CHAPTER

1 WATER RESOURCE POLICY, PLANNING AND MANAGEMENT IN AUSTRALIA—AN OVERVIEW

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CHAPTER OUTLINE

INTRODUCTION

Australia is the driest inhabited continent in the world. It is renowned for its highly variable climate, with a history of recurrent droughts often punctuated by large floods. The long, dry periods have always been a major challenge for communities and governments as they sought to develop and use the nation's water resources to provide secure water supplies for cities and towns and promote economic growth.

Australia is a federation of six states and two major territories. Under the Australian Constitution, state and territory governments have responsibility for land and water management. Water in Australia is owned by the Crown and its management is vested in state governments. The Commonwealth government's role is one of oversight, facilitation, and investment, ensuring that the national interest is

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met, particularly in transboundary river and groundwater basins, like the Murray-Darling Basin (MDB), the Great Artesian Basin, and the Lake Eyre Basin.

In these major transboundary systems, the relevant state and territory governments work with the Commonwealth government to develop ongoing, formal management arrangements covering water sharing and use and other related matters. The most famous of these is the MDB involving the states of Victoria, New South Wales, South Australia, and Queensland, the Australian Capital Territory (ACT), and the Commonwealth government. The MDB is often seen as the showcase for Australian water reform. It has been the area of greatest water use, biggest environmental challenges, and highest economic value, and its management has required the states and the Commonwealth government to work together for over 100 years on issues of water sharing between states, river management and key aspects of catchment and land management (see Chapter 2).

Once the higher order issues of water sharing between states have been agreed upon, states then manage land and water within their own individual legislative frameworks. Each state has its own system of water entitlements and water planning, frameworks for environmental protection and water industry regulation. In multijurisdictional basins, where required, these systems have been made compatible. When national approaches to water management have been desired in the national interest, they have been achieved through the agreement of all governments through the Council of Australian Governments (COAG).

Each state has established institutional arrangements to deliver water supply, sewerage, drainage, and irrigation services to local communities. In a number of states, these services are delivered through local authorities—either dedicated urban and rural water authorities or in some cases through local government.

Australia is a highly urbanized society, with approximately 90% of its 24.2 million people[1] living in cities and towns, and around 60% living in cities of greater than 1 million people. In 2014–15, a year in which rainfall was 10% lower than the national average, bulk water extraction across the country was 16,700 GL. Of this, 75% was used for irrigation, 19% for urban use, and 6% for mining and power generation (Bureau of Meteorology, 2016a).

This chapter provides a brief introduction to water management in Australia, including an overview of the history of water management in Australia since European settlement. It focuses particularly on the last 30 years during which Australian governments have been undertaking a program of water reform, transitioning to a new paradigm of environmentally and financially sustainable water resource management providing high economic value to the nation.

This chapter also sets the scene for the rest of the book. Individual chapters go into more detail about specific elements that have contributed to the implementation of the reform agenda.

PHASES IN AUSTRALIAN WATER MANAGEMENT

THE EARLY YEARS—THE "BUILD AND SUPPLY" PHASE

Since 1901, when Australia became a federation, up until the late 1970s, the focus of governments was on the construction of storage and delivery systems to provide water security for growing cities and towns, and to develop irrigation areas and mining industries. At the start of the 20th century, the combined storage capacity of all large dams across Australia was 240 GL. This grew to 7200 GL by 1950 and to

[1]Estimated as at December 1, 2016 (http://www.abs.gov.au/ausstats/abs@.nsf/0/1647509ef7e25faaca2568a900154b63?opendocument).

84,800 GL by 2005 (Australian Bureau of Statistics, 2010). This dam building was often undertaken in the aftermath of drought and funded, predominantly, by governments. As a consequence, Australia now has the highest per capita surface water storage capacity of any country in the world.

This period between federation and the late 1970s was, effectively, a major "build and supply" phase (Doolan, 2016a). However, even in this early phase where the focus was on infrastructure construction, serious attention was also paid to developing legislative frameworks and management systems to properly allocate and administer the resources that were then under control. There were early laws governing water allocation and management, which retained ownership of water with the Crown. Water systems were constructed using the contemporary understanding of the hydrology of the water systems involved, and water allocation systems were put in place that were meant to reflect the actual water availability at that time.

While this early phase provided a firm foundation for water resource management at the time, by the 1980s, at the end of this development phase, a number of new issues were emerging. These included large government debt, poor pricing policies, service delivery challenges and widespread environmental damage.

The high level of investment in water infrastructure had left governments with a significant legacy of debt and an ongoing future requirement for maintenance and refurbishment. While the gains in water storage had provided a level of water security, there was still increasing competition for these water supplies as towns and the irrigation industries grew. Every drought raised issues within communities and calls for more storage (Keating, 1992). However, by the 1980s, there was limited potential to increase supply in regions of high water demand, due to a shortage of cost-effective, large-scale dam sites.

With increasing competition for water, problems arose with the existing water rights systems. In many areas, existing water rights were not based on a good understanding of resource availability and the full suite of demands, leading to a number of systems being overallocated. This resulted in detrimental impacts to both the environment and downstream users. Additionally, water rights were tied to land, so the only way to effectively transfer water between users was through land purchase (National Water Commission, 2011a).

In urban areas, there were problems with service delivery. Many towns across the country were provided with water that did not meet drinking water quality standards, often by small local authorities that were not financially sustainable (Industry Commission, 1992). Water pricing was generally based on property value and did not reflect the costs of supply or water use. As a result, water use in cities was highly inefficient. In the 1980s, water use in Melbourne was greater than 180 kL per capita per year and greater than 160 kL per capita per year in Sydney (Water Services Association of Australia, 2003). In other areas, it was difficult to tell what the per capita use was because metering was not widespread. Urban wastewater discharges were also a major pollution source into rivers and marine environments.

In irrigation areas, water was being used inefficiently to produce low-value crops. For example, in 1991, over half of Australia's irrigated land was used for fodder production. The profitability of irrigated agriculture was low, with many farms considered to be marginal businesses, and irrigators still highly susceptible to drought. Moreover, irrigation authorities were highly dependent on government subsidies, with only part of their revenue being funded by irrigators (Industry Commission, 1992).

In addition to these issues, by the 1980s, it was clear that water management was also causing widespread environmental damage. Obvious problems included high salinity in the River Murray and extensive land salinization, which had major socioeconomic costs. In 1981, the mouth of the River Murray closed for the first time since European settlement as a result of upstream water extraction. In 1991, a toxic algal bloom extending over 1000 km occurred in the Darling River. Algal blooms were also occurring in Perth in Western Australia, and in the Gippsland Lakes in Victoria. There was extensive erosion and sedimentation in rivers and wetlands.

Many of these environmental issues had flow-on economic and social impacts on agricultural production, regional tourism, and community wellbeing.

THE REFORM ERA

The issues of environmental degradation, government debt, poor pricing for water services, and service delivery challenges caused governments to closely examine the way water resources were being managed in their jurisdictions. In the mid-1980s, in Victoria, a bipartisan review of water management across the state was undertaken by the Parliamentary Public Bodies Review Committee, which developed a long-term reform agenda covering almost every aspect of water resource management (see Chapter 3).

The MDB governments worked together with the Commonwealth government to first develop a strategy for salinity management in 1988. They then undertook a water audit in 1995, which showed that water extraction had reduced the median annual flow to the sea to 27% of that occurring naturally (Murray-Darling Basin Ministerial Council, 1995). This clearly showed that water use in the Basin was unsustainable and prompted a landmark decision by all governments in 1995 to "cap" water extraction across the MDB, generally limiting water diversions to 1993 levels of development (Murray Darling Basin Commission, 1996). This decision created the drivers for the evolution of more accurate water accounting, widespread water trading, and an interstate water market in the MDB. At the national level, governments worked together on strategies for managing water quality (ARMCANZ/ANZECC, 1994) and providing water for the environment (ARMCANZ/ANZECC, 1996).

Despite these efforts, by the early 1990s, governments had collectively recognized that overall water management across Australia was providing a poor return to the national economy and was causing significant environmental damage along the way. They agreed that the entire system of managing, using and funding water had to transition from the environmentally damaging, government-funded, inefficient, "build and supply" philosophy to a new system that was both economically and environmentally sustainable, providing a secure basis for future investment and capable of yielding high returns to the community (Doolan, 2016a).

In 1994, the COAG signed off on a national water reform framework (COAG, 1994)—a highly challenging, comprehensive policy agenda covering all elements of water management, which was intended to move Australia into a new phase of sustainable water management. It was reviewed in 2004 and extended as the National Water Initiative (NWI) (COAG, 2004). This was reendorsed by all governments again in 2014.

KEY ELEMENTS OF AUSTRALIAN WATER REFORM

The underlying objectives of the national water reform agenda were to transform the management of water in Australia to increase the productivity and efficiency of Australia's water use and ensure the health of river and groundwater systems while servicing the needs of rural and urban communities (COAG, 1994, 2004).

Doolan (2016a) reviewed the initial reform efforts of state governments, the collaborative efforts of the MDB governments and the national COAG and NWI reform frameworks, and identified four key overarching areas of water reform that have been pursued collectively over the past 30+ years, together with advances in two enabling areas. These are illustrated in Fig. 1 and include the following.

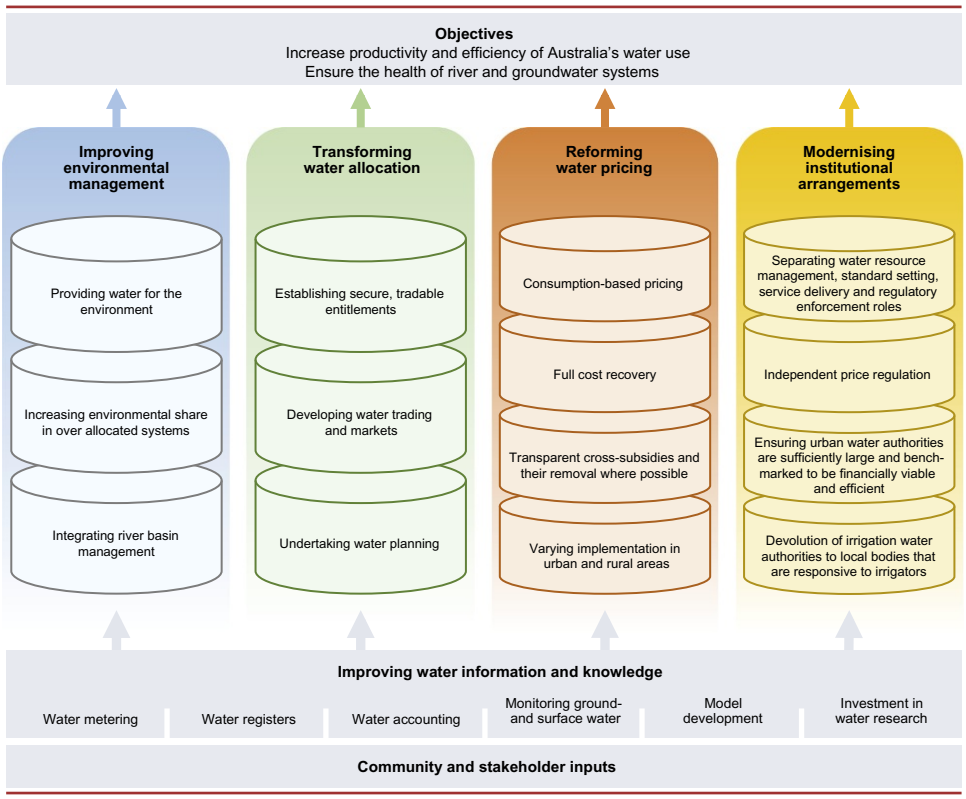

FIG. 1

Objectives and key elements of water reform in Australia over the past 30 years.

From Doolan, J. (2016a). The Australian water reform journey—An overview of three decades of policy, management and institutional transformation. *Australian Water Partnership. Canberra.*

Transforming water allocation: This involved moving from the old, administrative method of water allocation that assumed no environmental limits to the resource to a new system that works within sustainable resource limits, is market-based and provides economic value to individual water entitlement holders and the nation overall.

Critical steps in this process included, first, the conversion of existing ill-defined water rights into secure, legally defined, tradeable entitlements, which relate to the volume of water available, and, second, the establishment of diversion limits for surface and groundwater systems to protect the environment and the rights of existing users. These key steps were undertaken in a range of water-planning processes. Setting diversion limits effectively capped highly developed and overcommitted systems, which then created the driver for widespread water trading. The development of water trading rules and water markets was undertaken gradually in stages to minimize any adverse social and environmental consequences.

Improving environmental management: A market-based system of water allocation needs to be underpinned by a sustainable water resource base. This was achieved through providing a legally recognized share of water for the environment in all water systems, addressing overallocation in some

water systems to increase the environmental share and improve environmental condition and, finally, managing water within an integrated catchment management context.

Reforming pricing of water services: Reforming pricing involved implementing the principles of consumption-based pricing, full cost recovery, and removal of cross-subsidies. This was aimed at promoting efficient and sustainable use of water resources and assets and improving the financial viability of water businesses by providing adequate revenue streams to fund service delivery.

Modernizing institutional arrangements: This involved transforming old institutions and local water authorities into organizations that were financially viable and could provide services to their communities efficiently and effectively. Key actions included the separation of roles for water resource management, service delivery standard setting and regulation as well as the establishment of independent economic regulation of water pricing and benchmarking authority performance.

Throughout the process of reform, these four key areas were underpinned by work undertaken in two enabling areas.

Ensuring community and stakeholder engagement: Recognizing that every aspect of water reform requires trade-off decisions that affect individuals, water users, communities, industries, regional economies and environments, mechanisms for community and stakeholder engagement were built into every facet of reform.

Improving water information and knowledge: Improving metering, monitoring, modeling, water accounting, and water knowledge to underpin advances in water planning and management.

Each of these areas is described in more detail in Doolan (2016a).

PROGRESS WITH WATER REFORM

Over the 30+ years since the 1980s, work has been undertaken in the areas described above in every state and territory, facilitated by the Commonwealth government. Enormous progress has been made in shifting toward a model of sustainable water management. This has been documented in regular reports by the National Water Commission (e.g., National Water Commission, 2011b, 2014) and summarized in Doolan (2016a).

Legally defined, secure, tradeable entitlement regimes are in place in all Australian states but one. Water markets have been established in a number of systems across Australia and the value of water to the economy is being revealed through these markets. The most mature of Australian water markets is in the MDB, where in 2016 the estimated total value of all water entitlements in the southern part of the basin was greater than $13 billion (Aither, 2016). In this system, the total value of commercial trade in 2015–16 was $660 million (Aither, 2016) and at least 30% of water available in any one year has been sold since 2007 (Grafton & Horne, 2014).

Water-planning processes have been undertaken in all states. Through these processes, undertaken with community consultation, caps for consumptive use have been set and rules established for environmental and consumptive use. Most states now have more than 80% of water used managed under some form of plan or equivalent (National Water Commission, 2014).

There are clear, statutory-based provisions of water for the environment made through all water plans or planning processes. In most systems, these are "rules-based," placing constraints on the take of consumptive users. However, in a number of regulated systems, this is supplemented with environmental water entitlements with the same characteristics as other entitlement holders.

Where the latter is the case, there is considerable discretion in how, where and when this water can be used (Doolan et al., 2017). In Victoria and at the national level, formal statutory institutions have been established with the responsibility to make these choices and to use environmental entitlements to achieve the best environmental outcomes possible. Currently, the Commonwealth Environmental Water Holder holds a range of water entitlements with varying reliabilities, equivalent to 1703 GL (long-term average annual yield) as at Sep. 30, 2016 (Department of Agriculture and Water Resources, 2016).

Progress on restoring overcommitted systems to a more sustainable level of extraction has been slow because of the significant economic and social implications of taking water from the consumptive pool to provide to the environment. Most success has occurred when it has been possible for governments to purchase entitlements or to invest in more efficient water supply and irrigation systems and practices, saving water that can be converted to environmental entitlements. In the MDB, the Commonwealth government has a major long-term initiative to restore the Basin to a more sustainable balance. This involved setting a new sustainable diversion limit (SDL) for the Basin and the investment of around $13 billion in irrigation modernization, on-farm efficiencies and buying entitlements on the market to implement the new balance (see Chapter 13). As a result of this, all catchments in the MDB should be returned to environmentally sustainable levels of diversion by 2024.

In terms of water pricing, significant progress has been made in metropolitan systems where there is full cost recovery (although there is still some debate about what this actually means) and generally a return on assets. In regional urban systems, there is generally full cost recovery except in some remote areas. In irrigation systems, reform has been slower, but for the most part prices cover the provision of services and asset maintenance and refurbishment. In some states, water prices include components that cover planning and management costs and/or some environmental externalities. Some form of independent economic regulation of pricing is in place in every state.

Water services are now generally of a high standard, and the performance of water utilities is nationally benchmarked annually on a range of service parameters (Bureau of Meteorology, 2016b). Drinking water provided by urban water utilities is monitored against national guidelines and standards and is consistently safe and of a high quality.

This progress has been accompanied by considerable advances in metering, monitoring, measurement, reporting, and forecasting and significant institutional reform. Governance has been significantly improved with the separation of policy, service delivery, and regulatory functions, and the consolidation of water utilities into authorities of a size that is financially sustainable and able to deliver quality services efficiently to their local communities.

THE MILLENNIUM DROUGHT (1997–2009)

The progress outlined here has been achieved despite the fact that this period included the Millennium drought. This drought commenced in late 1996 and lasted through to 2009, affecting much of southern Australia (van Dijk et al., 2013). It was the longest, most severe drought on record, producing harsh conditions affecting the more densely populated southeast and southwest of the continent, including the MDB and Australia's largest cities: Perth, Adelaide, Melbourne, Hobart, Canberra, Sydney, and Brisbane (South Eastern Australian Climate Initiative, 2011). The 10th year of the drought (2006) was an extraordinary year, with the lowest inflows on record for most of the MDB and southern Australia. This produced conditions that were well outside the boundary settings that, based on historical records, had been used in the design of water planning and entitlement systems, river operations, and water supply management (DELWP, 2016).

The impacts on communities, regional economies, and the environment were extremely severe. Towns were on the highest level of water restrictions. In the MDB, production of annual crops like rice and cotton was reduced by 99% and 84%, respectively, between 2002 and 2009, while production of perennial crops fell by 32% between 2003 and 2007 (van Dijk et al., 2013). There were consequential losses in employment, reductions in household income, downturns in local business, reduced recreational and tourism opportunities as local lakes dried up, and a general break in social cohesion in rural areas, with resulting increases in mental health problems and suicides.

From an environmental perspective, the combined effect of river regulation and drought meant that streamflows in some systems were around 80% less than would have occurred under natural conditions (SEACI, 2011). This resulted in widespread deaths of river red gums, reductions in waterbird numbers, threatened species extinction, and the large Ramsar-listed lakes at the downstream end of the MDB at imminent risk of widespread irreversible acidification (Doolan, 2016b). Moreover, climate change predictions suggested that similar conditions could occur more frequently in the future (CSIRO, 2008).

While the impact of the drought was undoubtedly severe, in general, the economic and social consequences of the drought were considered to be less harsh as a result of the reforms that had been put in place (Frontier Economics, 2007; Productivity Commission, 2010).

During the drought, the water market became a critical tool, enabling the scarce water that was available to move to where it had highest value. Because of the market, irrigators survived consecutive years of drought, though with varying levels of impact. They could decide whether to plant a crop with the possibility that they would have to buy more water, or to sell their seasonal water allocation to realize cash. If the farm was financially unviable, they could permanently sell their water entitlements.

As a consequence, use of the water market increased significantly during the drought. Since 2007–08 about 30% of water allocated in any water year has been sold on the temporary allocation market (Grafton & Horne, 2014). For the most part, water moved to support high-value perennial plantings and horticulture. It has been reported that, without trading, the dairy industry would have fared much worse than it did during the years of the drought, and many horticultural farms in Victoria and South Australia would not have survived the extremely dry conditions (Productivity Commission, 2010). The market also revealed the economic value of water, which then created a drive for greater water efficiency. In the critical period between 2005–06 and 2008–09, although water availability for irrigation dropped by 53%, the gross value of irrigated agricultural production only fell by 29% (National Water Commission, 2011a).

In urban systems, demand was managed through a combination of restrictions, significant water conservation and behavioral change programs. In southeast Queensland, this resulted in reducing water consumption by 60% from predrought volumes to an average of 125 L per person per day (Turner et al., 2016). However, as the drought continued, most major cities and many towns had to augment their water supplies (see Chapter 5). As they did this, they looked to increase the diversity of their supplies and make more efficient use of existing regulated systems to be more effective in a drier future. Water utilities increased their use of recycled water and stormwater, using these as a substitute for potable water. A number built system interconnections to make more efficient use of existing supply systems. Some augmented with groundwater or used managed aquifer recharge. Several in the MDB bought permanent water entitlements on the water market from irrigators. Finally, most of the capital cities built desalination plants as a climate-independent water source. For the most part, as a result of the reform process, most of these strategies and augmentations were funded through water pricing with the result that water prices increased rapidly (Doolan, 2016b).

While the environment suffered significant degradation during the drought, once again it was not quite as severe as it would have been without the reforms. The provision of water for the environment provided some means of ameliorating the dry conditions. Environmental entitlements were used to protect drought refuges, prevent catastrophic events, and save species from extinction. As a result of environmental watering, a number of serious biological losses were avoided (Mount et al., 2016). In a number of rivers, environmental passing flows had to be reduced because of the extremely dry conditions. However, when this did occur, it was to provide water only for critical human needs and was undertaken in ways that minimized as far as possible the impact on the environment. In Victoria, in a number of cases, there was some form of compensation either through water payback at a future time or the provision of funds from urban water authorities for complementary works (DELWP, 2016).

One of the major initiatives taken in response to the drought was the Commonwealth government's long-term initiative to reset the balance in the MDB. The drought showed that, despite previous efforts of governments to improve environmental flows in the River Murray, the Basin was still overallocated. The Commonwealth government provided around $13 billion to assist in establishing a new sustainable balance for the Basin. This involved establishing a new authority to develop a Basin Plan, which set a new SDL for the catchments within the Basin and the Basin overall (see Chapter 13).

Funding was then provided to acquire water for the environment to meet the SDL through buying water entitlements from willing irrigators on the water market and through investment in irrigation modernization and on-farm efficiencies. The latter aimed to assist irrigation industries and communities to adjust to the new lower diversion limit and maintain production with less water, increasing their drought resilience at the same time. This whole initiative has been highly controversial within the Basin communities, with considerable community outrage occurring over the process, the actual final SDL, the science and the socioeconomic analyses behind the establishment of the SDL, the final volume of water to be recovered from irrigators, and the means by which it is being recovered. The Basin Plan is a major initiative, which illustrates both the difficulty of water reform and what can happen when the process goes awry. However, it also demonstrates some of the advances in analyses, information, and community engagement that this has necessitated to get it back on track.

The Millennium drought severely tested the water management framework built through the Australian water reform agenda and showed it to be robust. In general, the economic and social consequences of the drought were less severe as a result of water reforms that had been put in place. While governments shifted their priorities during the drought to deal with water scarcity, for the most part the actions they took either accelerated much of the water reform agenda or were consistent with it.

THE PROCESS OF WATER REFORM

While there has been significant progress over 30 years in Australian water reform, none of it has been simple or easy—nor has it led to perfect outcomes. Every advance under each of the key elements of reform had impacts on individuals, industries, communities, regional economies, and environments. Often, these advances are taken during periods of water scarcity when communities are already experiencing hardship. Because of this, community and stakeholder engagement has been absolutely critical to the reform process. Water reform affects their futures and this needs to be understood and respected.

Each step forward in the reform process has required trade-offs to be made and settlements to be negotiated to enable a politically feasible way forward at that point in time. Where community and

stakeholder engagement has not been undertaken well, proposed reforms have frequently foundered. The reality is that each step takes time to develop resources, and community acceptance and political capital take time to set up and time to consolidate. Each step then throws up new issues, which drive the next steps in the reform process. The pace of reform can only move as fast as community acceptance allows. The result is that water reform is an evolution of continuous improvement, occurring in a series of steps over decades.

Recognizing this, water reform in Australia over the past 30+ years has not just been the work of governments. Reform has involved communities, industries, local authorities, NGOs, and academics, with leaders emerging in all these areas over the decades. Often, the drive comes from governments, but just as frequently the impetus can come from stakeholder groups or communities concerned about issues or advocating for different outcomes.

The previous discussion has provided a high-level summary of the progress that has been made in Australian water management over the past 30+ years. Part 2 of the book provides more detail on this evolution from four key perspectives.

Part 2 starts with a long-term perspective capturing the history of water resource planning, policy and management in the MDB in the 100+ years since Federation in 1901 (Chapter 2, Guest). It outlines the key steps in reform and how they were achieved in a multigovernment, transboundary political setting, culminating in the recent Commonwealth government initiative to reset the MDB. This chapter provides a fascinating story of the political interactions between the Basin states (Victoria, New South Wales, South Australia, and more recently Queensland) and the federal government in water resources policy and management in the MDB.

The next four chapters in this section of the book cover the changes in water allocation and planning and the impacts of water reform for irrigation, major urban centers, and for the environment.

Fitzpatrick (Chapter 3) reviews the evolution of water entitlement frameworks and water markets in Victoria. The establishment of robust, secure statutory entitlement and water-planning processes is one of the critical steps in water reform. Secure water entitlement systems provide the foundation stone for the provision of water services, the protection of water environments, the operation of water markets, and future investment in water-related industries on which regional development is based. Ongoing community trust and support was highlighted as vital in underpinning these long-term reform processes.

Rendell (Chapter 4) provides a personal view of the changes that have occurred in the irrigation districts in the southern part of the MDB over the past 30 years. The focus is particularly on how individual farmers and farm businesses have modified their decision-making practices to take into account factors such as climate variability, changes in agricultural practice, the water market, and government policies.

Chong and White (Chapter 5) review the water reforms that have occurred in Australia's major cities. This commenced with the corporatization of the major urban water utilities in the 1990s, and since then has involved focus on supply-demand planning, the augmentation of supply options with the construction of desalinization plants, and increased emphasis on the integrated whole of water cycle management. They also speculate on some of the additional changes likely to occur in the future.

Bunn (Chapter 6) summarizes the significant water reforms that have been undertaken over the past three decades to improve the health of Australia's freshwater ecosystems and address overallocation. This started with the formal recognition of the environment as a user of water in the mid-1990s, following which governments introduced major changes to water legislation and planning to improve environmental outcomes.

DECISION MAKING IN WATER REFORM

Every step in the evolution of water reform requires decisions to be made that could potentially impact individuals, industries, communities, regional economies, and the environment in different ways. Because of this, decision making in water management in Australia generally involves a detailed process that includes community and stakeholder input to consider the issues, examine options, and understand trade-offs, to allow a broadly accepted position to be reached that can then be feasibly adopted by governments and practically implemented with communities. These decisions represent difficult trade-offs that balance social, economic, and environmental issues and sectoral impacts. Decision-making processes are run across all aspects of water resource management, and at local, state, MDB, and national scales, depending on the issue.

However, the most notable of these processes, where there are frequently competing views and hard trade-offs to be made, are those involving the following areas.

Water planning and allocation: where the aim is to provide a clear basis for the allocation of water entitlements for consumptive use, provide water for the environment, and develop implementation and operational arrangements. These processes are critical because they define the characteristics of entitlements held by consumptive users and the environment, establish whether and by what means water could be returned to the environment, and set up the conditions for water markets. Within a local water system, catchment or aquifer, they:

- Identify the nature and behavior of surface water and groundwater resources, resource availability under different climate scenarios and the environmental values and their water requirements,
- Involve key stakeholders and communities,
- Clarify and define the rights of existing users, including their relationship to water availability,
- Identify the agreed share of water for the environment,
- Cap water available for consumption,
- Develop implementation arrangements for the seasonal allocation of water for consumptive and environmental use, system operation, environmental obligations, and if relevant, market operation and investment programs.

The planning and allocation process in undeveloped water systems, while conceptually similar, is different from the processes used for highly developed or overcommitted systems, where there is real competition for water resources and real wealth and investment at stake. In undeveloped water systems, an environmentally sustainable diversion limit is set, the rights of any existing users are recognized, and a process by which additional consumptive water can be allocated is established.

In highly developed systems, the first stage of water planning generally establishes and defines the rights of existing consumptive users and caps the system so that no more water can be taken out, thereby allocating the residual water to the environment. Capping these systems means that no additional new water entitlements can be issued. This then creates the preconditions for a water market where water in the consumptive pool is able to be traded among new and existing users and enable water to move to higher-value uses. However, capping does not improve environmental sustainability—it simply stops the system getting worse. The second stage of water-planning processes in highly developed or overallocated systems is to decide on whether to recover water from the consumptive pool to enhance the environment. These decisions can involve very difficult trade-offs for communities and can be highly controversial: the Murray-Darling Basin Plan process of the MDB is the most notable instance of this

(see Chapter 13). Basins where this has occurred have set out pathways to achieve a more sustainable balance over time. The pathways can involve: (a) investment in efficient water and/or irrigation systems and on-farm efficiency with the water saved going to the environment, (b) purchase of water entitlements for the environment on the market, or (c) agreement to reduce entitlements at a rate of change to which the regional communities and economies can adapt over time.

Water-planning processes are undertaken at regular intervals for a water system as information improves, communities and industries become more sophisticated in their understanding of water management, the patterns of water use change and/or new risks to water resources become apparent. Each new iteration of a water plan builds on the knowledge of the previous plan and the experience of communities and industries in implementing it. With new knowledge and deeper experience, there are significant opportunities to improve system management rules, understand the surface water and groundwater connectivity, review the balance between environment and consumptive use and identify ways of moving closer to optimizing between environmental, social, and economic outcomes. Australian governments have developed a set of national water-planning guidelines which are used to guide state-based water allocation and planning processes (COAG, 2010).

Water service provision and pricing: the aim here is to work through types of water services to be provided to communities, the levels of service to be provided and the price to be paid for these services. These will include both urban and irrigation services and communities. In urban areas, they generally include discussions on the way to supply water in the future and will identify options for the next augmentation of water supply. These processes are of great interest to the communities involved and are critical to water authorities providing services as they establish the prices they are authorized to charge for the next pricing period, which is generally 5 years. These processes are undertaken regularly, are highly consultative and overseen by independent price regulation authorities who set guidelines for how they should be undertaken (e.g., the Victorian water pricing framework and approach; Essential Services Commission, 2016).

Environmental objective setting and catchment management: the aim here is to understand the environmental, social, and economic values provided by water environments and their catchments; understand trade-offs between environmental condition and various human uses of both catchment lands and water; and set objectives for environmental condition to provide the values that the community wants to see in the future. These processes often provide flow-related information to feed into water-planning processes. They also cover other critical elements of environmental condition, for example, river and aquifer water quality, habitat condition and catchment land use and management. These types of planning processes include: catchment management planning, waterway management planning, setting environmental protection standards, and integrated urban water management. This is where water management is set within the broader context of integrated catchment or natural resource management and integrates with water quality regulation undertaken by environmental protection agencies.

Regardless of the purpose, contemporary decision-making processes in Australian water management have a number of important and consistent attributes. These include:

- Comprehensive processes for community and stakeholder engagement to ensure that differing views are heard and taken into account, to provide sound information to all, and to ensure transparency in decision making.
- A triple bottom line (TBL) approach where the suite of economic, social, and environmental implications is recognized and understood as trade-off decisions are made.

- An evidence-based approach, using the best available science and socioeconomic analysis to underpin TBL decision making.
- An adaptive process, including regular review cycles to incorporate new knowledge, experience and emerging issues.

These four attributes are critical to successful decision making. And all four are referred to and required in some way by both the COAG water reform framework (1994) and the National Water Initiative (2004). Jurisdictions have had to report on their decision-making processes in their regular reports on implementation of the national water reform program. Undertaking decision making in this way is resource intensive and can take significant time (e.g., in Victoria, the water entitlement conversion processes took up to 3 years to complete in some systems; in New South Wales, many water plans took at least 2 years to prepare). However, these features build confidence in the planning and water management process, and the end result is one that is generally robust, understood by community and stakeholders, and able to be endorsed by governments and implemented.

These key features of Australian water planning and management have had significant implications for the state of water information and knowledge in Australia. Each step of the water reform process has been accompanied by investment in improved information, knowledge, evaluation methodologies, data management, and decision support systems. Advances have been made in water measurement, water monitoring, understanding of groundwater systems, and environmental flows, in socioeconomic analyses and in the development of water registers and water accounting—all to provide accurate, reliable, and relevant information to support decisions on water management not only by governments, but also by regional water authorities in their delivery of water services and by individual irrigators in the farm enterprises. These information bases are publicly available and underpin the operation of water management systems and the water market.

The preceding discussion provides a brief overview of how decision making has occurred during the 30+ years of Australian water reform. We have noted that contemporary water resources decision making should encompass TBL decision making, which, as far as possible, should be evidence based to enable informed trade-offs and judgments to be made. There is generally an assumption that the better the evidence that underpins the decision-making process, the more likely it is that better decisions will be made.

Part 3 of the book contains seven chapters that outline key elements of the essential TBL evidence base and the decision-making process in contemporary water resources decision making, particularly in relation to water allocation and planning.

Stewardson et al. (Chapter 7) review the largely eco-hydrological methods used in Australia to assess the environmental flow regimes required as a key input to water planning and allocation processes. These assessment methods are used to establish: the level of human impact on the river, estuary, groundwater-dependent, and wetland ecosystems; the environmental water requirements of the system; and potential environmental risks if the environmental water allocation scenarios fall short of the required environmental water.

James (Chapter 8) discusses the application of economic analysis in water planning and allocation, with particular reference to the Murray-Darling Basin Plan. The chapter covers the application of tools such as: cost-benefit analysis; valuing the environment; cost-effectiveness and cost trade-off analysis; economic impact analysis (input-output models and computable general equilibrium models); impact analysis at local community scale; and optimization of economic, social and environmental outcomes.

James notes the importance of ensuring that the economic analysis is focused at the appropriate level, for example, national, regional, and local.

Chapters 9 and 10 then cover the more social aspects of water resources decision making.

Bekessy and Selinske (Chapter 9) first review three frameworks for understanding social-ecological systems (Ostrom's social-ecological framework; the driver-pressure-state-impact-response framework; and the structured decision-making framework). They then review seven decision tools for modeling and analyzing social-ecological systems (agent based modeling, backcasting and forecasting, Bayesian belief networks, bioeconomic modeling, game theory modeling, social network analysis, and scenario planning and analysis). Finally, they describe pathways to mainstream the use of these approaches, and argue that more effort needs to go into the use of social-ecological modeling in water resources decision making.

Schirmer (Chapter 10) identifies key principles for assessing and managing the social effects of water reform, an often socially contentious exercise and one that is often a secondary consideration in the design and implementation of water reform. The development and implementation of the Murray-Darling Basin Plan is used to highlight three important principles: the need for good public participation; ensuring robust methods are used to assess the social outcomes of water reform throughout the development and implementation; and ensuring social effects are considered when selecting and designing the policy instruments used to enact water reform.

Tan and Auty (Chapter 11) discuss the importance of effective community engagement as an essential component of any water resources reform process. They analyze the community engagement processes adopted by the Murray-Darling Basin Authority (MDBA) during the 4-year period leading up to the successful adoption of the Basin Plan in 2012. They identify five key elements that underpin an effective community engagement process: engaging in places where people are on familiar territory and in places that people care about; taking the time to listen and share information; accepting that compromises will need to be made; seriously organizing and planning the process; and showing leadership in settings.

Pollino et al. (Chapter 12) discusses the need for more integrative approaches in water resource decision making. Integrative research applies to the multidisciplinary approaches that are central to tackling real-world, complex science, and social-political problems, where acceptable solutions often range across disciplinary boundaries. Recent literature on integration theory is reviewed, and three case studies from the MDB are used to demonstrate different approaches to integration, where each example has a different purpose and scale of application.

Part 4 of the book then provides three detailed case studies that outline recent reforms in three specific complex policy areas in Australia.

Hart and Davidson (Chapter 13) provide an analysis of the key decision-making aspects in the development of the Murray-Darling Basin Plan, with particular focus on the decision-making steps employed in developing the SDL, the key policy initiative that underpins the Basin Plan. This required a TBL approach to rebalance the overallocated Murray-Darling river system, specifically to provide more water for the environment with minimal impact on communities. They also provide an assessment of the updated decision-making process used to review and change the SDL set for the northern MDB.

Loo and Clarke (Chapter 14) discuss the process used to develop a new Victorian Waterways Management Strategy (VWMS), which provides the policy framework in which rivers, wetlands, and estuaries are managed in Victoria, including setting environmental condition objectives to support community values and integrating environmental flow management with other aspects of waterway

management. It outlines the process of reviewing and refreshing the 2002 Victorian River Health Strategy. New management issues addressed in the VWMS included: wetland, estuary, and urban waterway management, Traditional Owner involvement, management of invasive species, and recreational use of waterways. They considered that clear management arrangements, a dedicated fund source, political authorization and partnership with communities were key factors that underpinned the successful development and implementation of this new policy.

Eberhard et al. (Chapter 15) review the management of water quality in the catchments affecting the Great Barrier Reef, an internationally recognized World Heritage site. In overviewing the efforts of the Commonwealth and Queensland governments to improve water quality over the last 15 years, they note that these efforts have failed to deliver measurable improvements to the health of inshore reef ecosystems. In this period, four phases of bilateral water quality planning and programs have developed scientifically robust targets and reporting systems. They conclude that, despite the strong science and partnerships that support reef policy and programs, greater effort is needed to overcome constraints to current management approaches and to employ the additional policy measures required to help sustain the GBR into the future.

These last two chapters move the focus away from water allocation and planning to environmental objectives and catchment planning and are examples of how water reform has integrated with the broader processes of integrated catchment and natural resource management.

THE AUSTRALIAN EXPERIENCE—INTERNATIONAL APPLICABILITY

The situations that led to the water reforms in Australia are common to many other countries. While the Australian water reform journey is not finished, elements of this experience to date have proved useful to other countries as they tackle their own water management challenges. Part 5 describes three instances where this has been the case.

Campbell and Barlow (Chapter 16) describe the involvement of working in the transboundary Mekong basin and identify six challenges in the international transfer of knowledge between developed and less-developed countries. These include: differences in the biophysical environment; lack of knowledge and local capacity; differences in socioeconomic conditions; and differences in culture (e.g., importance of age/seniority, agreement, and social networks).

Pollino et al. (Chapter 17) report on a 3-year project aimed at using Australian water resources expertise to assist India in building capacity and managing water at a Basin scale. The project was largely technical, focusing on the Brahmani-Baitarni River Basin located in the eastern part of India, and used Australian expertise in river system modeling to build capacity in central and state government engineers in India. A number of challenges were experienced during the project and these are discussed.

Gippel et al. (Chapter 18) discuss Australia's assistance in developing a framework for a national program to assess the health of China's rivers. There is currently no consistent nationwide assessment of river health in China. The framework was shaped by Australian experience, and tailored to suit the resources and expertise available in China, the biophysical characteristics of China's rivers, and the key management issues.

A key message from all of these is that while the Australian experience can be helpful in providing guidance and tools to other countries, nothing is ever directly transferable and will always require adaptation to suit the physical systems, capability, and problem requirements of the home country.

WATER REFORM IN AUSTRALIA—THE FUTURE

In Australia, substantial progress has been made over the past 30+ years in shifting toward a model of sustainable water resource management. However, there is still much to do in the next phase of Australian water reform. In each of the key reform areas outlined here, there is still work to be done. The challenge of climate change means that the water entitlements and markets regime and the new environmental water management arrangements will need to continue to be effective in a future predicted to be much drier in parts of the country already dealing with water scarcity. Water use efficiency will need to continue to be improved in all sectors: urban, irrigation, and environment. Population growth coupled with climate change will create serious challenges for our cities and towns. In these urban environments, the role of water services in contributing to livability will be a major focus in the future, as will making the best use of all water sources, including recycled and stormwater. In irrigation, the drive will continue for increased efficiency in water use and distribution, higher productivity from water use and achieving financial and environmental sustainability.

Across the water sector, the issues of energy use and carbon emissions are a significant problem currently under consideration. All these issues will raise questions about water services standards and maintaining affordability. Finally, the water sector will need to improve their connection with communities, including indigenous communities, to ensure they meet their needs in the future in a rapidly changing environment.

Chapter 19 of the book discusses these challenges in more detail and outlines some of the ways in which water resource managers will have to respond to address them in the future. These will form the basis of the next wave of water reforms in Australia.

REFERENCES

Aither (2016). *Water markets report*. 2015-16 review and 2016-17 outlook. Melbourne.

ARMCANZ/ANZECC. (1994). *National water quality management strategy*. Commonwealth of Australia Canberra.

ARMCANZ/ANZECC. (1996). *National principles for the provision of water for ecosystems*. Sydney: Sustainable Land and Water Resources Management Committee, Subcommittee on Water Resources.

Australian Bureau of Statistics. (2010). Available at: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by Subject/1370.0~2010~Chapter~Water storage %286.3.6.2%292016.

Bureau of Meteorology. (2016a). *Water in Australia 2014–15*. Melbourne: Bureau of Meteorology.

Bureau of Meteorology (2016b). *National performance report 2014–15: Urban water utilities, part A*. Melbourne.

Council of Australian Governments. (1994). The Council of Australian Governments' Water Reform Framework. In *Extract from Council of Australian Governments: Hobart 25 February 1994 Communique*.

Council of Australian Governments (COAG). (2004). *Intergovernmental Agreement on a National Water Initiative between the Commonwealth of Australia and the Governments of New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and the Northern Territory*. Canberra.

Council of Australian Governments. (2010). *National water initiative policy guidelines for water planning and management*. Canberra.

CSIRO. (2008). *Water availability in the Murray-Darling Basin: Summary of a report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project*. Canberra.

DELWP. (2016). *Managing extreme water shortage in Victoria—Lessons from the Millennium Drought*. Melbourne: Department of Environment, Land, Water and Planning.

Department of Agriculture and Water Resources. (2016). *Progress of registered water recovery towards sustainable diversion limits at 30 September 2016*. Available at: http://www.agriculture.gov.au/SiteCollectionDocuments/water/register-water-recoveries.pdf. [Accessed 29 November 2016].

Doolan, J. M. (2016a). *The Australian water reform journey—An overview of three decades of policy, management and institutional transformation*. Canberra: Australian Water Partnership.

Doolan, J. M. (2016b). *Building resilience to drought—The Millennium Drought and water reform in Australia*. Canberra: Australian Water Partnership.

Doolan, J. M., Ashworth, B., & Swirepik, J. (2017). Planning for the active management of environmental water. In A. Horne, A. Webb, M. Stewardson, M. Acreman, & B. Richter (Eds.), *Water for the environment*: Elsevier.

Essential Services Commission. (2016). *Water pricing framework and approach: Implementing PREMO from 2018*. Melbourne: Essential Services Commission.

Frontier Economics. (2007). *The economic and social impacts of water trading: Case studies in the Victorian Murray Valley: Report for the Rural Industries Research and Development Corporation*. Canberra: National Water Commission and Murray–Darling Basin Commission.

Grafton, R. Q., & Horne, J. (2014). Water markets in the Murray-Darling Basin. *Agricultural Water Management*, *145*, 61–71.

Industry Commission. (1992). *Water resources and waste water disposal report no. 26*. Canberra: Australian Government Publishing Service.

Keating, J. (1992). *The drought walked through—A history of water shortage in Victoria*. Melbourne: Department of Water Resources Victoria.

Mount, J., Gray, B., Chappelle, C., Doolan, J., Grantham, T., & Seavy, N. (2016). *Managing water for the environment during drought—Lessons from Victoria, Australia*. San Francisco: Public Policy Institute of California.

Murray Darling Basin Commission. (1996). *The cap*. Canberra: Murray Darling Basin Commission.

Murray-Darling Basin Ministerial Council. (1995). *An audit of water use in the Murray-Darling Basin*. Canberra: Murray-Darling Ministerial Council.

National Water Commission. (2011a). *Water markets in Australia: A short history*. Canberra.

National Water Commission. (2011b). *The National Water Initiative – Securing Australia's water future: 2011 assessment*. Canberra: National Water Commission.

National Water Commission. (2014). *Australia's Water Blueprint: National reform assessment 2014*. Canberra.

Productivity Commission. (2010). *Market mechanisms for recovering water in the Murray-Darling Basin: Final report*. Melbourne.

South Eastern Australian Climate Initiative. (2011). *The millennium drought and the 2010/11 floods*.

Turner, A., White, S., Chong, J., Dickinson, M. A., Cooley, H., & Donnelly, K. T. (2016). *Managing drought: Learning from Australia*. Sydney.

van Dijk, A. I. J. M., Beck, H. E., Crosbie, R. S., de Jeu, R. A. M., Liu, Y. Y., Podger, G. M., et al. (2013). The Millennium Drought in southeast Australia (2001–2009): Natural and human causes and implications for water resources, ecosystems, economy, and society. *Water Resources Research*, *49*, 1040–1057.

Water Services Association of Australia. (2003). *Submission to the House Environment Committee to examine the future sustainability of Australian cities*.