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ORIGINAL ARTICLE

How the Resist-Accept-Direct framework is being used by communities for socio-economic climate adaptation: a case study in Australia's Murray-Darling Basin

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Abstract
Globally, water governance struggles to reconcile increased demands on water resources with climate change–induced reductions in supply, making climate adaptation in water governance a pressing concern. The Resist-Accept-Direct (RAD) framework has emerged as a climate adaptation tool designed to help make adaptation decisions. However, there is limited understanding of social and political factors, which are critical in driving RAD decisions. This paper explores how communities are employing RAD to make climate adaptation decisions, using a case study of the Goulburn-Murray Resilience Strategy (the Strategy); a community-led strategy that uses a version of the RAD framework to build regional resilience in the Goulburn-Murray Irrigation District (GMID) in Australia's Murray-Darling Basin (MDB). The Strategy focuses on building socio-economic, rather than ecological, resilience, making this research a valuable contribution to RAD literature. To apply the RAD framework to socio-economic adaptation, we adapted the framework to include IPCC language around incremental, transformational, planned, and autonomous adaptation. With the GMID considered a leader of resilience thinking in Australia, the Strategy may help decision-makers address water overallocation and contested governance in the MDB, and provide lessons for water governance globally. Data analysed from 20 semi-structured interviews with people involved with the Strategy revealed two main findings: (1) Communities and governments prioritise different actions under the RAD framework. Governments, particularly at the state level, preference incremental planned adaptation to maintain the status quo (resist), over incremental autonomous adaptation to changing conditions (accept), and transformational planned adaptation at various scales (direct). (2) Community and government actors perceive that factors driving governments' preference for incremental-resist adaptation include electoral short-termism, linear planning, and conservative government culture.

Keywords Water governance · Climate change · Community adaptation · Socio-economic adaptation · Resist-Accept-Direct framework

Introduction

Globally, water governance faces the challenge of climate change exacerbating conflict and contestation by threatening water security. There is increasing pressure for water resource managers to address climate change and balance consumptive and environmental water use for long-term sustainability. While doing so, natural resource managers are urged to adopt novel approaches, use the best available science, and incorporate diverse voices, including those of First Nations and communities, all in the context of deep uncertainty (Grafton et al. 2020; Alexandra 2021; Hart et al. 2021; Wyborn et al. 2023).

Climate adaptation tools have emerged to help assist natural resource managers make difficult trade-off decisions.

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Resist-Accept-Direct (RAD) is one such tool, which provides a simple decision framework to navigate adaptation decisions in the context of uncertain futures (Clifford et al. 2022; Lynch et al. 2022; Schuurman et al. 2022). However, RAD has almost exclusively been used in the context of ecological adaptation decisions, despite the potential for it to assist with social and economic adaptation. Literature on RAD has also, until recently, been largely absent in water governance contexts (see for example Ward et al. 2023). That social and political factors affect climate adaptation decisions is now well-recognised (Eriksen et al. 2015; Wyborn et al. 2015, 2023), and emerging literature discusses the personal, institutional, and cultural factors that shape adaptation decisions made using the RAD framework (Clifford et al. 2022). However, examining why decision-makers may preference certain RAD options over others is still largely conceptual. This research seeks to address this gap by answering the research question "why do decision-makers preference certain RAD options?", using empirical data of decision-makers in Australia's Murray-Darling Basin as a water governance case study. For the purposes of this research, we use the term "RAD decisions" to refer to adaptation decisions made using the RAD framework.

Australia's Murray-Darling Basin (MDB) is home to 2.4 million residents, over 50 First Nations, nationally and internationally significant wetlands, endangered species, and produces 40% of the nation's agricultural output (Murray Darling Basin Authority (MDBA 2023). However, water has been over-allocated for consumptive use, resulting in significant ecological degradation (Bouckaert et al. 2021), while climate change is driving an overall decline in rainfall, placing increasing pressure on consumptive and environmental water resources (Pittock 2019). The Basin crosses five jurisdictions, exacerbating contestation and resulting in intergovernmental and interagency conflict (Connell 2011). The complexity of Basin governance means that no single actor has the resources to generate solutions, requiring approaches that involve all potential governing actors (Abel et al. 2016). Further, there are calls for the Basin's governing bodies to better adapt the Basin to climate change (Alexandra and Rickards 2021; Prosser et al. 2021; Colloff and Pittock 2022) and empower communities to address governance challenges and trade-offs (Alexandra 2017; Grafton et al. 2020).

The Goulburn-Murray Irrigation District (GMID) is the largest irrigation district in the MDB (State Government of Victoria 2023). It has been home to significant thinking and practice related to the ideas of resilience (Walker et al. 2009; Abel et al. 2016), most recently manifesting in The Goulburn-Murray Resilience Strategy (hereafter the "Resilience Strategy" or "Strategy"). This community-initiated strategy aims to build the GMID's socio-economic resilience in collaboration with local, regional, and state governments. The Strategy was launched in December 2020 and the Resilience Strategy Taskforce (hereafter the Taskforce), responsible for implementation, was formed in December 2021. The Strategy involves a wide range of actors from community to state government with a socio-economic adaptation focus and employs a framework similar to RAD, making it an ideal case study through which to examine the preferences for RAD decisions. We interviewed 20 people who were either involved in the creation or implementation of the Strategy. This research did not seek to assess whether this is an objectively "good" strategy, but rather focused on understanding the governance challenges faced when implementing the strategy, and what can be learned about RAD decision-making in a water governance context.

Literature review

Climate adaptation is "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (Intergovernmental Panel on Climate Change 2022). Adaptation governance refers to the processes, policies, and structures that shape adaptation decisions (Wyborn et al. 2015). Numerous processes, tools, and concepts are emerging to support adaptation governance, including a group of frameworks that highlight different options in the face of change. This includes the Resist-Accept-Direct (RAD) framework (Clifford et al. 2022; Lynch et al. 2022), the Resistance-Resilience-Transformation framework (Peterson St-Laurent et al. 2021), and Resistance-Resilience-Response framework (Millar et al. 2007). These frameworks have slight variations; however, for the purposes of this paper, we will refer to all as "RAD frameworks". RAD frameworks emerged from the United States as assessment tools to assist natural resource managers face dramatic ecological change using a continuum of adaptation actions (Clifford et al. 2022; Lynch et al. 2022). This continuum is broadly defined in Fig. 1.

To date, RAD literature has focused on adaptation decisions concerning ecological systems in natural resource management, with very limited research into how RAD could be applied to socio-economic adaptation in broader social contexts (Peterson St-Laurent et al. 2021; Clifford et al. 2022; Lynch et al. 2022; Magness et al. 2022; Schuurman et al. 2022). Similar to the complexity uncovered when social scientists adapted the concept of resilience from ecological applications to socio-economic ones (Stone-Jovicich et al. 2018), our research found that applying the RAD framework to Social Ecological Systems (SES), rather than ecological systems, required a greater level of nuance. SES are interdependent and linked social and ecological systems that are nested across scales and highlight the complex

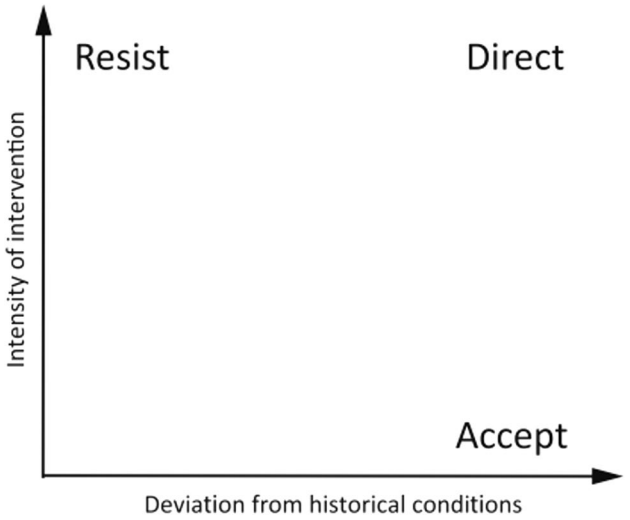

Fig. 1 (1) Resisting change to maintain current or historically defined conditions (resist); (2) accepting change with no or little intervention to prevent or direct it (accept); and (3) shaping management pathways to achieve desired conditions (direct). Figure adapted from Schuurman et al. (2022)

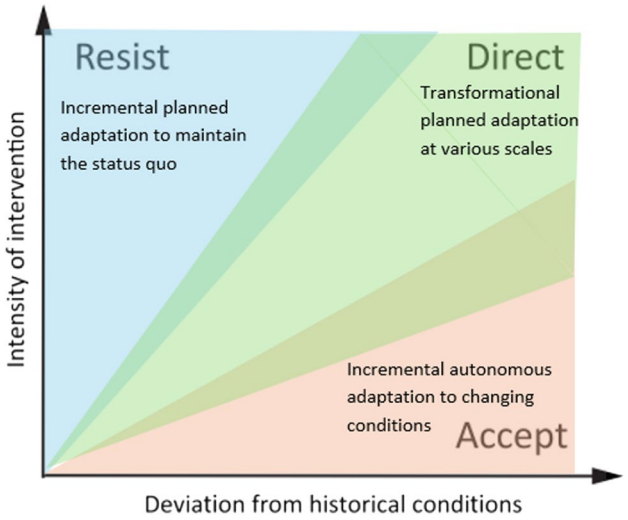

Fig. 2 The adapted Resist-Accept-Direct (RAD) framework which combines the IPCC adaptation terms of incremental, transformational, planned, and autonomous adaptation with the common RAD framework

relationship between people, ecosystems, adaptive management practices, and institutions (Colding and Barthel 2019).

The IPCC (2022) distinguishes between autonomous adaptation, which is an unconscious shift in response to changing conditions, often by individuals; and planned adaptation, which is a deliberate decision based on awareness of changing conditions and the need for action to achieve a desired state, often by policymakers. The IPCC (2022) also distinguishes between incremental and transformational adaptation: incremental adaptation maintains the essence and integrity of a system or process at a given scale, while transformational adaptation changes the fundamental attributes of SES. To expand the conceptual framing of RAD, we combined these IPCC adaptation terms with the original RAD framework in Fig. 2 to illustrate how RAD can be applied to social and economic adaptation.

The variation and scale of action by different actors across SES means the zones of the adapted RAD framework may overlap. Each zone is described as follows.

The blue zone: The inevitability of changing conditions means that incremental adaptation is required to maintain the essence and integrity of a system at a given scale. While this could be done by individuals, the intensity of intervention required in most situations means it is more likely to be planned adaptation by policymakers.

The red zone: An "accept" decision at a national, state, or regional level is a low level of intervention that allows the system to drastically change. However, incremental adaptation would likely occur at a local or individual level to retain values while there is a dramatic deviation of the SES from historical conditions. This incremental adaptation does not necessarily have to be autonomous, as an accept decision at higher level of government could be accompanied by planned adaptation support for local regions and individuals.

The green zone: Transformational adaptation is desired and planned. This could occur independently by national, state, or regional policymakers (without local or individual support) or conversely, solely at a local or individual level (although given the intensity of intervention required this is unlikely). However, transformational planned adaptation at various scales is most likely to occur where responsibility is shared by individuals and policymakers at all levels.

The RAD framework assumes that climate change is causing such dramatic change to SES, that reversing climate change impacts to approximate pre-disturbance conditions is no longer possible, and that adaptation with a goal of preserving values will achieve more positive outcomes (Morton and Magness 2020). A key tenet of RAD is that all three response options are explicitly considered in light of desired future conditions, which sets RAD apart from previous decision-making practices that tend to resist change (Clifford et al. 2022). Climate adaptation often requires trade-offs and creates winners and losers, as it will in the MDB, and is therefore inherently normative. As others have argued before, we suggest that these decisions require explicit conversations around values to understand "what does a desirable future look like, and for whom?", "how can adaptation be just?", and "what trade-offs should be made?".

Siders and Pierce (2021) argue that adaptation decision-makers are faced with a plethora of decision-making frameworks, most of which are complex, rigorous, and seek to be

"rational", but argue there is little evidence that using such frameworks lead to better outcomes than would otherwise have been achieved. Although the application of RAD can be complex, the simple heuristic of "Resist, Accept or Direct" provides a communication tool for facilitating conversations around values and highlighting that direct responses can preserve values despite SES undergoing transformative change. RAD is relatively new to both Australia and the Basin and as the application of the framework moves from the academic literature into decision-making practices, it is important for empirical research to examine how it is being adopted in practice, and to what effect.

Adaptation is impacted by interacting social, political, and economic forces (Eriksen et al. 2015; Wyborn et al. 2015), as are adaptation tools such as RAD frameworks. Clifford et al. (2022) examined the social and political factors influencing RAD decisions, as "ultimately, RAD decisions are judgements made by people, who are influenced by personal, institutional, and cultural factors, requiring a range of social science perspectives to understand how, when, and why decisions are made" (Clifford et al. 2022: 57). The IPCC emphasises that the interplay between top down (institutional) and bottom up (community) processes, and multiscale interaction at local, regional, national and international levels are critical in assessing adaptation progress (IPCC WGII AR6 Chapter 17). Despite this, examining the organisational and institutional context in which RAD decisions are made and actions are implemented is an emerging research area. Existing literature has been mostly conceptual, with case studies or research grounded in participants' experiences largely absent and there is little knowledge about what challenges decision-makers will face when applying RAD to socio-economic contexts (St-Laurent et al. 2021; Clifford et al. 2022; Lynch et al. 2022; Magness et al. 2022; Schuurman et al. 2022). We consider these issues through a qualitative case study design of a community-led regional strategy that uses a variation of the RAD framework to improve socio-economic resilience in the context of climate change.

As a result of historically poor community consultation in the MDB (Alston and Whittenbury 2011; Alston et al. 2016), there is a drive to effectively engage communities in water reform and climate adaptation efforts (Murray Darling Basin Authority (MDBA), 2021), alongside calls for greater empowerment of Basin communities (Tan and Auty 2017; Alexandra 2019; Grafton et al. 2020). Empowerment of communities is heralded as a means to address power disparities, navigate social judgments, and make difficult trade-offs in divided societies (Curato et al. 2017; Ercan et al. 2019). Scholars have suggested that climate change will exacerbate existing governance challenges and trade-offs in the MDB (Alston and Whittenbury 2011; Marshall and Alexandra 2016; Alexandra 2017; Tan and Auty 2017; Bell 2022), with some calling explicitly for empowerment of local communities to address these trade-offs (Alexandra 2019; Grafton et al. 2020). We contribute to emerging research on the governance context of RAD by examining the organisational and institutional factors influencing RAD decisions using the case study of the highly politicised Murray-Darling Basin.

Case study and methods

The Murray-Darling Basin and Goulburn-Murray Irrigation District

Known as Australia's "food bowl", the MDB produces 40% of Australia's agricultural production and contains over 9200 irrigated agricultural businesses (Abel et al. 2016; Murray Darling Basin Authority (MDBA), 2020). The MDB also contains a vast network of waterways, floodplains, and wetlands, and is home to 35 endangered animal species (Murray Darling Basin Authority (MDBA), 2020). Water in the MDB has been over-allocated for consumptive use, resulting in a series of drought-induced ecological crises (Grafton and Connell 2011). Efforts to share the MDB's waters across five states and territories have led to intergovernmental and interagency conflict since Federation (Connell 2011). In the most recent phase of water reform, the Water Act 2007, the Murray Darling Basin Plan 2012 (hereafter the Basin Plan), and the Murray Darling Basin Authority (MDBA) were created to address failing co-operative governance arrangements, over-extraction of water, and associated ecological degradation (Carmody 2013; Marshall and Alexandra 2016). However, these reforms have not ended conflict in the Basin, despite power being shared between the Commonwealth (national), and state and territory governments of Queensland, New South Wales, Victoria, South Australia, and the Australian Capital Territory. Some scholars argue the Basin Plan does not sufficiently address climate change and current environmental watering programs are achieving limited outcomes (Alexandra 2017, 2020; Colloff and Pittock 2022).

The Goulburn-Murray Irrigation District (GMID) in northern Victoria and the southern MDB (Fig. 3) is Australia's largest irrigation district, producing a wide range of agricultural commodities, including dairy, cropping, horticulture, beef, and sheep (Rothenburg 2021). Cropping is the most extensive land use by area (Goulburn Broken Catchment Management Authority (GBCMA) (2021a)) and is characterised by large paddocks of flat land (Fig. 4). The GMID has encountered many challenges, including salinity, drought, and growing farm debt (Walker et al. 2009). Climate change in the GMID will likely result in a warmer, drier region driven by increased temperature and rainfall

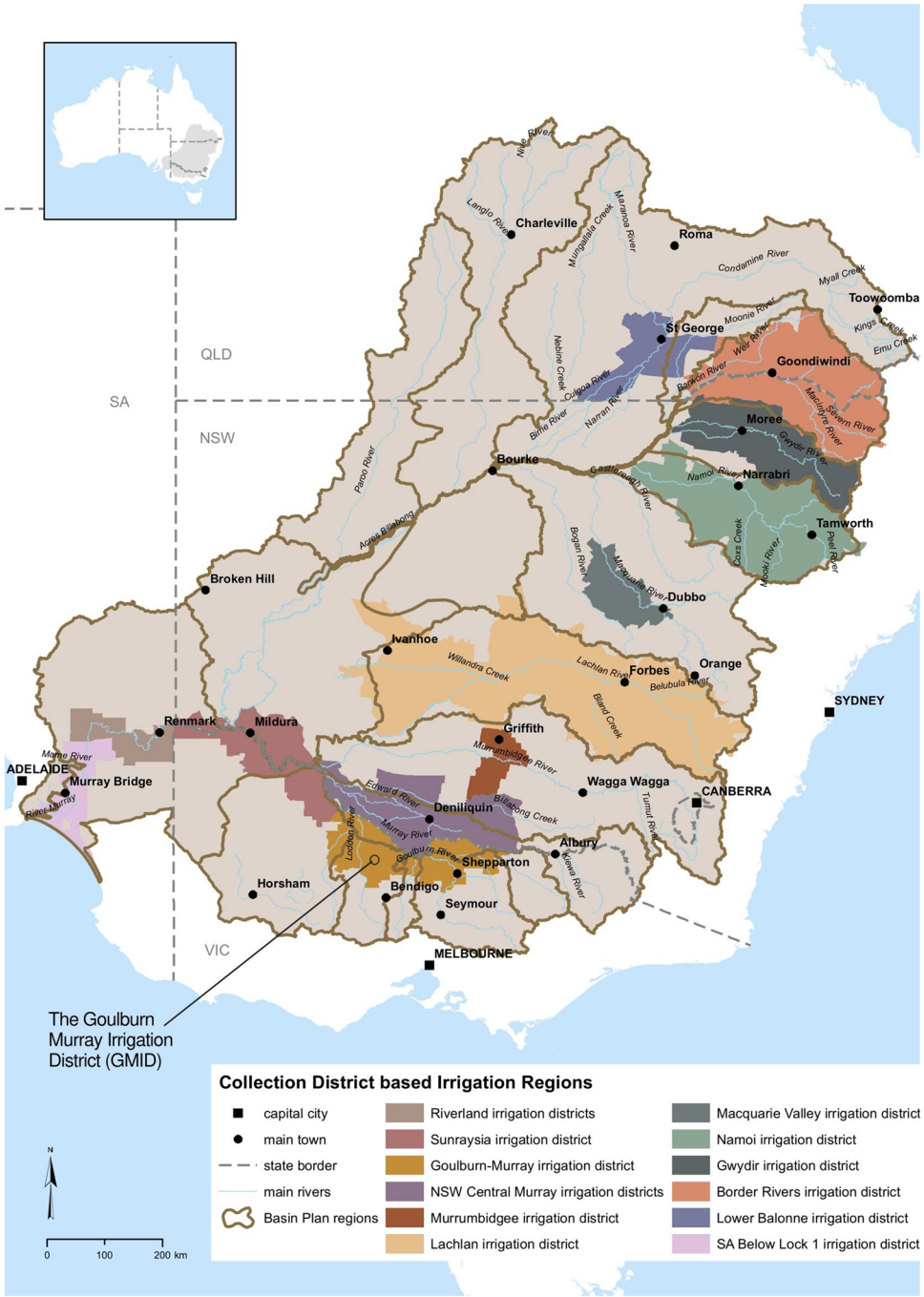

Fig. 3 Map of the Murray-Darling Basin showing the Goulburn-Murray Irrigation District. Source: Licensed from the Murray−Darling Basin Authority under a Creative Commons Attribution 4.0 International Licence

variability (Murray Darling Basin Authority (MDBA), 2020). Basin Plan water recovery has also impacted the GMID, reducing the total available water by over 300GL (20% reduction) and resulting in a loss of $525 million per year (RM Consulting Group (RMCG), 2016). Consequently, communities and entities in the GMID, such as the Goulburn-Broken Catchment Management Authority (GBCMA), are engaging with climate adaptation frameworks to address these challenges (Goulburn Broken Catchment Management Authority (GBCMA), 2021b).

The Goulburn-Murray Resilience Strategy

The Goulburn-Murray Resilience Strategy (Goulburn Regional Partnerships 2020) emerged from community concerns about projected declines in water availability due to climate change. The Resilience Taskforce includes community and government members tasked with implementing the Resilience Strategy. At the time of research, the Taskforce comprised 20 members: 9 community members, 3 members from Victoria's Regional Partnerships program,

Fig. 4 A ploughed paddock typical of the large, flat paddocks in the GMID (author's image)

4 organisational members (regional statutory bodies), and 4 state government members, plus a secretariat of 3 people.

The Strategy presents the "persist, adapt, transform" (PAT) framework (Fig. 5), akin to RAD frameworks, to highlight different layers of governance that shape decision-making in the context of climate change. "Adapt" and "accept" are more similar than they initially appear when accept is considered incremental autonomous adaptation to changing conditions (Fig. 2). The Strategy draws on the "iceberg model", a tool commonly used in systems thinking to illustrate the patterns of behaviour, structures, and mental models that underlie events. The Strategy's iceberg model seeks to highlight that deeper-level concepts are harder to recognise and require structural adjustment to change, yet form the foundations for concepts towards the tip of the iceberg. The Strategy focuses on the adapt and transform segments "below the waterline" of the iceberg, and argues that working in the persist segment fails to address the underlying patterns, processes, and systemic structures that will enable the GMID to adapt and transform in the face of change (Goulburn Regional Partnerships 2020).

There are some differences between the Strategy's conception of the PAT framework and the RAD framework, namely that PAT implies adapt is necessarily harder to implement than persist, and that persist is only a reactive response, that is easier, faster, and weaker to implement (whereas a resist response could also be planned, long term, and difficult to achieve). This is partly because the iceberg

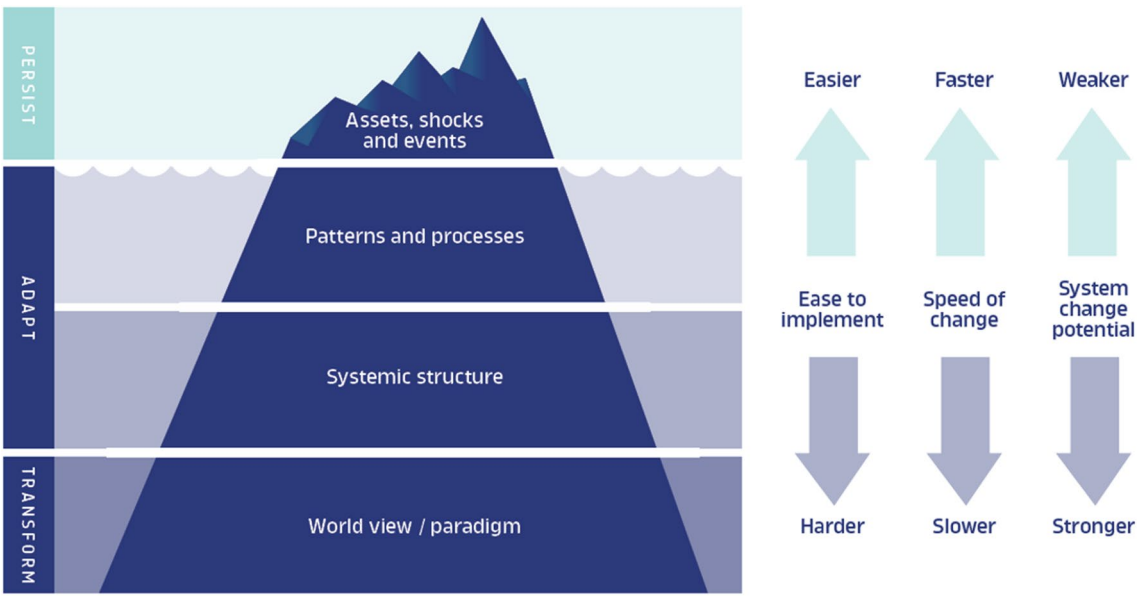

Fig. 5 The Iceberg Model in the Resilience Strategy (Australian Resilience Centre 2018)

model does not allow for the same nuance that the adapted RAD model (Fig. 2) provides. However, the use of the PAT framework indicates that the Strategy and Taskforce are grappling with the same concepts and challenges as the RAD framework, despite using different language. This research into how the Strategy and Taskforce are addressing these concepts and challenges is important as RAD continues to emerge in Australia. The Resilience Strategy defines resilience as "the ability to cope with and thrive in the face of change" and states "resilience is not a synonym for dogged maintenance of the current situation, or a return to the past" but rather "encompasses a system or the components within a system's capacity to persist, adapt and fundamentally transform" (Goulburn Regional Partnerships 2020). We acknowledge there are more academic definitions of resilience (e.g. Walker et al. 2004, 2009; Folke et al. 2010); however, for the purposes of this research, we use the Strategy's definition.

Data collection and analysis

Qualitative case studies are well suited to situations where the boundaries are unclear between the phenomenon and context (Yin 2009). Adaptation decisions are impacted by social, political, and economic forces (Wyborn et al. 2015) and are therefore contextually dependent, making a qualitative case study design appropriate for this research. We used an adaptive theory approach (Layder 1998) to guide our semi-structured interview design. Adaptive theory highlights the importance of the researcher engaging with theory to inform research questions and methods, but also developing theoretical understanding based on emerging findings in the data (Layder 1998). The orienting concepts shaping our interview guide were "climate adaptation decision-making" and "organisational culture". "Organisational culture" was chosen as an orienting concept due to literature identifying that institutional and cultural factors influence climate adaptation decisions (Bremer et al. 2021) and RAD decisions (Clifford et al. 2022). However, specific aspects of organisational culture (such as lack of flexibility) emerged during data analysis. Interviews were semi-structured, with standard questions asked in each interview to enable comparative data analysis (Young et al. 2018), while also allowing for additional lines of questioning to elicit richer responses (Kallio et al. 2016; Young et al. 2018).

We recruited the initial five participants through one of the Resilience Strategy facilitators, and subsequently used snowball sampling (Naderifar et al. 2017). The inclusion criterion for participants was involvement with the Resilience Strategy during the creation and/or implementation stages. Twenty participants were interviewed, with each allocated a number to maintain confidentiality. Two participants were from local government, six from regional government, two from state government, and ten from the community/private enterprise. Thirteen participants were members of the Taskforce (including secretariat). Each semi-structured interview was professionally transcribed and checked for accuracy against the original audio files. The transcripts were coded in NVivo 12 Pro using thematic analysis to identify, analyse, and organise themes within the data set (Braun and Clarke 2006). Interviews were first analysed individually, and then comparatively through an iterative process that sought to identify key concepts, themes, and patterns in the data. Other than the overarching theme of "organisational culture", all other themes were emergent. The lead author coded five initial transcripts to develop a codebook which was then reviewed and discussed with the co-authors (Saldaña 2013). Remaining transcripts were then analysed by the lead author and new themes were added to the codebook. A second round of coding was undertaken to ensure consistency across transcripts, and to categorise larger themes and sub-themes in the data.

Results

Two major findings emerged from the thematic analysis:

(1) Communities and governments prioritise different actions under the RAD framework. Governments, particularly at the state level, preference incremental planned adaptation to maintain the status quo (resist), over incremental autonomous adaptation to changing conditions (accept), and transformational planned adaptation at various scales (direct).
(2) Community and government actors perceive that factors driving governments' preference for incremental-resist adaptation include electoral short-termism, linear planning, and conservative government culture.

Different priorities

Participants described the Strategy as being concerned with "strategic", long-term decision-making at a regional scale, with a focus on accept and direct actions needed to address underlying issues threatening the region's resilience. Several participants stated that governments prefer resist actions over accept or direct actions and considered this a challenge the Resilience Strategy needs to overcome to improve the region's resilience in a changing climate:

> Just running around up there on top of the iceberg, "I'll fix it. I can do this. I can do that. I'll throw some money at it." That doesn't fix anything. You've got to go down and dig deep at the fundamental things that are causing the iceberg to shake and melt.

Participant 15, community/private enterprise

Participants identified a reluctance to redistribute power from governments to communities when making adaptation decisions, despite explicit calls for community empowerment in Basin adaptation (Alexandra 2019; Grafton et al. 2020).

> …you keep hitting ceilings if you like. You start from the ground up and then at some stage, you're going to need engagement and support from local, state, and federal governments and other organisations and each time, you'll hit, "Well, we'll just do it much more efficiently top-down".
>
> Participant 6, local government

Community empowerment would represent a direct response, as a planned adaptation that would transform adaptation governance in the region. The desire to maintain the same governance structures but make them work "more efficiently" is one example from participants of governments' preference to act within the blue zone of incremental planned adaptation to maintain the status quo.

Some participants considered strategic land use change, namely a renewable energy transition in the GMID, as another example illustrating governments' preference for resist actions. This is a contentious topic in the region with concerns that irrigation networks are not being fully utilised when productive agricultural land is instead used for solar farms or other renewable energy technologies. Part of the contention around irrigation network underutilisation is due to the perceived "Swiss cheese effect" (Wheeler et al. 2014; Whittle et al. 2020): when irrigators disconnect from the network, the fixed maintenance and operational costs are concentrated among a smaller number of remaining irrigators. The result is that irrigators fear being left with "stranded assets"—capital intensive irrigation farms that are no longer viable because there are an insufficient number of farms to share the costs (Bell and Quiggin 2008).

Many participants identified renewable energy as an opportunity for the GMID, particularly due to the energy-intensive industries in the region, such as dairy. Others mentioned green hydrogen powered trucking, as the GMID sits on arterial trucking routes between Australia's three biggest cities: Melbourne, Sydney, and Brisbane. Investment in renewable energy, specifically through solar farms, was identified as a means to improve socio-economic regional resilience in a future with less water.

A desire to maintain the viability of irrigation districts and avoid the "Swiss cheese effect" led the state government to introduce the Victorian Planning Amendment VC161 policy to protect declared irrigation districts (Department of Environment, Land, Water and Planning (DELWP), 2019). The state government also amended solar farm guidelines to declare:

> Solar energy facilities will not be permitted to undermine the integrity of the irrigation network within a declared irrigation district… Key policies include the need to protect agricultural land serviced by modernised irrigation infrastructure, to ensure the future viability of a declared irrigation district.
> DELWP (2019:10) Solar Energy Facilities: Design and Development Guideline

These policy amendments resulted in the Department of Environment, Land, Water and Planning (DELWP) rejecting a solar farm proposal in the GMID, and was the subject of a Victorian Civil and Administrative Tribunal (VCAT) case, *Green Gold Energy Pty Ltd v Minister for Planning 2022*.

Several participants stated that such "one-size-fits-all" solutions are ill-suited, suggesting that the policy should consider factors such as soil quality and proximity to core irrigation infrastructure. Participants considered that these policy amendments to "protect" irrigation districts represent incremental planned adaptation to maintain the dominance of irrigated agriculture in the regional economy, and therefore fall within the blue zone.

Governments' desire to retain existing governance structures and the state government's response to renewable energy transition in the region illustrate the broader concerns voiced by participants that governments tend to act within the blue zone. Participants believed operating predominately within the blue zone to be damaging to the GMID, as it would "lock in" an undesirable future for the region and result in missed adaptation opportunities. This research then attempted to identify the underlying factors driving this government preference for incremental planned adaptation to maintain the status quo.

Government short-termism, linear planning, and conservative culture

Both community and government participants identified government short-termism, linear planning, and conservative government culture as prominent factors hindering the implementation of the Strategy and transformational planned adaptation in the region. Government short-termism refers to governments' tendency to focus on short-term actions and outcomes rather than long-term ones. Several participants used the phrase "cut a ribbon" to describe a focus on short-term tangible outcomes, highlighting "tensions" this creates between governments and the Resilience Strategy.

Some participants attributed governments' focus on short-term actions to public and media attention, which one participant hypothesised is because governments are "bound

by the electoral cycle". While funding is often a challenge for any organisation, several participants perceived the Strategy's funding issues have emerged from its focus on longer-term, transformative change, rather than providing the government "announceables", such as specific projects or grants.

Participants also identified the organisational culture of government agencies as a driver of governments' preference for acting within the blue zone. Participants generally spoke about regional and state level governments' culture, as local governments were often considered less engaged with the Resilience Strategy and holding significantly less power. Participants did not consider the culture of all government agencies to be misaligned with the resilience principles, pointing to one regional agency—the Goulburn-Broken Catchment Management Authority—as a "key driver" of the Strategy.

Alongside short-termism, participants identified that long-term plans were the main way some government agencies managed uncertainty, but that the inflexibility of these long-term plans made them inappropriate tools to address climate change:

> The key agencies have got a linear planning perspective. They want to set five year and 10-year plans…we've seen things where there's 30-year plans with five-year review periods and the world is changing, and they're not hitting their targets and they just keep going.
>
> Participant 17, community/private enterprise

Participants suggested that this inflexibility will hinder planned, transformational adaptation in the region. However, one state government participant made the point that governments need to balance flexibility with risk management and accountability:

> The machinery of government is inherently slow and there's really good reason for that - there's real value in the strengths of those processes and institutions in terms of managing risk and being accountable…but certainly, I think the Resilience Strategy is an interesting tension to challenge that as well.
>
> Participant 10, state government

Some government participants identified that their agency's culture poorly aligned with Strategy's focus on governance that embraces change, particularly at the state level. One participant specifically pointed to clause 14.02-3S of amendment VC161 to the Victoria Planning Provisions, titled "Protection of declared irrigation districts" (DEWLP 2019:1), to illustrate that "protecting" is counter to change. This language was mirrored by one state government participant and reiterates others' statements that governments tend to preference incremental adaptation to maintain the status quo.

While risk management was identified as important, several participants also considered risk-averse culture of governments as an impediment to implementing the Strategy. Participants hypothesised risk aversion could be due to public pressure and a tendency to blame the government. One participant recognised that creating change, such as by redistributing power to novel decision-makers like communities or a transformational and planned renewable energy transition in the region, means "being prepared to fail" and needing to "do things and find that they don't work". Participants therefore identified that public support for governments to experiment will be crucial for government responses to move away from incremental planned adaptation that largely maintains the status quo.

Discussion

Our analysis found a strong preference among government actors for incremental adaptation actions that resist changes to the current socio-economic system. Participants suggested that this preference was driven in part by short-termism, linear planning, and a risk averse culture within government agencies. Despite the proliferation of frameworks and calls for transformative adaptation, there remains a gap between aspiration and effort from governments, both in Australia and globally. This suggests a need for greater research which considers the barriers to implementing adaptation strategies which seek to go beyond the status quo to transform systems in order to build resilience in the face of a changing climate.

We found when applying RAD to the Strategy's efforts of building socio-economic resilience that the original RAD framework (Fig. 1) lacked sufficient nuance to apply to the more complex socio-economic adaptation. To address the complexity of applying RAD to socio-economic adaptation, particularly across different actors and scales, we adapted the original framework to include the IPCC's terms of incremental, transformational, planned, and autonomous adaptation (Fig. 2). While our adapted framework does not "solve" the scalar issues in the original framework, it recognises and illustrates such complexity exists through the different overlapping zones.

Many scholars argue that all three RAD actions—resist, accept, and direct—have a legitimate place in natural resource management (Clifford et al. 2020; Williams 2021; Lynch et al. 2022). However, in this case study, participants believe preferencing incremental planned adaptation to maintain the status quo (resist/the blue zone) excludes consideration of desired future conditions and fails to accept that with both climate change and policy drivers, the GMID's current economy cannot be sustained in the future. Participants were concerned that governments' preference for working within the blue zone would "lock in" the region

to an undesirable future. This aligns with previous findings that some decision-makers consider resist options to require more intense interventions over time, making them increasingly expensive, less effective, and therefore less desirable and feasible than accept (the red zone) and direct (the green zone) responses (Clifford et al. 2020).

Short-termism in democratic governments is well-established in political science (Garrì 2010; Goldin and Lamy 2014; MacKenzie 2016), despite rarely being linked with RAD decision-making. Contributing factors include incentives driving governments to adopt policies with tangible, immediate benefits and to avoid policies with long-term benefits but near-term costs (Garrì, 2010; MacKenzie 2016). In Australia, Daley (2021) argues that public opinion has become an insurmountable obstacle for policy reform, in part due to the tendency of public opinion to focus on the immediate consequences and not long-term benefits. Blame avoidance in politics affects governments' decisions to continue with, adjust, or abandon existing policies (Howlett 2012). This reduces government's capacity to embrace change, and instead exacerbates the risk averse culture noted by some participants to drive acting within the blue zone.

Another reason for governments preferencing short-term actions is that long-term, transformative changes are often more uncertain and therefore riskier (Stanton and Roelich 2021). This is particularly the case for complex systems, such as the MDB, where defining cause and effect is difficult. Uncertainty can create a culture of blame, making it politically desirable to redistribute risks and avoid the allocation of responsibility (Scoones and Stirling 2020). However, climate adaptation requires making decisions with imperfect information, given the unpredictability of future climate conditions, and therefore embracing uncertainty is crucial to achieve transformations to sustainability (Scoones and Stirling 2020). That RAD decisions need to be made despite substantial uncertainty is well-established in RAD literature (Clifford et al. 2020; Crausbay et al. 2022) and Clifford et al. (2020) hypothesise that uncertainty shapes which RAD option a decision-maker selects. Clifford et al. (2020) suggest that high levels of uncertainty will drive resist options, as decision-makers with a low risk tolerance may feel they have insufficient information to shift their management, or accept alternative options, and delay action until they have more information. Our data supports Clifford et al.'s (2020) hypotheses, with the MDB facing deep uncertainty in the context of climate change and with risk aversion cited as a key driver of governments' preference for incremental adaptation to maintain the status quo.

Choice of policy language by government may reinforce the preference for resist adaptation responses or acting within the blue zone. Clifford et al. (2020) found that in an ecological adaptation context some decision-makers preference resist responses because social norms and policy language frame landscapes as more "natural" when they remain in their historical state. Our finding that governments use language such as "protecting" irrigation districts as part of incremental planned adaptation to maintain the status quo suggests policy language may influence risk adverse decision-making in both ecological adaptation contexts and socio-economic ones.

In line with participants' accounts, Harrison and Baird (2015) argue that the organisational culture of governments is critical to enact change, but that governments often make decisions by following past practices, rather than taking risks. Risk aversion is already recognised as a factor influencing water policy in the Murray-Darling Basin (Alexandra 2021). For example, Alexandra (2020) argues that the need to minimise political risks shaped the design of water entitlements and extraction limits in the 2012 Basin Plan, to the detriment of climate adaptation. Research indicates the dominant assumption in management practices is that future system behaviour will mimic past behaviour (Lynch et al. 2022; Schuurman et al. 2022). However, many scholars argue this will not be the case for future systems impacted by climate change (Williams and Jackson 2007; Lynch et al. 2022; Schuurman et al. 2022), including in the Murray-Darling Basin, meaning transformational planned adaptation at various scales (the green zone) within the Basin is essential (Alexandra 2018; Martin et al. 2023; Wyborn et al. 2023).

Lack of flexibility was also identified as a driver of incremental planned adaptation to maintain the status quo, and has been an enduring criticism of government (Pierre 2012). Flexibility is a key quality of robust policies (van der Brugge and Roosjen 2015), an important element of NRM initiatives, and a crucial element of water policy necessary to "create flexible pathways that avoid lock in actions" (Marshall and Alexandra 2016: 684). Governments may struggle to design for flexibility due to entrenched public sector values, such as due process, procedural fairness, accountability, and transparency (Eversole 2011; Pierre 2012; Dare and Daniell 2017). One state government participant argued that government processes and accountability are crucial, but acknowledged these attributes could hinder flexibility and governance that embraces change. This is consistent with Wyborn and Dovers (2014) who argue that accountability, statutory mandates, and regulatory and operational procedures are essential, but make it difficult for governments to be flexible and adaptive.

This paper's focus on regional RAD decision-makers also raises issues of scale that are not solved through our adaptation of the original RAD framework (Fig. 2). There are calls for more local and regional decision-making processes to redress the balance between centralised management and local engagement in the Murray-Darling Basin (Horne and O'Donnell 2014; Abel et al. 2016; Alexandra 2019; Grafton et al. 2020). However, decisions made at one scale often

have cross-scale impacts. For example, although the Strategy is only concerned with resilience of the GMID, participants expressed frustration that efforts to build this resilience, particularly through a renewable energy transition, were constrained by policy at different scales. This mirrors issues of scale experienced by natural resource managers making RAD decisions for an ecological adaptation context in the Upper Gunnison Basin, Colorado, United States (Clifford et al. 2020). The Upper Gunnison managers felt policy and public support restricted management to smaller scales or specific actions, driving concerns their responses would not match the scale of impacts anticipated under climate change (Clifford et al. 2020).

RAD has been heralded as a "common platform" that can support the collaborative development of joint or complimentary adaptation actions across scales and organisations (Schuurman et al. 2022: 26). However, this will require a broader, cross-scale policy environment that is supportive of risk taking, and engages with the political and economic trade-offs associated with transformational planned adaptation. At the time of writing, there is limited uptake of RAD in Australia and, given the breadth of climate adaptation frameworks available (Siders and Pierce 2021), it is unlikely RAD will become universally adopted, meaning mechanisms other than a common platform will be required to bridge scalar divides. Further research could examine how challenges of scale might be overcome when considering the integration of transformative adaptation options into governance institutions, supported by RAD or other adaptation frameworks.

Our application of the adapted RAD framework has highlighted that socio-economic contexts require a more nuanced version of RAD to address the complexities associated with many diverse actors across different scales. Many of the challenges faced by RAD decision-makers in ecological contexts are present in socio-economic contexts, including the impact of uncertainty, policy language, organisational culture, and scalar issues on decisions. The short-termism, risk aversion, and lack of flexibility identified in this study suggest a need to further examine what is driving these organisational cultures within government agencies, and how adaptation efforts can address these constraints to enable a wider range of RAD decisions to be plausible options for decision-makers seeking to move beyond incremental adaptation to transformative adaptation.

Conclusion

Climate adaptation decision-making involves multiple intersecting social, economic, and political factors which shape what options are available and possible in a given governance context. RAD frameworks have been developed to support decision-makers, natural resource managers, and communities confront difficult decisions about adaptation options in the context of increasing magnitudes of change. This research adapted the common RAD framework to include the socio-economic adaptation language from the IPCC. We then applied this adapted framework to examine the implementation of the Goulburn-Murray Resilience Strategy, which is grounded in a RAD framework and situated within the contentious water governance context of Australia's Murray-Darling Basin.

There are two primary implications of this research for the governance of RAD decisions. First, our findings illustrate the importance of considering organisational culture within climate adaptation decision-making. This has been highlighted previously (Clifford et al. 2020; Bremer et al. 2021), and our study calls attention to the ways in which short-termism, linear planning, and risk averse culture within governments constrain adaptation options which challenge the status quo, yet are likely to be critical in transitions that will enable regional resilience in the context of future climate change. This suggests that further work is required to understand what may enable decision-makers to adopt greater risks and embrace decisions which operate in the red and green zones of the adapted RAD spectrum, as the magnitude of projected climate impacts in our case study region will require.

Secondly, our research highlights the cross-scalar nature of RAD decisions. While the Resilience Strategy primarily focused on the GMID region, the adaptation options possible in that region are driven by policies determined by State and Federal governments and by the contentious politics which shapes water governance in the MDB. This suggests that further research could usefully consider both how regional scale RAD decision-making can be connected into broader cross-scale governance networks, and also how such cross-scale dynamics have influenced RAD decision-making in other contexts.

The RAD framework has the potential to help decision-makers build socio-economic resilience and address contestation and conflict exacerbated by climate change. However, this research indicated that RAD decisions are not being made solely on the basis of desired future conditions, but are impacted by social, political, and cultural factors. Recognising and mitigating these factors will be essential to enable a desirable and resilient future for the Murray-Darling Basin in the context of climate change.

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References

Abel N, Wise RM, Colloff MJ, Walker BH, Butler JRA et al (2016) Building resilient pathways to transformation when "no one is in charge": insights from Australia's Murray-Darling Basin. Ecol Soc 21(2). https://doi.org/10.5751/ES-08422-210223

Alexandra J (2017) Risks, uncertainty and climate confusion in the Murray–Darling Basin reforms. Water Econ Policy 3(03). https://doi.org/10.1142/S2382624X16500387

Alexandra J (2018) Evolving governance and contested water reforms in Australia's Murray Darling Basin. Water 10(2):113. https://doi.org/10.3390/w10020113

Alexandra J (2019) Losing the authority–what institutional architecture for cooperative governance in the Murray Darling Basin? Aust J Water Resour 23(2):99–115. https://doi.org/10.1080/13241583.2019.1586066

Alexandra J (2020) The science and politics of climate risk assessment in Australia's Murray Darling Basin. Environ Sci Policy 112:17–27. https://doi.org/10.1016/j.envsci.2020.05.022

Alexandra J (2021) Navigating the Anthropocene's rivers of risk—climatic change and science-policy dilemmas in Australia's Murray-Darling Basin. Clim Change 165(1):1. https://doi.org/10.1007/s10584-021-03036-w

Alexandra J, Rickards L (2021) The contested politics of drought, water security and climate adaptation in Australia's Murray-Darling Basin. Water Alternatives 14(3):773–794

Alston M, Whittenbury K (2011) Climate change and water policy in Australia's irrigation areas: a lost opportunity for a partnership model of governance. Environ Politics 20(6):899–917. https://doi.org/10.1080/09644016.2011.617175

Alston M, Whittenbury K, Western D, Gosling A (2016) Water policy, trust and governance in the Murray-Darling Basin. Aust Geogr 47(1):49–64. https://doi.org/10.1080/00049182.2015.1091056

Australian Resilience Centre (2018) The iceberg model. The Goulburn Murray Resilience Strategy, Goulburn Regional Partnerships, Victoria.

Barnaud C, van Paassen A (2013) Equity, power games, and legitimacy: dilemmas of participatory natural resource management. Ecol Soc 18(2). https://doi.org/10.5751/ES-05459-180221

Bell S (2022) The limits of federal state capacity in managing Australia's Murray-Darling River Basin. Water Alternatives 15(1):129–149

Bell S, Quiggin J (2008) The limits of markets: the politics of water management in rural Australia. Environ Politics 17(5):712–729. https://doi.org/10.1080/09644010802421448

Bouckaert F, Wei Y, Pittock J (2021) Governing the Murray-Darling Basin: integrating social and biophysical indicators for better environmental outcomes. Environ Sci Policy 124(5):101–114. https://doi.org/10.1016/j.envsci.2021.05.019

Braun V, Clarke V (2006) Using thematic analysis in psychology. Qual Res Psychol 3:77–101. https://doi.org/10.1191/1478088706qp063oa

Bremer S, Glavovic B, Meisch S, Schneider P, Wardekker A (2021) Wiley Interdiscip Rev Clim Change 12(6):1–20. https://doi.org/10.1002/wcc.739

Carmody E (2013) The silence of the plan: will the convention on biological diversity and the Ramsar Convention be implemented in the Murray-Darling Basin? Environ Plan Law J 30(1):56–73

Chaffin B, Garmestani A, Gunderson L, Benson M, Angeler D et al (2016) Transformative Environmental Governance. Annu Rev Environ Resour 41:399–423. https://doi.org/10.1146/annurev-environ-110615-085817

Clifford KR, Yung L, Travis W, Rondeau R, Neely B et al (2020) Navigating climate adaptation on public lands: how views on ecosystem change and scale interact with management approaches. Environ Manag 66:614–28. https://doi.org/10.1007/s00267-020-01336-y

Clifford KR, Cravens AE, Knapp CN (2022) Responding to ecological transformation: mental models, external constraints, and manager decision-making. Bioscience 72(1):57–70. https://doi.org/10.1093/biosci/biab086

Colding J, Barthel S (2019) Exploring the social-ecological systems discourse 20 years later. Ecol Soc 24(1). https://doi.org/10.5751/ES-10598-240102

Colloff MJ, Pittock J (2022) Mind the gap! Reconciling environmental water requirements with scarcity in the Murray-Darling Basin Australia. Water 14(2):208. https://doi.org/10.3390/w14020208

Connell D (2011) Water reform and the federal system in the Murray-Darling Basin. Water Resour Manage 25(15):3993–4003. https://doi.org/10.1007/s11269-011-9897-8

Cooke B, Kothari U (2001) Participation: the new tyranny? Bloomsbury Publishing, United Kingdom

Crausbay S, Sofaer H, Cravens A, Chaffin B, Clifford K et al (2022) A science agenda to inform natural resource management decisions in an era of ecological transformation. Bioscience 72(1):71–90. https://doi.org/10.1093/biosci/biab102

Curato N, Dryzek J, Ercan S, Hendriks C, Niemeyer S (2017) Twelve key findings in deliberative democracy research. Daedalus 146(3):28–38. https://doi.org/10.1162/DAED_a_00444

Daley J (2021) Gridlock: removing barriers to policy reform. Grattan Institute, Australia

Dare M, Daniell KA (2017) Australian water governance in the global context: understanding the benefits of localism. Policy Stud 38(5):462–481. https://doi.org/10.1080/01442872.2016.1188908

Department of Environment, Land, Water and Planning (DELWP) (2019) Solar energy facilities: Design and Development Guidelines 2019. Melbourne, Victoria

Dessai S, Hulme M, Lempert R, Pielke R (2009) Do we need better predictions to adapt to a changing climate? Eos Trans AGU 90(13):111–112. https://doi.org/10.1029/2009EO130003

JS Dryzek H Stevenson 2014 Democratizing global climate governance: accountability Cambridge University Press https://doi.org/10.1017/CBO9781139208628

Ercan SA, Hendriks CM (2013) The democratic challenges and potential of localism: insights from deliberative democracy. Policy Stud 34(4):422–440. https://doi.org/10.1080/01442872.2013.822701

Ercan SA, Hendriks CM, Dryzek JS (2019) Public deliberation in an era of communicative plenty'. Policy Polit 47(1):19–35. https://doi.org/10.1332/030557318X15200933925405

Eriksen SH, Nightingale AJ, Eakin H (2015) Reframing adaptation: the political nature of climate change adaptation. Glob Environ Chang 35:523–533. https://doi.org/10.1016/j.gloenvcha.2015.09.014

Eversole R (2011) Community agency and community engagement: re-theorising participation in governance. J Publ Policy 31(1):51–71. https://doi.org/10.1017/S0143814X10000206

Folke C, Carpenter S, Walker B (2010) Resilience thinking: integrating resilience, adaptability and transformability. Ecol Soc 15(4). https://doi.org/10.5751/ES-03610-150420

Garrì I (2010) Political short-termism: a possible explanation. Public Choice 145(1):197–211. https://doi.org/10.1007/s11127-009-9561-5

Gherghina S, Mokre M, Miscoiu S (2021) Introduction: Democratic deliberation and under-represented groups. Politi Stud Rev 19(2):159–163. https://doi.org/10.1177/1478929920950931

Goldin I, Lamy P (2014) Overcoming short-termism: a pathway for global progress. Wash Qu 37(2):7–24. https://doi.org/10.1080/0163660X.2014.926205

Goulburn Broken Catchment Management Authority (GBCMA) (2021a) Goulburn Broken Regional Catchment Strategy 2021–27. Shepparton, Victoria

Goulburn Broken Catchment Management Authority (GBCMA) (2021b) Regional irrigated land and water use mapping in the Goulburn Murray Irrigation District 2019/20, spatial mapping technical report September 2021. State of Victoria, Australia

Goulburn Regional Partnership (2020) Goulburn Murray Resilience Strategy 2020. The Victorian Government and Goulburn Regional Partnership, Victoria

Grafton RQ, Colloff MJ, Marshall V, Williams J (2020) Confronting a 'post-truth water world' in the Murray-Darling Basin Australia. Water Alternatives 13(1):1–28

Grafton RQ, Connell D (eds) (2011) Basin futures: water reform in the Murray-Darling Basin. ANU Press. https://doi.org/10.22459/BF.05.2011

Gunderson L, Cosens B, Chaffin BC, Arnold T, Fremier A et al (2017) Regime shifts and panarchies in regional scale social-ecological water systems. Ecol Soc 22(1):1. https://doi.org/10.5751/ES-08879-220131

Harrison GL, Baird KM (2015) The organizational culture of public sector organizations in Australia. Aust J Manag 40(4):613–629. https://doi.org/10.1177/0312896214529440

Hart BT, Alexandra J, Bond N, Byron N, Marsh R et al (2021) The way forward: continuing policy and management reforms in the Murray-Darling Basin. Murray-Darling Basin, Australia. https://doi.org/10.1016/B978-0-12-818152-2.00019-X

Horne A, O'Donnell E (2014) Decision making roles and responsibility for environmental water in the Murray-Darling Basin. Aust J Water Resour 18(2). https://doi.org/10.7158/W12-032.2014.18.2

Houston A (2022) The future of the Murry-Darling Basin. River Reflections, Murray Darling Basin Authority, Mildura, NSW

Howlett M (2012) The lessons of failure: learning and blame avoidance in public policy-making. Int Polit Sci Rev 33(5):539–555. https://doi.org/10.1177/0192512112453603

Intergovernmental Panel on Climate Change (IPCC) (2022) Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., https://doi.org/10.1017/9781009325844

Jentoft S (2000) Legitimacy and disappointment in fisheries management. Mar Policy 24:141–148. https://doi.org/10.1016/S0308-597X(99)00025-1

Kallio H, Pietilä A, Johnson M, Kangasniemi M (2016) Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. J Adv Nurs 72(12):2954–2965. https://doi.org/10.1111/jan.13031

Layder D (1998) Sociological practice. SAGE Publications Ltd, London. https://doi.org/10.4135/9781849209946

Lockwood M, Davidson J, Curtis A, Stratford E, Griffith R (2010) Governance principles for natural resource management. Soc Nat Resour 23(10):986–1001. https://doi.org/10.1080/08941920802178214

Long W (2018) Prime agricultural land or booming future energy? That's the solar planning conundrum for Victoria. The Australian Broadcasting Corporation. https://www.abc.net.au/news/rural/2018-05-01/solar-farm-boom-leading-the-bust-in-prime-agricultural-land-use/9713954. Accessed 16 Feb 2023

Lynch AJ, Thompson L, Morton J, Beever E, Clifford M et al (2022) RAD adaptive management for transforming ecosystems. Bioscience 72(1):45–56. https://doi.org/10.1093/biosci/biab091

Mackenzie M (2016) Institutional design and sources of short-termism. In: González-Ricoy I, Gosseries A (eds) Institutions for future generations. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198746959.003.0002

Magness DR, Hoang L, Belote R, Brennan J, Carr W et al (2022) Management foundations for navigating ecological transformation by resisting, accepting, or directing social–ecological change. Bioscience 72(1):30–44. https://doi.org/10.1093/biosci/biab083

Marshall GR, Alexandra J (2016) Institutional path dependence and environmental water recovery in Australia's Murray-Darling Basin. Water Alternatives 9(3):679–703

Martin P, Alexandra J, Holley C, Thoms M (2023) Murray-Darling Basin Plan mark II. What should stakeholders plan for? Aust J Water Resour 27(2):211–22. https://doi.org/10.1080/13241583.2023.2173049

Melnychuk N, de Loë R (2020) Legitimacy assessment throughout the life of collaborative water governance. Environ Policy Gov 30(1):14–28. https://doi.org/10.1002/eet.1872

Millar CI, Stephenson NL, Stephens SL (2007) Climate change and forests of the future: managing in the face of uncertainty. Ecol Appl 17(8):2145–2151. https://doi.org/10.1890/06-1715.1

Morton J, Magness D (2020) Resist-Accept-Direct (RAD)— a framework for the 21st-century natural resource manager. National Park Service, U.S. Department of the Interior https://doi.org/10.36967/nrr-2283597.

Murray Darling Basin Authority (MDBA) (2020) The 2020 Basin Plan Evaluation, Canberra, ACT

Murray Darling Basin Authority (MDBA) (2021) Managing water under a changing climate: the Murray-Darling Basin Authority climate workplan. Canberra, ACT

Murray Darling Basin Authority (MDBA) (2023) The Basin. Available at: https://www.mdba.gov.au/basin (Accessed February 2024)

Naderifar M, Goli H, Ghaljaei F (2017) Snowball sampling: a purposeful method of sampling in qualitative research. Strides Dev Med Educ 14(3). https://doi.org/10.5812/sdme.67670

Newman J, Barnes M, Sullivan H, Knops A (2004) Public participation and collaborative governance. J Soc Policy 33(2):203–223. https://doi.org/10.1017/S0047279403007499

Nissan H, Goddard L, Coughlan de Perez E, Furlow J, Baethgen W et al (2019) On the use and misuse of climate change projections in international development. Wiley Interdiscip Rev Clim Change 10(3):e579. https://doi.org/10.1002/wcc.579

Peterson St-Laurent G, Oakes LE, Cross M, Hagerman S (2021) R-R-T R-R-T (resistance-resilience-transformation) typology reveals differential conservation approaches across ecosystems and time. Commun Biol 4:39. https://doi.org/10.1038/s42003-020-01556-2

Pierre J (2012) Governance and institutional flexibility. In: Levi-Faur D (ed), The Oxford Handbook of Governance. Oxford Academic, Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199560530.013.0013

Pittock J (2019) Are we there yet? The Murray-Darling Basin and sustainable water Management. Thesis Eleven 150(1):119–130. https://doi.org/10.1177/0725513618821970

Prosser IP, Chiew FHS, Stafford Smith M (2021) Adapting water management to climate change in the Murray-Darling Basin Australia. Water 13(18):2504. https://doi.org/10.3390/w13182504

RM Consulting Group (RMCG) (2016) Basin Plan – GMID socio-economic impact assessment: final report. Goulburn Murray Irrigation District Water Leadership Forum. Bendigo, Victoria

Rothenburg D (2021) Too much water: how salinisation transformed Australia's "food bowl", 1945–2017. Int Rev Environ History 7(2):145–168. https://doi.org/10.22459/IREH.07.02.2021.06

Saldaña J (2013) The coding manual for qualitative researchers, 2nd edn. Sage, London

Schuurman GW, Cole DN, Cravens AE, Covington S, Crausbay SD et al (2022) Navigating ecological transformation: resist–accept–direct as a path to a new resource management paradigm. Bioscience 72(1):16–29. https://doi.org/10.1093/biosci/biab067

Scoones I, Stirling A (2020) The politics of uncertainty: challenges of transformation. Routledge, London. https://doi.org/10.4324/9781003023845

Siders AR, Pierce L (2021) Deciding how to make climate change adaptation decisions. Curr Opin Environ Sustain 52:1–8. https://doi.org/10.1016/j.cosust.2021.03.017

Stanton MCB, Roelich K (2021) Decision making under deep uncertainties: a review of the applicability of methods in practice. Technol Forecast Soc Change 171(10):120939. https://doi.org/10.1016/j.techfore.2021.120939

State government of Victoria (2023) Murray-Darling Basin overview: the Murray-Darling Basin Plan aims to share water sustainably for the long-term health of the environment, community and industry, Department of Energy, Environment, and Climate Change, https://www.water.vic.gov.au/our-programs/murray-darling-basin/murray-darling-basin-plan. Accessed 18 Mar 2023

Stone-Jovicich S, Goldstein B. E, Brown K, Plummer R, Olsson P (2018) Expanding the contribution of the social sciences to social-ecological resilience research. Ecology and Society, 23(1). https://www.jstor.org/stable/26799031. Accessed 18 Mar 2023

Tan PL, Auty K (2017) Finding diamonds in the dust: community engagement in Murray-Darling Basin Planning. In: Hart, B. and Doolan, J. (eds), Decision making in water resources policy and management: an Australian perspective. Academic Press. https://doi.org/10.1016/B978-0-12-810523-8.00012-4

Taylor M (2021) Farmers shouldn't have to compete with solar companies for land: We better policies so everyone can benefit. The Conversation. https://theconversation.com/farmers-shouldnt-have-to-compete-with-solar-companies-for-land-we-need-better-policies-so-everyone-can-benefit-173333. Accessed 22 Feb 2023

Tuffield R, Long W (2019) Farmers slam controversial Victorian solar decision as 'gutless' with community concerns 'ignored'. The Australian Broadcasting Corporation. https://www.abc.net.au/news/2019-08-23/solar-farms-approved-goulburn-valley/11443774. Accessed 24 Feb 2023

van der Brugge R, Roosjen R (2015) Journal of Water and Climate Change 6(4):743–758. https://doi.org/10.2166/wcc.2015.001

Walker B, Abel N, Anderies J, Ryan P (2009) Resilience, adaptability, and transformability in the Goulburn-Broken Catchment Australia. Ecol Soc 14(1):284–294. https://doi.org/10.5751/ES-02824-140112

Walker B, Holling CS, Carpenter S, Kinzig A (2004) Resilience, adaptability and transformability in social-ecological systems. Ecol Soc 9(2). https://doi.org/10.5751/ES-00650-090205

Ward NK, Lynch AJ, Beever EA et al (2023) Reimagining large river management using the Resist–Accept–Direct (RAD) framework in the Upper Mississippi River. Ecol Process 12:48. https://doi.org/10.1186/s13717-023-00460-x

Wheeler SA, Zuo A, Bjornlund H (2014) Investigating the delayed on-farm consequences of selling water entitlements in the Murray-Darling Basin. Agric Water Manag 145:72–82. https://doi.org/10.1016/j.agwat.2013.10.015

Whittle L, Galeano D, Hughes N, Gupta M, Legg P et al (2020) Economic effects of water recovery in the Murray-Darling Basin. Department of Agriculture, Water and the Environment, Australia. https://doi.org/10.25814/5f43047c3ba0b

Williams JW (2021) RAD: a paradigm, shifting. Bioscience 72(1):13–15. https://doi.org/10.1093/biosci/biab123

Williams JW, Jackson ST (2007) Novel climates, no-analog communities, and ecological surprises. Front Ecol Environ 5:475–482. https://doi.org/10.1890/070037

Wyborn C, Dovers S (2014) Prescribing adaptiveness in agencies of the state. Glob Environ Chang 24(1):5–7. https://doi.org/10.1016/j.gloenvcha.2013.11.020

Wyborn C, Yung L, Murphy D, Williams D (2015) Situating adaptation: how governance challenges and perceptions of uncertainty influence adaptation in the Rocky Mountains. Reg Environ Change 15(4):669–682. https://doi.org/10.1007/s10113-014-0663-3

Wyborn C, van Kerkhoff L, Colloff M, Alexandra J, Olsson R (2023) The politics of adaptive governance: water reform, climate change, and First Nations' justice in Australia's Murray-Darling Basin. Ecol Soc 28(1). https://doi.org/10.5751/ES-13641-280104

Yin RK (2009) Case study research: design and methods. Thousand Oaks, CA, Sage. https://doi.org/10.33524/cjar.v14i1.73

Young JC, Rose D, Mumby H, Benitez-Capistros F, Derrick C et al (2018) A methodological guide to using and reporting on interviews in conservation science research. Methods Ecol Evol 9(1):10–19. https://doi.org/10.1111/2041-210X.12828