policy and practice (Allen and Garmestani 2015; Rist et al. 2013; Westgate et al. 2013). West et al. (2016) found that implementing adaptive management, within a large land management organisation in Australia, was dictated by different and sometimes competing organisational logics. Scientific logics prioritise experimentation and learning, public logics emphasise accountability and legitimacy, and corporate logics emphasise efficiency, effectiveness and high performance.

Similar logics can be seen to be at play in the Lachlan case study; for example, in the ‘reacting and experimenting’ style of adaptive management, individual practitioners of this style were driven to experiment by a scientific logic; however, this was at times in conflict with public logics, which favour less risky actions with a more certain outcome (and less opportunity for learning); and corporate logics which advocate for demonstrating success and value for money.

### Sociocultural Influences on Learning

Attention to the sociocultural influences on adaptive management may provide a pathway towards reconciling the different logics driving the policy-practice gap. While statutory support for adaptive management is essential, adaptive management also requires an enabling social setting (Lee 1999). The literature on social learning explored earlier in this paper showed the powerful influence of social dynamics, individual and group identities, trust and attention to broader political, cultural and historical contexts for creating an environment that stimulates learning within the practice of adaptive management.

Interview participants involved in the agricultural industry described how water users in the Lachlan felt threatened from the beginning of the water reform process, as they were being told to significantly change their water use behaviour. This conflicted with their perception of the river system as being underdeveloped in comparison to other catchments. The lack of trust between government agency staff and non-government water stakeholders in the early stages of water reforms was a significant barrier to learning and the implementation of adaptive water management.

Learning is deeply embedded in social interaction, and thus deeply connected to the construction of culture, identity, knowledge and values (McInerney et al. 2011). While water stakeholders in the Lachlan had different knowledge about the river system and different values, the ‘reacting and experimenting’ style of adaptive management enabled

them to build trust through participation in joint fact-finding missions and co-construction of knowledge, which contributed to a learning culture, shared understanding and convergence of goals within the diverse group of stakeholders.

Shrinking the theory, policy, practice gap, in a broader sense, will require researchers, policy makers and practitioners to internalise both ‘intellectual complexity’ (differences in knowledge and ways of knowing) and ‘lived complexity’ (ways of being and practicing) (Rogers et al. 2013; Schultz et al. 2018). Frames of mind that assist individuals to live with complexity in social-ecological systems are openness, situational awareness and acceptance of uncertainty and paradox (Rogers et al. 2013). Cultivating these frames of mind as habit will encourage the deep reflection and transformational learning needed to improve the practice of adaptive management in complex social-ecological systems.

## Conclusion

Water managers in the Murray–Darling Basin are increasingly being exposed to anthropogenic challenges, such as extreme weather associated with climate change, declining biodiversity and expanding human populations with competing uses and values around water. The literature promotes active adaptive management to bring about transformative learning and enable managers to adapt to these complex challenges. However, the only transformative learning reported by participants in this study occurred outside of any intentional, structured learning process and was driven by crisis.

The different meanings ascribed to adaptive management by different stakeholders had a substantial influence on how learning was experienced, with the water policy setting supporting more passive and ad hoc versions of adaptive management. The disconnects between literature, policy and practice described in this study are most likely a result of competing logics at play when implementing adaptive management. Water policy and some government actors are driven by corporate and public logics emphasising planning, accountability and efficiency, which is at odds with the scientific logic of adaptive management, which strives for experimentation and learning.

This paper has emphasised the importance of socio-cultural factors for bridging the gap between conflicting logics and developing an environment that encourages shared learning. Sustained social interactions between stakeholders from diverse backgrounds assisted practitioners to learn about the river system and develop shared goals and understanding. However, the water policy setting, with its aversion to risk and focus on achieving quite narrowly

defined objectives, was constraining opportunities for higher level and transformative learning in practice.

While adaptive management as a concept appears to be thriving in the Lachlan catchment, and elsewhere, this study has shown significant variability in the range of understandings and practices associated with the concept. Internalising these complex ways of knowing, learning and acting, will aid practitioners to move towards a more transformative practice of adaptive management.

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## Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Ethical Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

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