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Review

Evolving Governance and Contested Water Reforms in Australia's Murray Darling Basin

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Abstract: This paper explores the ways water governance adapts to changing social values and political imperatives by examining the case of water policy reforms in Australia's Murray Darling Basin. Over more than two decades, Australia's water reforms have explicitly aimed to promote ecological sustainability and economic efficiency, attempting to balance pro-market, micro-economic reforms with broader social and sustainability goals. Despite the formality of Australia's intergovernmental agreements, water reforms have been expensive and heavily contested, experiencing many implementation challenges. However, water market reforms have generally been regarded as successful, enabling the reallocation of water for environmental and extractive uses, contributing to flexibility and adaptive capacity. Recognising that discursive contestation is central to policy development, the paper documents the way the reform processes have attempted to broker compromises between three competing policy paradigms—national development, economic rationalism and environmentalism. These inherent tensions resulted in prolonged contests for influence over policy directions long after formal statements of policy intent by Governments. Given that climate change is driving the need for water governance reforms, the paper looks to what lessons can be learnt about the redesigns of meta-governance arrangements, including through structured commitments to independent audits and evaluations that can provide the feedback needed for adaptive governance and policy learning.

Keywords: water policy reform; irrigation; water markets; institutional re-design; enforcement innovation; climate adaptation; adaptive water governance; Murray Darling Basin; Australia

1. Introduction

Enhancing water governance is recognised as a global challenge, with increasing interest in water as a strategic resource, linked to health, food, security and economic growth [1]. Water resource management also has significant implications for conservation of biodiversity. With the escalating pressures and uncertainties induced by climate change amplifying these global challenges, institutional innovations are needed that enable more adaptive governance [2].

The Organisation for Economic Co-operation and Development (OECD) [3] defines water governance as "*the set of rules, practices, and processes through which decisions for the management of water resources and services are taken and implemented, and decision-makers are held accountable*". It claims that most water problems result from governance problems and that better governance can tackle problems at source. Therefore, it is useful to attempt to understand how and why water governance adapts within the wider processes of how societies evolve and governments function in terms of adopting and implementing policies, allocating resources and resolving conflicts. To this end, this paper examines Australia's water reforms in the Murray Darling Basin (MDB), which can be seen as experiments in adaptive governance.

Adaptive water governance is a fluid and evolving concept, hard to divorce from either conceptualisations of adaptive management or the politics and policy process of governments [4] because their legal powers enable the allocation and enforcement of rights to water resources [5]. Governance rules, practices and processes are institutionalised, but, like all politicised processes involving conflicts and their resolution, water governance regimes evolve in ways framed by laws and legal institutions, their socialised and cultural contexts and their philosophical underpinnings [5,6]. Therefore, while water governing occurs within established institutionalised processes of government and governmentality that embed logics, epistemologies and techniques [7], these adapt in response to changing circumstances and societal values that disrupt established practices and patterns.

One overriding disruption is climate change, providing an impetus for understanding adaptive governance [2,8]. This paper aims to contribute to this understanding by examining water governance in the MDB and how it has adapted to changing values, worldviews and prevailing political philosophies through processes of conflict and contestation expressed in policy narratives [9,10]. The MDB is a high profile case study being a major river basin whose governance has been focused on environmental management and restoration for over four decades. Such an examination is also timely because it is ten years since the dedicated national water legislation—the Water Act—was passed and five years since the first Basin Plan was gazetted in 2012 [11].

The paper is structured to illustrate how changing values and political philosophies have influenced the evolution of water governance in the MDB. Section 2 sketches a history of water resource development, profiling some of historical transitions and the dominant paradigms framing contemporary debates. Indigenous systems of water governance are beyond the scope of this paper but Australia's laws and public institutions are tentatively recognising these through native title claims and the formal exploration of cultural water [12–14].

Section 3 outlines how water policies adopted through the Council of Australian Governments (COAG) and the Commonwealth Water Act of 2007 have been important drivers of reform. These enabled water markets and environmental flows—two substantive shifts in water policies that had previously been orientated towards state sponsored and controlled water supply for irrigation [15]. Section 4 documents the evolution of water markets in the MDB. These enable more parties to determine where and how water is used, radically altering Australia's water laws which had defined all fresh water as state property [5,16].

Section 5 focuses on the need for feedback to inform governing outlining the importance of monitoring, auditing and evaluations in generating the feedback useful for adaptive governing and policy learning.

Finally, because water governance evolves via conflict and contestation, Section 6 examines the nature of inherent tensions in Australia's reforms. Overall, the paper concludes with the finding that adaptive water governance is a meta-governance challenge that requires institutional redesigns in order to handle the intensifying pressures on water management, including from climate change.

2. A Brief History of Australia's Water Resources Development

2.1. Colonial Foundations for Boosterism and Agrarianism

After observing the landscapes of the Blue mountains between Sydney and Bathurst on his travels in 1836, Charles Darwin noted that Australia could never become another great nation like America because, with its poor soils and climate, "*agriculture can never succeed on a very extended scale; therefore, so far as I can see, Australia must ultimately depend upon being the centre of commerce for the Southern Hemisphere and perhaps on her future manufactories*" [17] (p. 327). In the same year, explorer Thomas Mitchell [18] glowingly described "Australia Felix"—rich country suitable for abundant wheat crops with ample water for irrigation. These starkly contrasting assessments, albeit at different locations in Southern Australia, during the early Colonial period pre-empted persistent debates about Australia's agricultural

and irrigation potential that were to continue throughout the 20th century [19,20] and for northern Australia into the 21st century.

Cathcart [21] documents how an obsessive "water dreaming" started with British occupation in 1778 because, when compared with the colonist's former lives steeped in the dampness of Britain, Australia was dry, dangerous and disappointing [21]. A comprehensive analysis of the nation's official lexicon [22] reveals prevailing conceptions of Australia as a "default" country remains firmly embedded in the body politic, with the country seen as dry and disappointing demanding "drought proofing". Through ambitious engineering schemes water was pressed into the service of colonial development [23]. However, there were dissenters with policy debates about whether environmental and climatic constraints should be accepted or overcome through ambitious national investments in large-scale irrigation [24]. In the period between the First and Second World Wars, Griffith Taylor countered governments' vigorous promotion of inland settlements with arguments that extremes of heat, punishing droughts and aridity represented insurmountable limits to European style production over large areas of Australia [19]. With remarkable prescience, he predicted that the majority of Australia's population would eventually live close to the coast where conditions favour settlement [19]. However, despite being a brilliant geographer, he was ruthlessly persecuted for publicly criticising Governments' policies on inland settlement, until he left the country [24].

Plans for expanding irrigation across northern Australia—despite poor soils, extreme climates and lack of infrastructure—have reignited similar debates in the first decades of the 21st century. This can be seen as an obstinate struggle between two conflicting paradigms. National development or "boosterism" sees a cornucopia of resources awaiting exploitation [25] while others have argued that climatic and ecological conditions fundamentally constrain European style development patterns [23,24].

Throughout the 20th century boosterism dominated Australia's water policies. Due to an alignment of prevailing ideologies and technologies [26], most rivers in Southern and Eastern Australia, including in the MDB, were dammed at the nation's expense to supply irrigation (see Figure 1). While irrigation secures agricultural production in a variable climate, these impressive water storages are more than pragmatic responses to a variable climate. Large dams provide potent symbols of the modern state [27] satisfying dreams of taming rivers, greening deserts and making land productive that run deep in the nation's psyche [23]. Irrigation development was enabled by technology but driven by ideals of progress, agrarianism and national development [23,28].

2.2. Early Irrigation Development and the Victorian Irrigation Act

Starting in the 1880s, state governments developed irrigation in distinctly Australian ways [15]. Investigations of irrigation in the USA convinced the young Victorian politician, Alfred Deakin of the necessity for active state interventions, including taking control of water resources before the vested interests of commercial irrigators became too entrenched. The Victorian Irrigation Act of 1886 gave legislative effect to his ideas that "*the state should exercise the supreme control of ownership over all rivers, lakes, streams and sources of water supply*" [29] (p. 114). The Victorian Act became the foundation of Australian water law, partly dispensing with the British "riparian doctrine" under which land titles adjoining streams granted rights over the water within the stream [5]. As the owner of all water, states granted "water rights" to develop irrigation [30]. These were attached to land titles until late in the 20th century, when, consistent with prevailing market orientated political ideologies [5] governments created tradable titles to water, effectively "privatising" publicly owned water resources.

Building on Deakin's interventionist approach, state governments began developing irrigation systems after privately developed schemes struggled financially in the 1890s [29]. Across the MDB, vast irrigation networks were developed to promote rural development [31] with many used for government sponsored, soldier settlement schemes for returned servicemen after the First World War. These were motivated by agrarian ideals of rural livelihoods combined with political opportunism—the ruling classes feared that disaffected, unemployed former servicemen, under the influence of communists and union agitators would ferment revolution [28]. The soldier settlement schemes

provided opportunities to disperse many to small farms where most struggled and many failed [28]. While individual farms failed, irrigation became the dominant users of water resources engendering many productive industries and rural settlements with its intensive and reliable production [31].

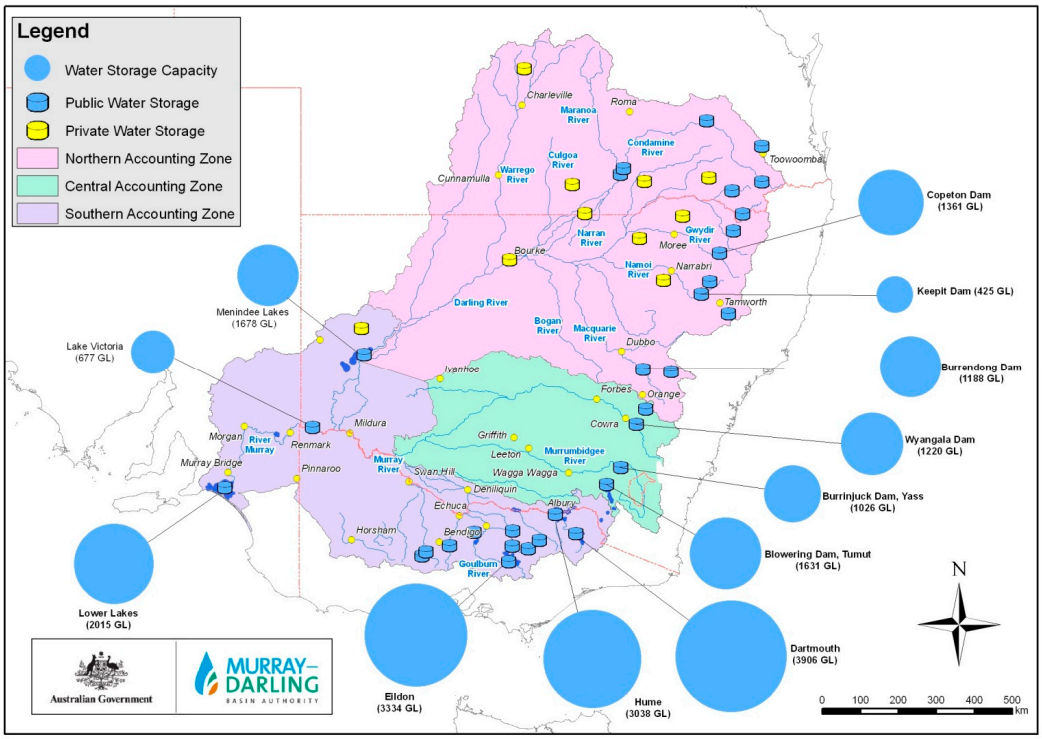

Figure 1. Map of major water storages in the Murray Darling Basin (MDB) indicating major dams on the majority of rivers [32].

2.3. Public Policy and Societal Change in Values

By the 1990s, the serious environmental problems of irrigation became more widely recognised. Successive national reviews highlighted the ecological and economic consequences of major salinity and water quality problems and the lack of environmental flows degrading rivers and wetlands [33]. Continuing large-scale environmental degradation was unacceptable to most Australians. A profound community desire for more sustainable management of the continent engendered a new generation of policies focused on sustainability. Legislation, statutory plans and other policy documents charted new directions that routinely defined societal objectives in terms of sustainable development and the conservation of biodiversity, ecosystems and natural resources [25].

These changes can be traced to the 1980s, when against a backdrop of global anxieties about an emerging ecological crisis, Australian politics recognised emerging environmental values. The planned Franklin Dam in Tasmania became a highly charged symbol of unwanted destruction, mobilising intense community opposition through well organised environmental activism that highlighted ecological values of waterways and the narrow instrumentalist treatment in economic development policies [21]. Public policies also shifted in response to community concerns about land and water degradation in rural areas. Australian governments committed to conserving and restoring landscapes, building on an emerging landcare ethos that engaged communities as partners in natural resource co-management [34]. Landcare was widely supported in rural Australia, and enthused communities, influenced public policies and the activities of countless local networks of farmers and conservationists [34]. Politically savvy and pragmatic alliances between environmental and farmer groups successfully promoted Landcare to governments resulting in support being formalised in 1989,

when Prime Minister Hawke launched the Decade of Landcare at the confluence of the Darling and the Murray Rivers [34].

Australia's transitions also reflected global trends. Sustainable development was adopted internationally with its fertile ambiguity and alluring ambitions of integrating social, environmental and economic development [9,35]. Water policies gave sectoral expression to sustainability aspirations, with catchments successfully promoted as the preferred spatial unit for integrated resource management [27,36].

After a century-long development phase—with governments building water infrastructure to foster economic development—sustainable development ideals found expression in Australia's 1994 Water Reform Agreement. After a century of nation building that involved taming rivers, the emergence of ideals of conserving and restoring rivers indicated that changing community values were reshaping the policy agenda, even if institutionalised logics that underlay governance processes remained largely intact [6]. This shift reinforces the idea that changing community values are key drivers for changes in governance regimes.

3. Australia's Water Policy Reforms

3.1. Introducing Co-Operative Federalism and the COAG Water Reforms

Australia's water governance is nested within a system of co-operative federalism. States hold the majority of responsibilities and legal powers over natural resources, while the Commonwealth has the majority of taxing power and responsibility for international relations, including International Treaties [5]. Inter-jurisdictional structures, such as Ministerial Councils and the Council of Australian Governments (COAG), are used to enhance coordination [15].

In the COAG Water Reform Agreement of 1994 Australia's governments formally agreed to water reforms as part of wider micro-economic reforms [37]. Aligned with dominant political philosophies of economic rationalism [38] governments agreed to greater financial accountability, including ending subsidies and rationalizing expenditure, introducing user pays and establishing water markets. They also committed to improving water quality and other ecological outcomes by providing environmental flows for all rivers based on best available science [6,39].

A decade later, in 2004, Australian Governments agreed to the National Water Initiative (NWI) recommitted to the COAG reform agenda articulating their aims of increasing productivity, sustainability and efficiency of water use and improving the health of aquatic systems through addressing over-allocation and providing environmental flows. As in the earlier COAG Agreement, governments aimed to improve water security and enable efficient water markets [15]. These high-level policy frameworks laid out broad aspirational goals that were of particular relevance to the MDB where water laws and administration had evolved separately in each jurisdiction.

3.2. The Murray Darling Basin—Wetlands and Environmental Water Needs

Geographic scale and institutional complexity contribute to the difficulty of managing the MDB. Spanning five jurisdictions, the MDB covers approximately 15 per cent of Australia extending about 1250 km east to west and about 1360 km north to south. Over two million people live in the Basin and a further million beyond it rely on its water resources. The MDB produces approximately two-thirds of the value of Australia's irrigated agriculture and approximately 40 per cent of Australia's total gross value of agricultural production, including dryland crops and livestock. The southern Basin has the majority of irrigated agriculture from large government owned storages generally managed by statutory irrigation corporations (see Figure 1).

With the majority of the Basin in the Mediterranean and semi-arid climatic zones, it is estimated that 94% of precipitation is returned to the atmosphere as evapotranspiration with the remaining 6% forming the many thousands of kilometres of flat "lazy" rivers and creeks, snaking across wide, flat plains [40]. These flood episodically nourishing floodplains, woodlands and wetlands, bringing

an explosion of life to the inland [41]. An estimated 30,000 semi-contiguous floodplain wetlands cover over 6.3 million hectares (see Figure 2). Most are dependent on water for which there is intense competition from agricultural production, especially during droughts. The rivers and their floodplains have high cultural and conservation value, with sixteen larger wetlands recognised under the Ramsar Treaty, but until recent decades few had secure water supplies [42]. Floodplain and wetland condition is influenced by flood frequency, duration and timing with irrigation extractions degrading the majority of the Basin's wetlands through altering flood size and frequency [41,42]. While all Australian Governments committed to environmental flows, based on best available science in 1994, progress on achieving this was slow until the Commonwealth Government intervened with the Water Act reforms of 2007 [6]. Floodplain and other wetlands are particularly stressed during dry climate phases, like the Millennium drought when the majority of water was used for irrigation.

Water, while vitally important, is not the only factor affecting wetland health, with most threatened by climate change and also degraded by over grazing, feral animals and weeds [41] thus land managers play core roles in their management and conservation. Therefore, the management, restoration and conservation of the riverine ecosystems across the MDB depends on cooperation between governments and communities in processes described as adaptive co-management [4,43,44]. Thus, adaptive water governance requires the application of the principles of subsidiarity so that arrangements align and function across multiple scales from farms and local wetlands to major irrigation schemes and transboundary basins [43,44].

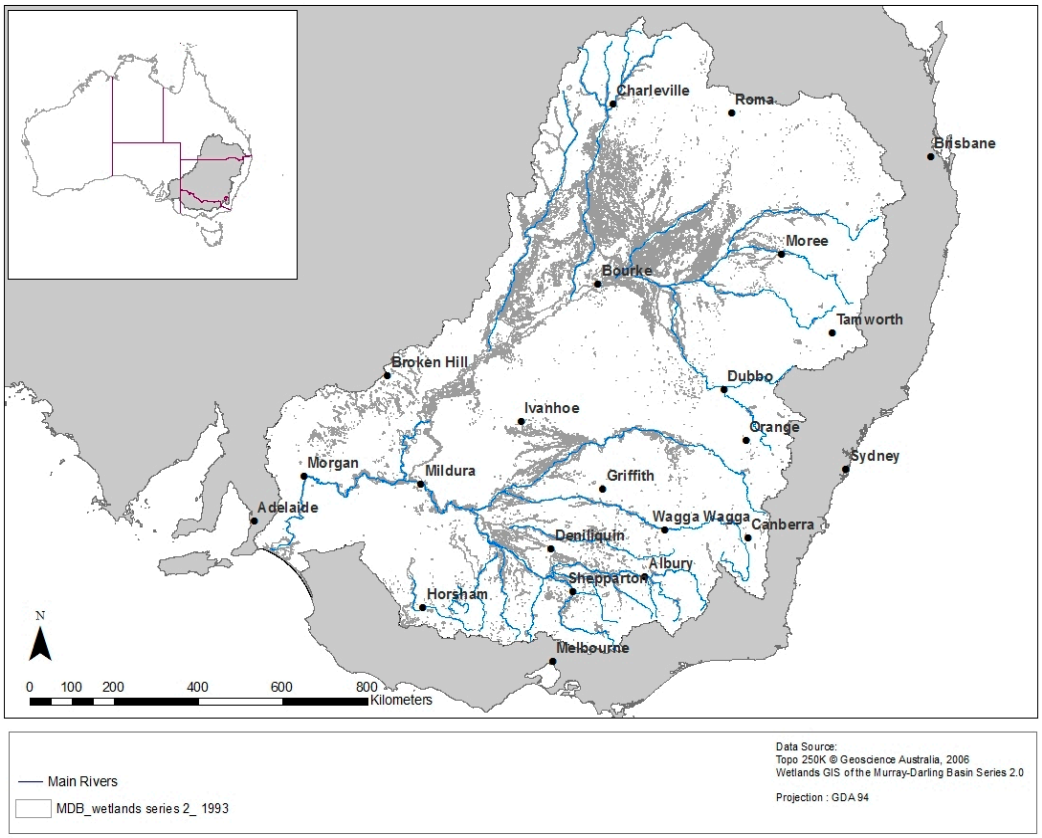

Figure 2. Major rivers and the extent of floodplain wetlands in the MDB [45].

3.3. Water Reform Implementation Challenges

Despite two formal national agreements, many water reforms proved to be highly contested and difficult to implement, encountering significant opposition that resulted in slow progress on critical commitments, particularly achieving environmental flows and redressing over allocation [6,44,46].

For example, in both agreements it was agreed that statutory water plans would delineate the respective shares between extractive and environmental uses within defined hydrological systems, usually a river catchment (see Figure 3). In these statutory water plans extraction rates were to be set below "sustainable" limits. However, whilst negotiating the NWI, New South Wales (NSW)—the largest state in the MDB—flouted commitments made in the previous COAG reform agreement by locking in existing water plans for a further 15 years [15]. This appears to have been an example of blatant and duplicitous "gaming" of the COAG process because these plans had patently not addressed over-extraction or ensured adequate environmental flows [15].

Furthermore, statutory water planning shifted responsibility for resolving complex water policy issues to an administratively complex, bureaucratic and technical processes that embedded hydrology as the primary discipline [47]. The planning processes used participatory negotiations that empowered well-informed, irrigation interests [6]. Technically water planning depended on historic stream-flow measurements and hydrological models run by water resource agencies that had limited experience in dispute resolution [5], or knowledge of systematic conservation planning [48] for floodplain, wetlands and aquatic ecosystems, despite biodiversity conservation objectives mandated in legislation. After two formal agreements, slow progress on many key dimensions of water reform gave the appearance that the process had stalled [15].

3.4. The Murray Darling Basin Reforms—The Third Wave of Australian Adaptive Water Governance Reforms

In 2007, after a decade of drought, Australia adopted its third national water reform with the gazetting of the first national Water Act [11]. Slow implementation of environmental flow policies by the state governments and fears of a looming environmental crisis in the MDB including in the Ramsar listed Lower Murray Lakes [49] provided a trigger for Commonwealth intervention.

The Commonwealth Water Act continued the broad trajectory of the COAG reforms, but it also marked some significant shifts, particularly the increased use of Commonwealth power and money. The Commonwealth Water Act of 2007 aimed to optimise social, economic and environmental outcomes with specific objectives to restore riverine ecosystems and their capacity to deliver ecosystem services and to give effect to international agreements on wetlands (the Ramsar Treaty) and biodiversity conservation. It was accompanied by the AU$13.4 billion Water for the Future Program to be used to address over allocation through upgrading infrastructure and purchasing extractive water rights that would be held by the newly established statutory office, the Commonwealth Environmental Water Holder (CEWH) for provision of environmental water [11].

The Water Act built on nearly 100 years of intergovernmental agreements for the Murray River that had partially resolved intense debates about water politics between the States. Agreed to in 1902, but formalized in 1914, the Murray River Agreement specified water sharing, navigation rights and responsibilities for shared works. It was superseded in 1987 by the Murray-Darling Basin Agreement that established a consensus governance framework for the "effective planning and management for equitable, efficient and sustainable use of land, water and other environmental resources" [15].

The Water Act (Commonwealth 2007) established the Murray Darling Basin Authority (MDBA) as a Commonwealth agency with new powers and functions. These included a Basin Plan that sets limits on extractions (a "sustainable diversion limit"), and specifies environmental watering plans and water market rules [11]. The Basin Plan requires consistent Water Resource Plans for all water resources within the basin (see Figure 3).

The Water Act (Commonwealth 2007) legitimised all state water resource plans. This had the effect that statutory plans enable previous levels of extraction to remain in force until these plans are revised (with most in force until or beyond 2019). However, the Commonwealth reduced consumptive use by acquiring approximately 20% of state issued water rights—through outright purchase of entitlements or through investment in water efficiency measures—reallocating these for environmental use [6]. These water rights are held by the CEWH in Australia's largest portfolio of water rights. This changes water governance fundamentally, with the Commonwealth Government the largest

holder of entitlements while also influencing water policy through it legislative and expenditure programs. However, like any government policies, those supporting environmental watering are vulnerable to change unless they have strong public and political support. For example, irrigation groups' opposition to further purchase of extractive rights resulted in the Commonwealth purchases being limited by legislative reforms in 2015. These groups had been vocal in opposing the Basin Plan throughout its development and continued to exert influence as demonstrated by the legislation that placed a 1500 gigalitre limit on recovering of environmental water through direct buy-backs even though these were the most cost effect measure [6].

Figure 3. Surface water resource plan areas as defined by the MDB Plan [50].

3.5. Preparing for Climate Change—Risks, Models and Future Directions

Preparing for the prospects of climate change was only breifly referred to in the COAG water reform agreement, but by 2007, at the height of the Millennium Drought it provided as one of the

main justifications for the Water Act [39]. Under the Act, the Basin Plan is required to assess risks and prepare for climate change [39].

The majority of climate models predict reduced rainfall and runoff in the MDB [51]. There are multiple lines of evidence indicating that tropical influences on weather systems are expanding southward and the southern storm tracks that historically brought cool season rains to southern Australia are also contracting pole-ward. These factors are likely to change the amount, seasonality and reliability of rainfall, with episodic large floods punctuating longer periods of drier conditions likely for southern Australia [39].

As this science became more conclusive, in both 2008 and 2010 Commonwealth Scientific and Industrial Research Organisation (CSIRO) cautioned that it was prudent to plan for drier futures in South Eastern Australia and reduced water availability in the MDB [51]. This warning raises several substantive questions: What enables planning for deeply uncertain futures if past climatic and hydrological conditions are no longer suitable guides to future conditions? With stationary approaches to hydrology redundant, what flexible approaches can be used to explore uncertain futures [52]?

Uncertainty about future climates and their hydrological and ecological impacts requires a range of adaptive responses including on-going systemic risk assessment. Systemic assessments of climate, water resources and catchment processes are required, but reliance on historic water availability and modelled averages may be mal-adaptive, particularly if step changes result in major changes to run-off and stream flow. With the uncertainty induced by climate change questions of how to better handle risk across a range of uncertainty becomes paramount. Scenario planning offers techniques that can accommodate a range of uncertainties enabling consideration of how to confer adaptive capacity [53]. However, despite comprehensive modelling, the 2012 Basin Plan made no specific reduction in estimates of long term water availability [54], so future arrangements for managing variations in water availability will need to build on existing adaptive mechanisms that include flexible allocation systems, periodic revision of water plans and water markets [39,54]. These specific mechanisms operate within larger frameworks of adaptive governance that need to be capable of policy and institutional innovations including incorporating changing knowledge about the climate [55,56].

3.6. Infrastructure Renewals and Water Buy Backs

The Millennium Drought (1996–2010) intensified fears about water security and climate vulnerability. Concerns escalated that the drought indicated a step-change in the climate. The idea of climate proofing water supplies was used to justify constructing desalination plants for most Australian cities and to promote the virtues of water saving infrastructure. Crase et al. [37] claim that during the drought the focus of water policy shifted from ecological and economic accountability to politically expedient engineering solutions that suited vested interests. Crase et al. argued that rent seeking in pursuit of public subsidies for "water saving" infrastructure subverted the COAG policies, despite prominent warnings that rebuilding irrigation channels was remaking in steel and concrete mistakes originally made in clay and sand. The subsidised refurbishment of infrastructure supported irrigators in established channelized districts, relieving them of the prospect of user pays policies being fully applied to the cost of infrastructure maintenance and renewal [37]. These infrastructure subsidies also provided a politically acceptable way of bribing the states to agree to the increase in Commonwealth power and influence in the affairs of the MDB. If they had been intended to buy irrigator support for the reforms this did not work, resulting in protracted, outspoken opposition from irrigation groups to the reallocation of water to the environment, even though this has been achieved via on-market purchases of water rights or through Government provision of infrastructure. Establishing tradable rights and water markets facilitated the on-market purchase of water rights as a means of the reallocation of water rights to the environment. This was only possible because water market reforms had progressed sufficiently, such that during the height of the drought the market functioned, supporting adjustment, accelerating structural changes and enabling water to

move between uses and users, sustaining environmental, urban and horticulture areas during a period of intense scarcity [57].

4. The Evolution of Water Markets in the Murray Darling Basin (MDB)

4.1. Water Trading for Irrigation

Australian governments' water allocation regimes aim to control water use by licensing diversions. These aim to maintain security for entitlement holders and limit damage to riverine ecosystems, protecting private capital of irrigation farms and public assets like urban water supplies, water quality, rivers and wetlands. Governments committed to introduce water trading in the COAG Agreement of 1994. This required water entitlements to be separated from land titles so irrigators could trade water independently of land, either permanently or temporarily [5]. The NWI reaffirmed commitments to water market reforms and to enable trading between districts and States. This was given further legislative backing by the Commonwealth's Water Act and the MDB Plan [58].

Water markets in the MDB are a cap and trade system with zones that demarcate where water can be traded (see Figure 4). A cap on surface water diversion was imposed in 1995 to limit growth in extractions and inter-jurisdictional arrangements for interstate water markets evolved cooperatively between jurisdictions [59]. Developing capacity to trade water across the three MDB States that share the Murray River—NSW, Victoria and South Australia—was challenging due to each State having separate water law and administration. A tristate water market pilot ran from July 1998 to May 2006 with expanded interstate water trade permitted after 1 July 2006 [59,60]. Interstate water trade increased rapidly following this decision due the limited water availability [61]. A further complication is that water rights are not uniform with many types of licences. These are generally structured so that entitlements define "rights" to a share of a water resource against which seasonal amounts are allocated. Depending on the entitlement's security class and the water available, annual allocations can vary from 0% to over 200% of the "notional" amount of an entitlement. Entitlements trades are defined as permanent trades while allocation trades are temporary.

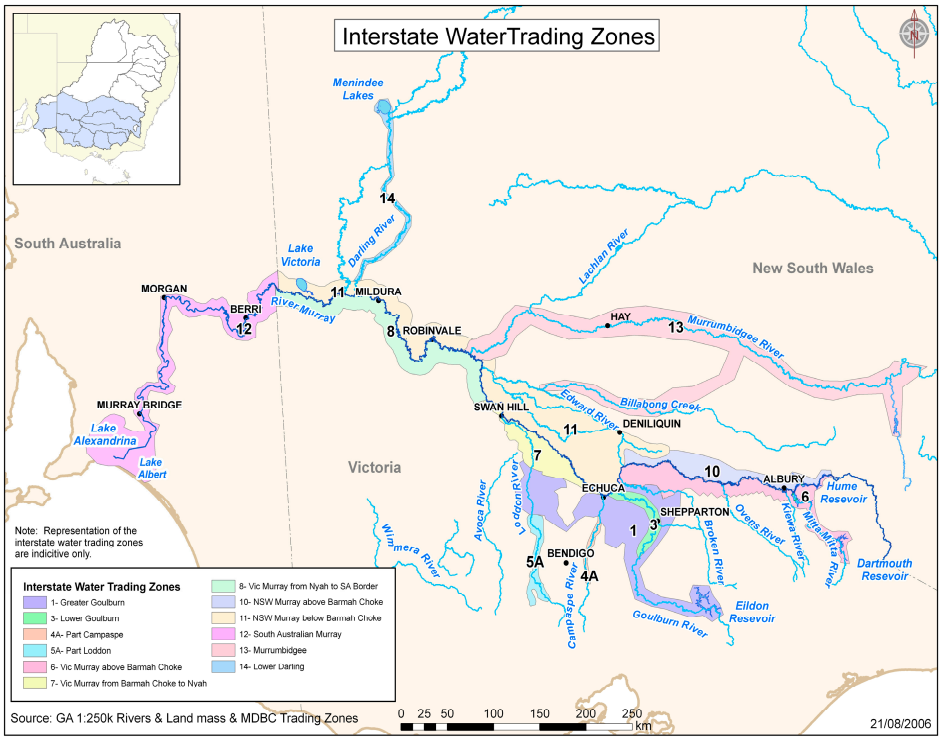

Figure 4. Map of the Murray Darling Basin Southern Basin interstate water trading zones [59].

Water markets have enabled irrigators to adjust to variable seasonal conditions by opting to buy water, or sell or lease water to optimise crop, risk and business planning. The market value and availability of water, crop demands, and relative values of prospective crops influence these decisions [60].

Irrigation in the MDB is vulnerable to changes in water availability driven by climate variations. During the lowest allocation years of the Millennium Drought (2006–2009) water markets enabled scarce water to be the reallocated, providing flexibility for both irrigators and environmental managers. Examples included the first temporary environmental water traded to sustain a bird-breeding event in the Ramsar listed, Narran Lakes [60]. During the 2007–2008 water season, unprecedented amounts of water were traded with over 40% of the water used for irrigation traded in the three Southern Basin states [59]. During 2008–2009, this trend continued with over 50% of water used traded. The volumes traded and prices paid for water have varied substantially depending on levels of scarcity. Based on assessments of prices and gross margins of crops, the majority of water traded was used to enable production and survival of capital-intensive orchards and vineyards [61]. Thus, the market contributed to economically efficient water use during a period of extremely low irrigation allocations between 2006 and 2009. If governments had not started implementing reform policies a decade earlier, this would not have been achieved.

Analysis undertaken by the Murray Darling Basin Commission (MDBC) identified that by 2008 over 32,000 hectares of new irrigated orchards and vineyards had been established on green-fields sites using entitlements traded out of established irrigation districts [60]. To enable better economies of scale former dryland farms were converted to irrigation using privately built infrastructure to supply irrigation water up to 14 km from water sources, mostly rivers [60]. Government subsidies for infrastructure refurbishment have favoured established irrigation systems by lowering capital and maintenance cost there, despite evidence that the majority of private sector investment in new irrigation enabled by trade has gone into green field sites. This raises questions about the rationales for government funding infrastructure refurbishment in established irrigation areas when adoption of user pays principles, coupled with water markets would have enabled the private sector to make rational investment decisions as to where it is economical to irrigate.

In summary, market mechanisms for reallocating water proved to be important for adaptation, helping to optimize water use decisions, supporting increased economic productivity, risk management and longer and short-term adjustment in the irrigation sector [57,61]. Water markets demonstrated that dispersed allocation decisions complemented state centric water planning and while the impacts of water markets are generally regarded as positive, a number of concerns have emerged about the impact of water markets on downstream users and riverine environment in some rivers [11].

4.2. Cross Sector Trade and Flexible Adaptation

The water markets that enabled adjustment in the irrigation sector also enabled major reallocations from irrigation to environmental use and increased security of urban water supplies. For example, Adelaide purchased water to reduce drought impacts and in central Victoria, the urban water authority, Coliban Water, purchased irrigation entitlements to secure water supply for regional cities like Bendigo. This portfolio is managed primarily to ensure reliable urban supplies; however, surplus annual allocations are sold temporarily for irrigation [62].

The Australian Government used the water market to purchase entitlements, contributing to the 20% of MDB entitlements held as environmental water [6]. The CEWH holds over 2.6 million megalitres of entitlements that provide an average annual yield of 1.8 million megalitres [63]. This is a substantial and valuable portfolio. In 2017 the Commonwealth's Productivity Commission [64] estimated the capital value of Southern Basin entitlements (about 80% of all water rights) at AU$13 billon, which coincidently is roughly the amount the Commonwealth committed to addressing chronic over allocation in 2007.

Water markets provide some useful adaptation measures in the face of uncertainty induced by climate change. Markets mechanisms deliver flexibility by dispersing water governance decisions amongst businesses and environmental managers allowing market participants to manage risks [57] They enable reallocation between crop types and from established irrigation districts to new areas. Experience during drought demonstrated that water markets supported dynamic adjustment in periods of water scarcity with trading of large volumes continuing after the drought ended at significantly lower prices. However, markets generate a range of potential risks including insider trading, gaming, monopolization, manipulation, inadequate enforcement and corruption [65,66]). Reliance on market mechanisms cannot overcome the need for sound water governance processes, including the resource planning and enforcement delivered by Governments. Within appropriate policy settings and regulatory frameworks, markets contribute to adaptation, enabling increased flexibility. However, to avoid perverse outcomes careful design and implementation of market-based reforms is needed. In addition, innovative monitoring and enforcement regimes are needed to cover the more dynamic characteristics of resource use [65].

5. Critical Assessments, Independent Monitoring, Effective Enforcement

In November 2017, the Wentworth Group of Concerned Scientists released its review of MDB reforms in the "first independent and comprehensive review of the Basin Plan" that evaluates "progress towards the social, environmental and economic objectives" [11]. This comprehensive evaluation finds some substantive progress—particularly for water markets and the provision of environmental water—but also identifies a tendency towards institutional inertia since the gazetting of the Basin Plan in 2012. The Wentworth Group's review emphasises concerns raised in the national media about accusations of water theft, chronic lack of enforcement, suspected corruption and alleged cover-ups that highlight the way Government agencies can become captured by vested interests [11]. These scandals cast serious doubt about the likely success of reforms, and demonstrate the need for systemic evaluations, independent audits, and adequate monitoring, and enforcement [11]. Accountability regimes need mechanisms nested across agencies and scales because of the large temporal and spatial scales involved and the institutional complexity of the Basin [32]. While broad national assessments can assist in tracking progress and contribute to policy development these need to be supported by local scale intelligence and compliance measures [65].

The Wentworth Group raised profound concerns about inadequate compliance and enforcement regimes and the conflicted roles of water agencies [11]. Government's ability to deliver reforms is routinely compromised by entrenched pressures from vested interests, institutionalised logics and inertia or lack of capacity in agencies [6]. These constraints are exacerbated by under resourcing of monitoring and enforcement programs and the lack of consistent, efficient and cost effective methods of auditing water extractions [65].

Enhanced enforcement regimes are needed to restore confidence in governance arrangements, but effectively regulating water use is problematic given that thousands of licenced irrigators, extract water from surface flows, groundwater and rivers and can also trade water [65]. In response to this challenge the modernization of the monitoring and enforcement systems has been proposed using annual water-use declarations—similar to tax returns—that are verified using satellite data of areas irrigated [65].

There is little point in elegant policies and detailed plans without a corresponding ability to determine whether they are given effect in practice. Despite repeated commitments to independent monitoring and evaluation Governments repeatedly constrain these functions including through budgets cuts. Abolition of programs or agencies with independent evaluations and audits functions may be due to concern about scrutiny. For example, the National Water Commission (NWC) was established to audit progress on the NWI water reforms but was abolished in 2014 [11]. Similarly, governments terminated the Sustainable Rivers Audit in 2012, ending the only long-term basin-wide

scientific assessment of riverine ecosystem leaving the future of ecosystem monitoring uncertain despite the Water Act mandating monitoring and evaluation [11].

Water governance systems need the oversight of rigorous monitoring and evaluations that can support accountability and policy learning. To inform adaptive learning evaluations of policies and programs need to be able to attribute causality [4]. Well-designed and nested accountability measures can contribute to the systemic, holistic and integrated assessments needed to support adaptive capacity in socio-ecological systems [67] but Australia's experience underlines the need for structural commitments to independent and credible oversight functions.

6. Policy Contests and Resistance to the Reforms

For several decades, water reforms have been heavily contested. Despite the formality of Australia's COAG reform agreements, these have not guaranteed success with progress on some key commitments disappointing [11]. The costs of environmental water reforms have been estimated to have exceeded $20 billion [6]. Connell [46] claims repeated failures of MDB reforms indicate deeply institutionalised settings inherently resistant to change. He claims vested interests appropriated key concepts affecting outcomes. Countering this, other have proposed that consistent, gradual progress has been achieved, citing the many of the same examples that Connell claims failed as evidence of moderate success, attributing key reform successes to the Commonwealth's interventions [58,68]. In contrast, Crase et al. [37] claims that rent seeking by powerful vested interests subverted reforms by lobbying successfully for infrastructure subsidies. This aligns with overseas studies highlighting the sector's ability to appropriate reforms, whilst retaining its construction orientation and "command-and-control" modalities [69].

The highly contested and conflictual nature of water reforms led the Australian Public Service Commission to define water policy reforms as a "wicked problem"—systemic, persistent and resistant to simple solutions because of conflicting policy positions between pro-irrigation and environmental interests [6]. However, defining water reform as a "wicked problem" raises significant questions about governments' ability to deliver public interest reforms. Tingle [70] claims systemic policy failures are symptomatic of a deeper malaise of modern Australian governments describing a paralyzing policy amnesia. The factors that caused this condition include the endemic fear of risk taking in a public service gutted by corporatised, new-public management and the dominance of economic rationalism [70]. However, the multi-billion dollar subsidies for irrigation infrastructure indicate that the irrigation sector has been immunized against stringent forms of economic rationalism and insulated from the strictures of government ideologies that imposed user pays on many other sectors. An alternative analysis is required.

Attempting to modernise established water governance institutions involved complex, multi-layered policies with fundamental tensions in terms of conflicting values, rationalities and imperatives [71]. Extended and politicised processes of resolving these tensions enabled powerful vested interests to lobby for the modification of reform principles [37]. Government subsidies flowed to the irrigation sector due to asymmetric power relations and political influence that enabled it to capture natural and financial resources in ways that contradicted commitments to adopt economically rational policies and apply user-pays and full cost recovery principles [6]. These political decisions appealed to popular national ideals about the virtues of agrarianism and irrigation [6,72].

Therefore, the inherent tensions in Australia's water reforms arise from the contestation of fundamentally conflicting and competing paradigms: firstly, the established national development paradigm (described as boosterism in Section 2); secondly, the economic rationalist paradigms that sought to introduce water markets and reduce subsidies that has dominated most policy processes of Australian governments [38]; and, thirdly, the environmentalist or moderate ecological paradigms [73] which sought to conserve and restore rivers via reforms about environmental flows.

Contemporary Australian water governance conflicts result from the tensions of attempting to incorporate and broker compromises that accommodate all three paradigms. As a result, the contests

for influence over policy directions continue well after the formal statements of policy intent by Government. Each water resource planning process has become a theatre for these conflicts, a forum for attempting to resolve complex and contradictory policies, whether at the regional or at the Basin scale [71]. Across multiple scales policy or discourse coalitions attempt to steer policy choices and influence directions through processes of discursive contestation using political symbolism within multifaceted power relationships [7,9]. Hajer [73] states that it is the nature of discourse coalitions to refashion concepts to suit specific political ideologies while ecological modernisation supports the internalisation of moderate ecological agendas by established institutions, reinforcing their power [73].

Affected parties who may stand to lose in terms of influence, legitimacy or financially, actively resist major reforms. Importantly this includes senior decision makers who are mindful of their professional and reputational risks [74]. Further, the amnesia afflicting policy agencies seriously constrains adaptive governance and policy leaning [70]. There is an over-arching need to establish functional meta-governance arrangements because multiple agencies, overlapping responsibilities and institutional inertia tend to make responsibilities for reforms opaque [75].

7. Conclusions

The progress of reforms in the MDB provides a high profile case study with wider relevance to water governance. This paper examines how changing community values, knowledge and political philosophies—as expressed in laws and public policy—have driven adaptation in water governance in Australia's MDB. This examination offers several insights into the multifaceted societal challenges involved in reforming water institutions that are pertinent to adaptive governance.

Firstly, established policy settings embed institutionalised logics, framings and values that exert substantial power to restrain reforms. The difficultly and expense of introducing environmental water reforms in the Basin demonstrate the powers of incumbent policy settings. In the COAG water reform agreements of 1994, there were unequivocal statements of political support for increasing environmental flows, but slow progress on this indicates that effective reforms were heavily constrained, until the Commonwealth intervened in 2007. This illustrates that broad statements of policy intent are insufficient without also attending to the design and delivery of effective implementation pathways.

Secondly, robust reform architecture needs to be built on solid foundations. Australia's attempt to modernise established water institutions involved complex, multi-layered policies. These embedded inherent tensions arising from three conflicting policy paradigms—defined in this paper as boosterism (or national development), economic rationalism and environmentalism or moderate ecological paradigms. Due to the unresolved tensions politicised contestations continued throughout water planning processes at the regional and basin scale. These became forums for attempting to resolve complex and contradictory policies. In extended contests over policy directions, powerful vested interests successfully lobbied for the modification of reform principles. This enabled the irrigation sector to capture substantial subsidies for infrastructure refurbishment, even though provision of these subsidies contradicted agreed policies on application of user-pays and full-cost recovery principles. However, provision of these subsidies largely failed to garner political support for environmental water reforms.

Thirdly, it is to be expected that major reforms encounter opposition and resistance. Discursive contestations are to be anticipated for reforms that alter access to resources, change established power relations or undermine orthodoxies about human relationships to nature. The MDB reforms encountered multiple challenges from commercial, ideological and bureaucratic interests. These ensured slow, difficult and deeply contested processes of reform, although eventually progress on both environmental flows and water markets was achieved. Even though introducing water markets required fundamental redefining water property rights, these reforms proceeded because they aligned with dominant political philosophies about the virtues of markets. In contrast, environmental water reforms encountered more sustained and effective opposition. The prospects of well-orchestrated

opposition to reforms emphasises the importance of building sustained public and political support. This includes developing strong narratives about wider public benefits because it is the nature of discourse coalitions to refashion narratives and redefine terms in order to influence decisions and policy agendas.

Fourthly, this analysis highlights matters of institutional learning and professional capacity within water agencies. For example, planning for environmental watering highlights the need for expertise in riverine ecology and systematic conservation planning. Likewise, climate change is driving new challenges requiring professional and institutional capacity for adaptive responses.

Finally, the MDB reforms demonstrate that adaptive water governance is a meta-governance challenge. Alignment is needed between macro-scale reforms, like those that occur in the political and legislative domain, with more routine governance functions, like those ensuring adequate compliance and enforcement. Australia's experience underlines the importance of structured commitments to independent and credible oversight. This is needed because institutional complexity and multiple agencies with overlapping functions can obscure responsibilities. Effective oversight requires rigorous monitoring and evaluation to support accountability and policy learning. Therefore, there is value in carefully structuring independent oversight roles that provide informed assessments of progress, or lack of it, towards agreed reforms.

Oversight roles are an important element in the architecture of reforms, but as argued above, institutional redesigns are needed that enable functional meta-governance. Investigating how to design and implement institutional reforms to enable adaptive water governance provides a relevant focus for further research. Undertaken in conjunction with water users, managers and policy agencies, this research could aim to design context specific, feasible and effective reforms that increase the prospects of successful transitions to more adaptive governing.

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