# Building Resilience to Drought

## The Millennium Drought and Water Reform in Australia

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# Contents

# 1 Executive Summary

Australia has been implementing a national program of water reform for over 30 years – aiming to build a water sector that is economically and environmentally sustainable, offers a secure basis for future investment and yields high returns to the community. Water reform has involved transforming water allocation, developing water trading and water markets, providing water for the environment and dealing with over-commitment, and reforming urban water and irrigation management. Much of this water reform has occurred in the Murray-Darling Basin, Australia's largest and most complex river basin.

Australia's Millennium Drought (1997–2009) severely tested these reforms. The drought was the worst on record. Its harsh conditions affected the Murray-Darling Basin and most of Australia's large cities, including Perth, Adelaide, Melbourne, Sydney and Brisbane. The climatic conditions were well outside the boundaries that, based on historical records, had been used in the design of water planning systems and water supply management. Moreover, climate change predictions suggested conditions like these could occur more frequently in the future.

Given this situation, the state, territory and national governments' responses to the drought were not just to 'get through the crisis' but to develop new policies and approaches. They made investment and policy decisions that consolidated and embedded the existing water reform directions and built greater resilience to drought over the long term. These included

- determining clear rules for water sharing during extreme water scarcity, to provide for critical needs;
- facilitating water market operation in dry years to enable holders of water entitlements (including irrigation farmers) to use the market to manage their businesses during water scarcity and to mitigate their risks;
- investing in modernising irrigation systems and in water-efficient irrigation farms, to encourage greater production with less water and enable irrigation communities to adjust to a drier future;
- in urban areas, managing demand and encouraging water conservation through use of restrictions, incentives, regulation and programs to change consumer behaviour;
- augmenting urban water supplies and creating a more diverse portfolio of supply options, including use of recycled water, stormwater and groundwater and building desalination plants as rainfall-independent supplies;
- developing clear decision-making frameworks for the efficient use of environmental water under all climatic conditions, which would resonate with local communities.

In addition, the drought conditions showed clearly that the water resources of the Murray-Darling Basin were over-committed. In response, the Australian Government announced a major and comprehensive long-term program worth AUD13 billion, to reset the balance between environment and consumptive use. This program will move the Murray-Darling Basin onto a more sustainable basis for managing water resources, and enable irrigators and irrigation industries to adjust to a lower 'diversion limit' and build drought resilience in anticipation of a drier future.

In implementing these actions and responding to the drought, water-resource managers and policy-makers learnt a number of lessons that have now been incorporated into all aspects of water management in Australia. These included:

1. understanding that historical records of minimum rainfall records can be broken;
2. moving to a more sophisticated approach of scenario planning for water management, using a range of climate and demand scenarios;

3. the importance of drought- planning at all scales, by all parts of the water sector and with a multi-year horizon. This includes water- system operators, urban water managers, irrigators and environmental water managers. Effective drought-planning provides the means for all sectors to cope better through periods of water scarcity, minimising the impacts of water scarcity as far as possible and building long-term resilience to drought;
4. the importance of the water market in enabling
    - all holders of water entitlements (including irrigation farmers) to make choices and mitigate their own risk,
    - the available water to move to its highest value use and maximise its value to the community;
5. the need to pursue water use efficiency in all areas: household, commercial, industrial, irrigation, environment. This lessens vulnerability to drought and builds greater resilience for the future;
6. the requirement for a diverse portfolio of water supplies, encompassing direct use, reuse and desalination options to ensure continuing water supply in a drier future;
7. the need to understand community impacts and provide good communication and support to communities under stress to enable them to adapt to extreme conditions;
8. the need for improved climate and stream-flow forecasting to enable better planning and preparation by all parts of the water sector (i.e. urban water authorities, irrigators and environmental managers) which can reduce the damage and economic shocks caused by drought and build greater resilience to water scarcity.

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. In most cases, the actions taken during the drought accelerated and embedded much of the water reform agenda and built resilience to drought. However, the prospect of climate change means there is still significant ongoing work to be done to further improve water-use efficiency and build greater drought resilience in all sectors.

# 2 Introduction

For over 30 years Australia has been implementing a program of reforms in the way water is used and managed across the nation, aiming to build a water sector that is economically and environmentally sustainable, provides a secure basis for future investment and yields high returns to the community.

Reform has occurred on many fronts: in transforming water allocation; in developing water trading and water markets; in environmental water management and dealing with over-commitment of water resources; in water pricing and service delivery; in managing urban water and irrigation; and in establishing strong institutional arrangements to manage the water sector. Many of these reforms have been accelerated by crises of drought and floods over the years, and many have been developed in Australia's largest and most complex river basin, the Murray-Darling Basin. The Murray-Darling Basin is a multi-jurisdictional basin where state and territory governments work together with the national government to meet common imperatives. It has been the proving ground for many of Australia's most successful water reforms.

This paper presents a short account of the influence of drought on water management in Australia. It particularly focuses on the response of the Australian water sector to the Millennium Drought (1997-2009), and the role that drought played in progressing water reform and building resilience to future water scarcity. The paper briefly outlines the broad directions of national water reform, the progress that had already been made in the years leading up to the Millennium Drought, and the policies and actions that came about during the drought in relation to water allocation and markets and in managing urban, rural and environmental water in response to the extreme water scarcity the drought caused.

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## *The Australian context*

*Australia is renowned for its extremely variable climate and its history of recurrent droughts punctuated by floods. The often irregular rainfall and high rates of evaporation result in limited reliable surface flows in streams and the smallest volumes of run-off of all the inhabited continents. Consequently, Australia depends on its water storage more than other developed countries do, and stores more water per head of population than anywhere else in the world. Groundwater is also a vital component of Australia's water systems.*

*Australia's population is ~23.4 million, of which ~90% lives in urban areas and ~60% lives in cities that have >1 million people. Water usage across the whole of Australia in 2013–14 was estimated at 23,500 GL*[1]*. Of this, 17% was used in urban areas, and more than 60% in irrigation.*

*Australia is a federation of six states and two territories. Under the Australian Constitution, state governments have responsibility for land and water management. Territory governments have assumed responsibility for land and water management through Commonwealth legislation. The Australian national government has an oversight, facilitation and funding role, ensuring that the national interest is served particularly in the transboundary Murray-Darling Basin and other trans-state river and groundwater basins. Accordingly, developing a national water reform agenda required the agreement of the national government and the governments of each of the states and territories.*

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1 Australia has adopted the metric system for water measurement. Large volumes of water are measured in megalitres (1 ML = 1 million litres) and gigalitres (1 GL =1000 ML). 1 GL converts to 1 000 000 cubic metres or 810.7 acre feet.

## 2.1 Drought and Australian water management

The water history of Australia is strongly linked to the political, social and economic needs of the country. Australia became an independent federation in 1901, and from then until the 1970s the national and state governments focused on developing water resources to supply growing cities and townships and to support irrigated agriculture and the mining industry.

This was a major 'build and supply' phase in water management, involving the construction of dams and distribution systems across the country. Looking back across those decades, there is a pattern of semi-regular significant droughts were followed by periods of construction of water storages and regulating structures. The first Murray-Darling Basin water sharing agreement was also signed in 1914 and legislated in 1915.

Droughts hit hard in urban and rural communities, particularly when the drought persists across years. City and town authorities apply water restrictions. In the worst cases, water carting becomes necessary and sheep and cattle losses are high. There is little water for irrigation, crop yields are low, dairy herds are sold off, annual crop plantings (e.g. rice, cotton) are foregone and perennial crops (e.g. citrus, grapes) are reduced. Farmers can be forced to sell their farms when they cannot meet loan repayments, and many rural businesses indirectly dependent on farming income can become bankrupt. All these impacts have significant economic and personal consequences that can be reflected in community fragmentation and rises in mental health problems and suicides. Moreover, recovery can take years after the drought breaks. As droughts hit and people struggle with social and economic hardship, there is always a consequential rise in social concern, even outrage, about water management and political scrutiny consequently escalates.

In the past, the general response of governments was to build new water storages and distribution schemes, and to inter-connect water systems to improve the reliability of water supply. This was frequently because the political imperative was to be seen to be reacting positively and emphatically to the problems of drought. Despite this, there were water security issues in virtually every major drought of the 20$^{th}$ century. Between droughts, much of the increased supply gained through each new dam or augmented system would be consumed by population growth in cities and towns and by new irrigation licences in rural areas. Memories of the difficulties caused by drought would fade and when the next drought occurred the issue of water scarcity would again be raised.

By the 1980s, this approach to water management had resulted in a legacy of debt, poor pricing policies, service delivery challenges, recurring drought-related water scarcity and widespread environmental degradation. In addition, there was limited potential to increase supply in regions of high water demand, due to a shortage of cost-effective, large-scale dam sites or limited groundwater resources. These problems led to the end of the 'build and supply' phase and helped drive a national water reform agenda which was first agreed in 1994 and refreshed and extended in 2004.

## *The Australian water reform agenda*

*The underlying aims of the Australian water reform agenda were to increase the productivity and efficiency of Australia's water use and ensure the health of river and groundwater systems, whilst servicing rural and urban communities and enabling greater responsiveness to changing conditions including drought. During three decades of water reform, four key areas, underpinned by two essential enablers, have been consistently pursued.*

***Transforming water allocation and establishing water markets** – moving from an old administrative method of water allocation which assumed no environmental limits to the resource, to a new system of tradeable water entitlements and water markets, working within sustainable resource limits and providing more flexibility and economic value to individual holders of water rights and to the nation overall.*

***Improving environmental management** – Achieving a sustainable water resource base, to underpin water allocation and the water market, by improving environmental condition through providing a legally-recognised share of water to the environment and tackling over-commitment of water to other uses.*

***Reforming pricing of water services** – applying the principles of consumption-based pricing, full cost recovery, and removal of cross-subsidies, to promote efficient and sustainable use of water resources and assets, as well as financial viability of businesses and provision of adequate revenue streams for service delivery.*

***Modernising institutional arrangements** – transforming old institutions and local water authorities into organisations that were financially viable and could deliver water services to their communities efficiently within environmental constraints.*

***Enabler: Ensuring community and stakeholder engagement in all reform processes.***

***Enabler: Improving water information and water knowledge** – improving metering, monitoring, modelling, water accounting and water knowledge to underpin advances in every element of water planning and management.*

A summary of the Australian water reform process is outlined in a companion document: *The Australian water reform journey: An overview of three decades of policy, management, and institutional transformation.*

## 2.2 Australian water reform at the start of the Millennium Drought

By 2000, when the first impacts of the Millennium Drought were being felt, Australia had made some progress in each of the key reform areas noted above, particularly in Australia's largest irrigated agriculture region the Murray-Darling Basin (MDB), and in the major cities. Secure and tradeable water entitlements had been implemented in most areas. In New South Wales and Victoria these included both high- and lower-reliability entitlements, which had been designed as a mechanism to manage climate variability. The entire MDB, was capped and a small limited interstate water market was operating in the MDB, trading both seasonal water allocations and permanent water entitlements. Statutory provisions for environmental water (environmental flows) provisions had been determined in many river catchments (sub-basins), but there had been little progress in increasing these provisions in over-committed basins, including the MDB.

The service delivery role had been separated from governments' roles in policy, planning and regulation in major urban areas and a number of irrigation regions. Consumption-based water pricing had been introduced in most urban centres, moving towards full cost recovery. Progress had been made on rural water pricing where it had been accompanied by devolution of management to local bodies. However, irrigation was generally still inefficient in its water use and productivity. There had been improvements in water metering and monitoring, and significant research was underway on freshwater ecology and catchment hydrology, to support the reform directions.

Much of this work was both developed and implemented in the MDB, which has been highly significant in the Australian water reform journey. It has been a dominant factor in the water management programs of relevant states for over 100 years. Managing the MDB has required these relevant state governments to work together and with the Australian national government, on common imperatives. In doing so, they have formed long-standing and trusted water sharing arrangements and have jointly developed and tested water-reform solutions. Together, they have worked through issues of water sharing in past droughts, developed strategies to manage salinity, agreed to cap extractions of surface water across the entire MDB in 1995, and set up an interstate water market. The MDB has been the incubator and proving ground for many of Australia's most successful water reforms.

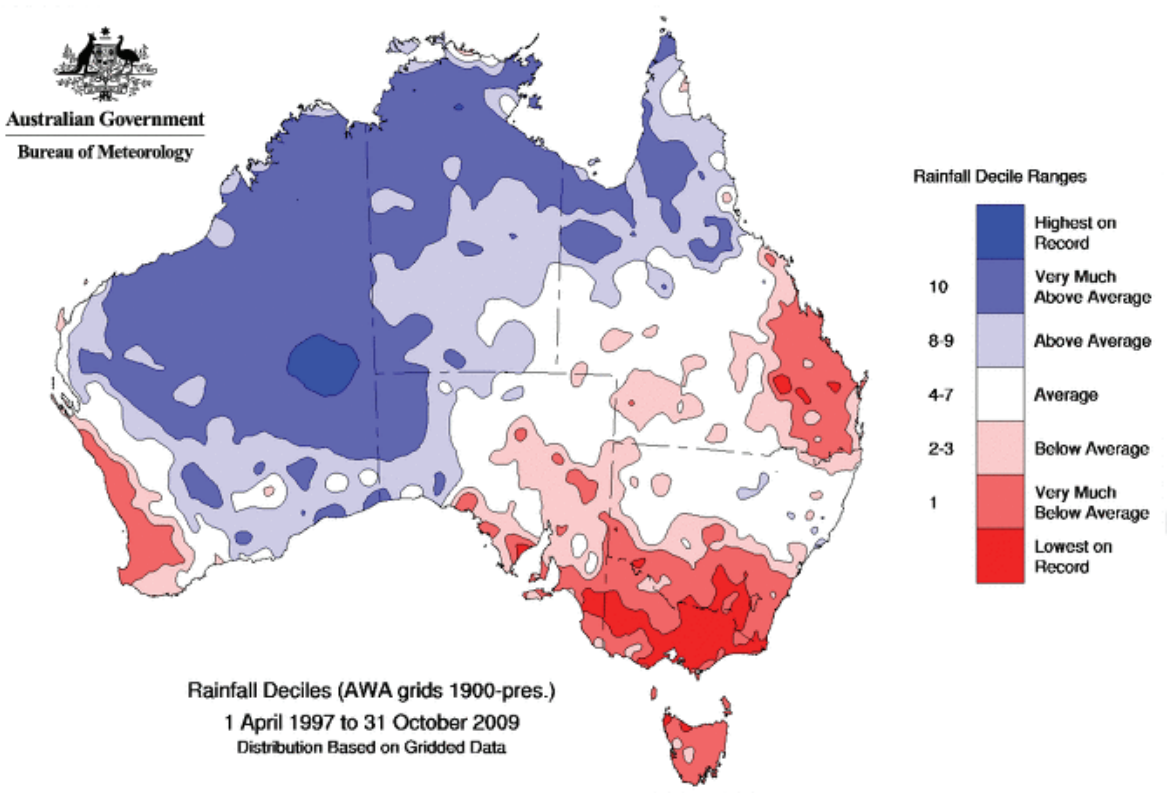
In responding to the Millennium Drought, Australian water managers, communities and industries built on those earlier reform efforts. Throughout this drought, they undertook actions that further progressed the national water reform agenda, enabled communities and industries to survive the drought and made them more resilient to potentially increased water scarcity in future as a result of climate change. These are described in Section 3.

## 2.3 The Millennium Drought – a portent of things to come

The Millennium Drought commenced in late 1996 and lasted through 2009 and into 2010, affecting much of southern Australia (Figure 1). It was the longest most severe drought on record, with a rainfall deficit 73 mm below average (or 12.4% below the 20th century mean) for the years 1997–2009 inclusive.

The geographic distribution of drought conditions coincided with major population centres and irrigation areas. Conditions were particularly harsh in the more densely populated south-east and south-west of the continent, and severely affected the Murray-Darling Basin and Australia's largest cities: Perth, Adelaide, Melbourne, Hobart, Canberra, Sydney and Brisbane. The rainfall deficit was amplified in streamflows, which were reduced by ~46%. From an ecological perspective, the combined effects of river regulation and drought meant that actual river flows were ~80% less than would have occurred under natural conditions. The effects were cumulative and worsened as the drought lengthened. There was long-term drying of water catchments and vegetation, and a drawdown on water resources.

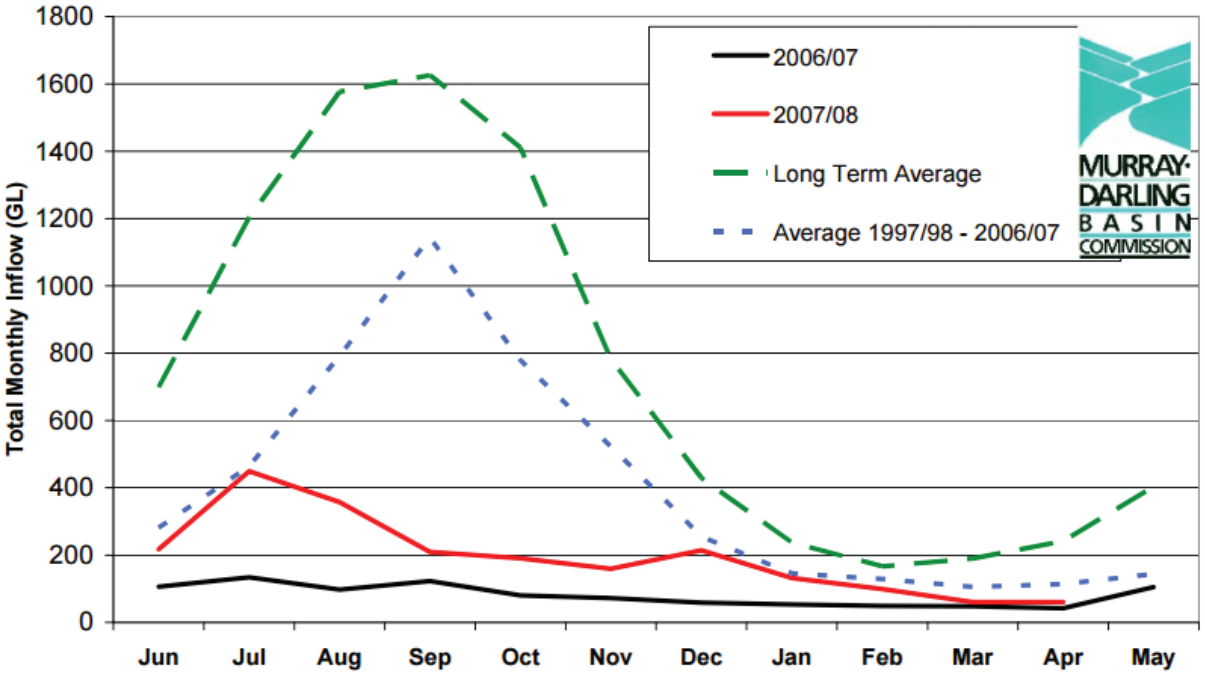
**Figure 1. Rainfall deciles for the Millennium Drought (1997 to 2009)**




(Source: http://www.bom.gov.au/climate/updates/articles/a010-southern-rainfall-decline.shtml).

The year 2006, the tenth year of the drought, was an extraordinary year. Most of the south-east of Australia recorded less than 60% of normal annual rainfall, and some parts experienced their driest year on record, including key catchment areas feeding the River Murray. This resulted in inflows in these areas that were the lowest on record (Figure 2). Following this year, water storage across Victoria was only 26% of the long-term average volume; irrigation allocations in 2007 in the MDB were at their lowest ever; and the large Ramsar-listed lakes at the downstream end of the MDB were at risk of widespread irreversible acidification. The year 2007 was also the driest ever recorded along parts of the Western Australian coast, including the city of Perth, though that region has since experienced even drier conditions.

**Figure 2. Murray river system monthly inflows (excluding Darling River inflows and Snowy River water releases)**

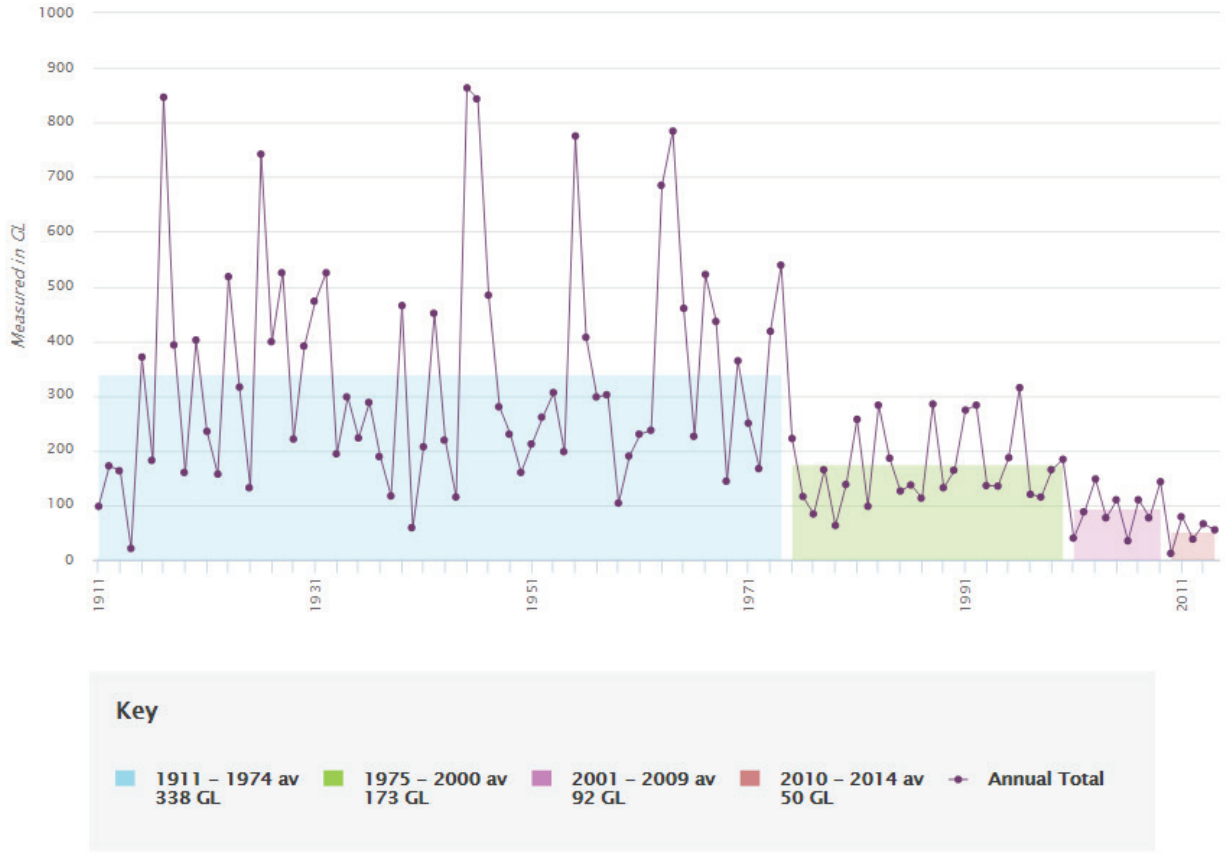



(Source: http://www.mdba.gov.au/sites/default/files/archived/mdbc-drought-updates/MDBC_Drought_Update_Issue_12_March_2008.pdf).

In response to extreme water scarcity, the Prime Minister called an emergency MDB drought summit in November 2006 to assess the situation and determine action. There was particular concern that the level of water scarcity being experienced at the time could worsen in the short term and become more frequent in the longer term with the potential impacts of climate change. The national government commissioned a scientific study to examine the impact of climate change on the surface and groundwater resources of the MDB under a range of climate scenarios. The study results predicted that, in the southern MDB, there would be a median 13% reduction in surface water availability by 2030 under a median climate change scenario. However, also under this scenario, the reduction in extremely dry years could be as much as 70–80% in the parts of the MDB in Victoria.

The general conclusion was that for the MDB and much of southern Australia, the Millennium Drought could be 'the portent of things to come'. Future climate predictions were for a reduction in rainfall and consequentially a more severe reduction in streamflows. Moreover, people in south-east Australia could see what was happening in the south-west of Western Australia. This region had experienced a 10–20% drop in winter rainfall since around 1970. Perth itself had already experienced a reduction of nearly 80% in total annual inflows into its dams since the mid-1970s. (This declining trend has continued ever since; for example, the inflows in 2015 were less than 4% of the annual average inflows prior to the 1970s (Figure 3.) These observations raised the possibility that the south-east of Australia might also experience a significant change, and a prospect of, effectively, never coming out of the drought.

**Figure 3. Streamflows into Perth's dams**




(Source: http://www.watercorporation.com.au/water-supply-and-services/rainfall-and-dams/streamflow/streamflowhistorical/).

This prospect of climate change in general, and in particular the potential that it could occur as a step-change, were significant influences on water managers' responses to the challenges of the Millennium Drought. Effectively, any solutions undertaken needed to work under a potentially drier and more variable future, and to build resilience to future water scarcity.

## *2.4 Impacts of the Millennium Drought*

The 13 consecutive years of drought, including 2007 with the lowest recorded inflows to storages, resulted in conditions well outside the boundaries for which the water-supply systems and water-sharing rules across southern Australia had been designed. The impacts on communities, regional economies and the environment were severe.

Water-use restrictions were imposed in most capital cities and regional towns across Australia. In the later years of the drought, water restrictions were at maximum level – in most cases allowing only indoor use, or in some cases allowing minimal watering of gardens. By July 2007, some 457 towns in Victoria were subject to restrictions and a number of them had been on the maximum level (indoor use only) for up to three years. Some towns were carting in water to meet essential needs because no other feasible supply options were available. Water to maintain public open spaces in urban areas was strictly limited. In parts of Melbourne as the drought persisted, only one in four sporting ovals could be watered. A number of local governments were carting treated wastewater to support significant trees and priority parks. The economic costs of these restrictions were estimated to be in the order of several billion dollars per capital city, although there was considerable debate around some of these figures.

In the irrigated agriculture sector, losses were felt everywhere but were particularly harsh in the MDB. Production of annual crops in the basin fell sharply between 2002 and 2009; irrigated rice production was cut by 99% and cotton by 84%. Production of perennial crops was 32% lower in the period 2003–2007. Between 2007 and 2008, Gross Regional Product in the southern MDB fell 5.7% below forecast and was accompanied by the temporary loss of 6000 jobs. In the Murray region, there was an estimated loss of AUD70 million in tourism revenue in 2008 because of the fewer visitors. By mid-2010, the Australian Government had paid out AUD4.4 billion in direct drought assistance to farmers.

From a social perspective, the drought caused significant hardship particularly in rural communities. They experienced loss of employment and household income, downturns in local business, reduced recreational opportunities as local lakes dried up, and a general break in social cohesion, with flow-on effects of increased mental health problems and suicide rates.

From an environmental perspective, the reduced streamflows, which were amplified by the effects of river regulation and compounded by loss of habitats, caused significant environmental damage. For example, in 2007, over 70% of River Red Gums along the River Murray were found to be declining or dead. In 2008, waterbird numbers in eastern Australia were reduced to one-third of those found in normal non-flood years, and water levels in the system of Ramsar-listed large lakes at the lower end of the River Murray were 0.5 m below sea level, as well as at high risk of widespread acidification (from where continually waterlogged sediments, rich in iron sulphides, are exposed to air as wetlands dry up for the first time).

The unprecedented nature of the Millennium Drought, particularly its extent, length and severity, put the ‘blowtorch’ on the water policies and management arrangements existing at that time. Faced with the prospect of more frequent and deeper droughts in the future, building resilience to future water scarcity became a critical objective for Australian governments.

# 3 Water management responses to the Millennium Drought

Under the Australian Constitution and Commonwealth legislation, state and territory governments have responsibility for land and water management, and the Australian national government has an oversight, facilitation and funding role, particularly in the Murray-Darling Basin. Whilst each state government took its own decisions in response to the impacts of drought in its jurisdiction, they all generally worked with the national government on key issues throughout the period. In the MDB, the partner governments worked together under the existing partnership arrangements to manage water sharing, river management and other trans-boundary water issues. However, this fully-shared governance model was challenged and modified in the later years of the drought.

Looking back on how governments responded to the Millennium Drought, both individually and jointly in the MDB, the general approach was not just to 'get through the crisis' but to develop new policies and approaches, and to make investment decisions that would build greater resilience to drought over the long term. Across the country, contingency measures were introduced, policies were reviewed, system management was improved, infrastructure was upgraded, augmentations were brought forward and knowledge and understanding of climate variability was increased. In general, the process was to make decisions and undertake actions that:

- built on and were consistent with existing national water reform policy and directions;
- would continue to be effective under drier or more variable future climates and would build resilience to drought;
- balanced economic, social and environmental objectives and outcomes;
- improved water-use efficiency and promoted water conservation;
- enhanced the operation of water markets;
- enabled all holders of water entitlements – including irrigation farmers, urban water authorities and environmental-water managers – to make choices and manage their own water-shortage risks;
- embedded drought-planning across all sectors.

The drought raised major issues for irrigation farmers, for cities and towns and for the environment. The following sections of this paper describe the major responses by governments and local water managers in each of these sectors. The paper also outlines the significant decision of the national government to rebalance the MDB over the longer term, as the actual effects of over-commitment became obvious during the drought.

Nevertheless, all these sectors continue to rely on the basic framework for water entitlements and planning and systems operation, which underpins how water is managed in each Australian state and territory and nationally. The framework was the fundamental base for each sector's responses to the drought, and upon which the water market is based. Improvements were made to the operation of these entitlement and planning frameworks to enable better functioning under water scarcity and build resilience to drought.

## 3.1 Improving water allocation and system operation and facilitating the water market

Creating a system of tradeable water entitlements and establishing water markets have together been a key direction of the Australian water reform agenda since its inception. Water entitlements are provided to urban water authorities to deliver water to urban communities and industry, to individual irrigation farmers and to the environment and each sector is expected to manage its own risk during droughts. By 2000, in the early years of the Millennium Drought, secure and tradeable water entitlements had been established in almost all jurisdictions. Across the entire MDB surface water extractions were 'capped' – that is, no more water could be legally taken from surface waters for human uses. An interstate water market was operating in a limited way, enabling trading of both seasonal water allocations and permanent water entitlements.

The water market, particularly in the MDB, is critical in managing through droughts as it enables entitlement holders to make their own water use decisions and mitigate their supply risk through trading. Irrigators can choose to sell their seasonal allocations or buy additional water on the market according to their own business needs, financial position and risk appetite. Urban water authorities can sell surplus water or buy additional allocations to top up supplies. However, the initial provision of water entitlements, the annual processes for determining seasonal water allocations to these entitlements and the operating rules for regulated water systems that delivered water to entitlement holders had all been designed on the basis of historic climate records. By 2007, after the lowest ever recorded inflows, many of the regulated water systems had such low volumes of water in storage that they could no longer be operated as designed or as the entitlement rules described in individual river catchment or sub-basin water-sharing plans. These systems were having to be operated in conditions that were outside of all previous planning horizons. In some systems, under the normal sharing arrangements, there was insufficient water to provide for essential human needs in urban communities.

Within the MDB, the extreme water scarcity during the Millennium Drought tested the long-standing agreed interstate water-sharing arrangements. At the highest level of water sharing between states, there was insufficient water to provide for essential needs in Adelaide (the capital city of South Australia) under the normal arrangements, should the extremely dry conditions persist. In addition, there was not enough water available to operate many parts of the connected irrigation systems because of large operating losses inherent in these systems. This meant that, overall, there was very little water available, and such water as was available could often not be delivered to entitlement holders; as a result, the water market could only operate in a very limited way.

Water management responses to this situation fell into two broad categories:

- Determining how to share water in extreme water scarcity to provide for critical needs
- Providing more choices for entitlement holders and facilitating water market operation in dry years

Each of these is briefly described below. However, it should be noted that the actions taken did not change the nature of the secure tradeable water entitlements held by water users. They simply defined how they would operate under extreme scarcity, provided entitlements holders with some additional flexibility and facilitated the operation of a water market under very dry conditions.

## Providing for critical needs during extreme water scarcity

Determining how water should be shared during extreme water scarcity became a critical issue. This only occurred when water resources were so depleted that the existing sharing arrangements were no longer adequate to supply critical needs in the short term. In these circumstances, the legislation in all states enables the relevant Minister to intervene to declare new temporary rules for how water must be used to meet critical needs during the water shortage. In Victoria, the situation is managed through a temporary 'qualification of rights' process. In New South Wales, it is managed through a temporary 'suspension of water sharing plans', and legislation then specifies the priorities for sharing the available water. For water sharing between states in the MDB, there are special provisions in the Murray-Darling Agreement between governments to enable this to occur. In most cases, these powers were required in situations where there was insufficient water to provide for essential human needs in towns. The most common solution was to reduce 'passing flows' normally provided for environmental purposes, thereby making more water available.

Until 2006, these ministerial powers had rarely been used. However, because of the unprecedented severity of the Millennium Drought they were used in many river systems across the MDB and southern Australia between 2006 and 2010. This was the first time it had been necessary to use these powers so extensively, and it became necessary to clarify the rules for triggering when interventions should be allowed, and then determining water sharing in these extreme circumstances. In general, there were two policy principles underpinning these 'ministerial intervention' processes:

- they were only to be implemented when all other reasonable contingency measures had been exhausted; and
- under a ministerial intervention, as water became available, it was to be allocated according to a hierarchy of supply priorities. As the first priority, water was to be provided for essential (or critical) human needs, including domestic water supply for towns (under severe restrictions) and landholders' basic rights. Next priorities were critical environmental needs and essential commercial and industrial use.

The hierarchy of supply priorities differed slightly depending on the complexity of the system and the types of water users in it. However, in all situations, the top priority for the allocation of water under extreme water scarcity was the provision of 'essential human needs'. In addition, Victoria required the beneficiaries of the ministerial intervention to pay to manage and mitigate any impact on other parties whose rights were affected.

Within the MDB, states were willing to temporarily modify their water sharing arrangements, through a system of borrow and pay-back, to ensure that critical human needs could be met through the period of extreme water shortage. Throughout these negotiations, it was crucial to identify the relative beneficiaries and equity implications at each point. Once critical human needs were assured, states then aimed to provide sufficient water to enable water delivery and assist the water market to operate.

After the drought, formal government policy guidelines were modified to include the experience gained from working through the temporary sharing of water and operation of highly regulated systems in extreme water scarcity. Water sharing between governments in the MDB was codified in a three-tiered set of water sharing arrangements in the Murray-Darling Basin Plan, to enable the provision of 'critical human needs' at different levels of water scarcity.

However, ministerial interventions are a 'least preferred' option in dealing with water scarcity, given the third-party impacts on the environment and potentially on other users. The preferred solution is that entitlement holders manage within their water entitlements and use the water market to mitigate their risk. During the drought, significant action was taken to augment urban water supplies (described in Section 3.3) to minimise the need for ministerial intervention in the future.

### Facilitating water market operation in dry years

The water market, particularly in the MDB, is seen as critical in enabling entitlement holders to make their own decisions in drought. It is a particularly important mechanism in drought because it enables the water available in the system to move to the highest value use. However, for water markets to function, some water needs to be available, and there needs to be sufficient volume in the system to ensure water can be delivered to entitlement holders.

Years like 2007, when there were initial seasonal allocations of 0% in many parts of the system, challenge the efficiency of market operation. Moreover, the number of these years was predicted to increase under climate change. Water managers looked at ways to change the operation of the system to ensure that water could be delivered in very dry years and thereby enable the water market to operate.

A critical change was the widespread introduction of 'carryover'. Under the previous rules, if a water entitlement holder had not used all of their seasonal allocation by the end of the water year, the remaining water was simply absorbed back into system. Introducing carryover enabled holders of water entitlements to, effectively, 'bank' some of their allocation in storages for use in the following year. Carryover had been possible in some systems in Queensland since the 1980s and was introduced in New South Wales in the mid-1990s for holders of lower-reliability entitlements. Victoria introduced it for all their water entitlement holders in 2006–07, as did South Australia, enabling it across the whole MDB. It was initially introduced as a temporary measure to mitigate the effects of drought. However, the widespread application of this provision has been very successful and it has since been made a permanent aspect of most regulated water systems across the MDB and south-eastern Australia because it allows individuals to manage their own risks of supplies in the future. Generally, the opportunity to carry over allocation has been increasingly used by irrigators, water corporations and the environment.

Carryover is particularly important for irrigators during low allocation years because, provided the system is operational, it means water they have saved from the previous season is accessible to them at the beginning of the next season when allocations are likely to be low. Urban water authorities connected into these water systems in Victoria now use carryover to help manage through dry years and avoid severe water restrictions. Carryover also gives environmental water managers greater flexibility to manage important environmental assets and ensure survival of aquatic plants and animals in the years of greatest water shortage. In drought years when allocations are very small, water carried over from previous years can be used to provide a minimum supply for river systems or to top-up drought refuges.

The carryover arrangements have improved the operation and use of the water market. Many irrigators are now buying at the end of the season to set themselves up for the following year and mitigate their risk. They can decide to sell their carryover water early the next season, thus releasing more water into the water market in those critical early periods.

The introduction of carryover was possible in a number of Australian systems where there is significant storage available. It required considerable effort in policy development to ensure equitable arrangements, adequate charging policies and clear rules for covering storage spills. It also required advances in hydrological modelling and water accounting to keep track of the decisions made by individual holders of water entitlements.

Water managers also reviewed the system-reserve rules in large regulated systems, to provide greater surety that water would be able to be delivered in dry years. They also refined procedures for the allocation of water against entitlements, to take account of the new low-flow regimes that were being experienced. Overall, the changes made to processes for water allocation and sharing and to system operations during the Millennium Drought provided entitlement holders with greater flexibility and facilitated water market operation under very dry conditions. All these adjustments were aimed at building greater resilience to drought.

## 3.2 Irrigation

It was very difficult for irrigators throughout the drought, particularly in the MDB. In very dry years like 2007, seasonal allocations at the start of the irrigation season were at 0% for irrigators in most parts of the distribution system, and at 10% in some areas. The water market became a critical tool for irrigators, enabling them to decide whether to plant a crop and potentially buy more water or to sell their water allocation to realise cash. Use of the market increased significantly during the drought, and the market continues to be well used; since 2007–08, about 30% of water allocated in any water year has been sold. In many cases, water was traded to support high value perennial plantings in the drought, and as a result the production of lower value annual crops (such as rice and cotton) dropped to almost zero in areas that were reliant on surface water. The market provided flexibility for irrigators to adapt their businesses to water scarcity and enabled irrigation industries such as horticulture to survive.

The combination of the water market – which provided a realisable value for water – and water scarcity created a drive for efficiency in irrigation, both on-farm and at the system level. During the Millennium Drought, in the critical period between 2005–06 and 2008–09, although there was 53% less water available for irrigation, the gross value of irrigated agricultural production only fell by 29%.

Given the evident importance of the water market to irrigators and the need to improve water use efficiency, governments responded in two main ways to help build resilience to drought:

- facilitating the operation of the water market during extreme water scarcity; and
- investing in ways to make irrigation farms and delivery systems more efficient over the long term.

As already discussed in Section 3.1, the first response involved widespread introduction of carryover provisions enabling entitlement holders to ‘bank’ water for the following year, and changes to some of the system management rules to reduce the likelihood that irrigation years would open with zero allocations in future. The second response is discussed below.

Both these reforms provided more flexibility and choice for individual irrigators and enabled the water market to function in extreme water scarcity.

### Investing in water-efficient irrigation: a long-term measure

Australia’s national and state governments have invested heavily over a long period to make irrigation more efficient and achieve economic and environmental outcomes. Currently, government funding programs are investing in modernising irrigation systems to save water. Old distribution infrastructure is being renewed with modern equipment and technology that improve the efficiency of water delivery and use. The modernisation includes automating channels, lining channels to reduce losses or installing piping, and upgrades to metering. It also involves rationalisation, in which some irrigation areas are being modified to provide a different level of service, and others are being shut down and the formerly irrigated land returned to dryland uses. The overall water savings are converted to water entitlements either for water users or for the environment.

As an example, in northern Victoria, the national and state governments and the Melbourne Water authority are investing around AUD2.1 billion in a large-scale modernisation project. When completed, the project will have saved ~435 GL, of which ~285 GL will have been provided to the environment, 75 GL to Melbourne to augment its urban water supply and 75 GL to irrigators.

Governments have also been investing in programs to make irrigation farms more efficient in their water use, enabling individual irrigators to upgrade the watering systems on their farms. In return, in some programs, irrigators are required to give back some component of their water entitlement, which is then provided as an entitlement for the environment.

The national government's investment, in recent years, has been made as part of its initiative to reset the water balance in the MDB. This is discussed in more detail in section 3.5. Under this initiative, between 2008 and 2019, the national government is investing AUD$2.245 billion in irrigation modernisation and an additional AUD $491 million in on-farm programs across the MDB. It also has a water purchase program where the government buys water entitlements for the environment from willing irrigation farmers on the water market. These programs are aimed at achieving a new sustainable water balance in the MDB in the longer term and assisting irrigators and irrigation industries to permanently adjust to a new, lower diversion limit. As the government programs have rolled out, they have offered irrigators options that have eased some of the impacts of the drought.

Apart from specific programs to improve water efficiency in irrigation in the MDB, governments have also provided direct drought assistance to irrigation and dryland farmers: for example, providing rebates on water bills, drought employment programs, support services such as financial and personal counselling and financial assistance. In 2008, governments undertook a national review of general drought policy and programs affecting all agricultural producers. As a result, drought assistance programs were restructured to improve the capacity of primary producers to manage business risks and build greater resilience to drought.

## *3.3 Urban water management*

Most Australian urban water authorities had well-developed drought contingency plans which had been designed based on historical records of rainfall and climate. The duration and severity of the Millennium Drought produced conditions that were far worse than anything that had been planned for. As water scarcity hit and worsened over the 13 years of drought, urban water managers dealt with the crisis in three complementary ways:

- reducing water demand;
- providing contingency supply; and
- diversifying and augmenting water supplies.

### Reducing water demand

Urban water authorities implemented a sliding scale of water restrictions on residential properties: the most severe restriction levels limited households to indoor water-use only. In general, restriction levels increased as water storage decreased in dams or in river flows. By 2007, the capital cities of Brisbane, Sydney, Melbourne, Adelaide, Canberra and Perth and most regional towns in south-east Australia were on restrictions that limited water use to indoor use, though some allowed a little water for gardens (for example, in Sydney hand-held hoses or dripper systems could be used on two days per week between 4 pm and 10 am). Analysis of the impact of restrictions in Sydney between 2005–06 and 2008–09 estimated they saved in the order of 60 L per person per day.

The use of restrictions for residential use was coupled with the introduction of water conservation programs that encouraged more efficient use of water both in households and in industry. For households, mechanisms included exchanging old shower heads for more efficient types and giving out free shower timers, providing rebates for purchases of water-efficient appliances and products, providing rebates for installing rainwater tanks and greywater reuse systems, and introducing household water audits and programs of replacing toilets with models using less water. In Melbourne, 460 000 showerheads were exchanged between 2006–07 and 2010–11. In Sydney, 28 000 toilets were replaced between 2008 and 2011 with each toilet replacement saving an estimated 22 kL per household per year. Water conservation in gardens was encouraged by rebates for more efficient watering systems and encouraging the use of drought tolerant vegetation in domestic gardens, public parks and sporting facilities. Non-residential consumers such as industry and local governments were also offered incentives to identify ways to reduce water use and adopt alternatives where possible.

In addition to rebates for installing rainwater tanks and/greywater tanks at existing homes, building regulations were changed in Queensland, New South Wales and Victoria to require improvements in water efficiency and reductions in water use in new dwellings. Many of these made it mandatory to install rainwater tanks or similar water- or energy-efficiency measures in new houses. In addition, a number of new developments incorporated third-pipe systems for use of recycled water, making that a feature of their suburban design and a selling point to new home buyers. As a result, there are now whole suburbs that have third-pipe systems in place in Australian cities.

Alongside these initiatives, governments also ran behavioural change campaigns. The most notable was the T140 campaign in South East Queensland (SEQ) which aimed to reduce residential water-usage to 140 L per person per day. A similar program in Melbourne, T155, invited people to use no more than 155 L per person per day. These were generally very successful. In SEQ the combination of restrictions, water conservation programs and behavioural education in 2007–08 reduced water consumption by 60%, from pre-drought volumes to an average 125 L per person per day. In Melbourne, the combination of approaches saved over 250 GL between 2002 and 2007, allowing authorities time to augment supply (Figure 4). Moreover, despite the return to wet conditions in Melbourne since, there has only been a minor bounce-back. Usage was reported at 160 L per person per day in 2014–15, suggesting that many of the water-saving initiatives have effectively become ‘hardwired in’, and that people remain committed to water conservation.

**Figure 4. Historical Melbourne system storage and demand.**


(Source: Office of Living Victoria (2013). *Melbourne's water future*. Melbourne.)

## Provision of contingency supply

Urban water authorities identify contingency options for water supply in their drought plans. However, given the length and severity of the Millennium Drought, particularly through the years 2006–2009, urban water authorities had to implement a number of their contingency options in short succession and within very short timeframes, and then look elsewhere to identify new contingency options to increase their immediately available supplies. These included pumping dead storage, installing emergency groundwater bores, using temporary pumps in nearby rivers and streams, applying evaporation retardants to minimise evaporation losses, resurrecting old disused connections, and disconnecting wetlands. In many systems, normal water sharing arrangements were suspended, with ministerial interventions (see above) when there were no feasible alternatives, and environmental passing flows were reduced to provide additional water to meet essential human needs in towns. Water carting was implemented to supply water to a number of small rural towns. As they ran out of short-term options, the authorities began to consider long-term augmentations to supply. A number of regional water authorities started to connect their systems together, which allowed them to manage more flexibly within their combined water entitlements.

## Diversifying and augmenting water supplies

Finally as the drought continued, most major cities and many towns had to augment their water resources. Many urban water authorities looked at a range of options to diversify their supplies, enable more efficient use of existing regulated supplies, and be effective in a drier future.

A number of water authorities augmented their water supply networks from groundwater resources. Some within the southern connected MDB bought permanent water entitlements from irrigators on the water market. A number of systems interconnections were built so that water in regulated systems could be used more efficiently over time. Several of these, notably in Victoria, SEQ and Perth, connected very large systems, creating the concept of water grids. These enable water authorities to move water across their grids to where it is needed most, making more efficient use of available resources and effectively increasing the overall reliability of supply.

Generally, water authorities tried to increase their use of recycled water and storm water during the drought as a substitute for potable water, where it was appropriate for the use. Suitable purposes included agriculture, watering sporting grounds and public open space, and industrial use. A number of these non-potable sources became ongoing elements of the supply portfolios. Some authorities experimented with managed aquifer recharge, taking the opportunity to work through a number of the regulatory issues involved. Perth now has a system of aquifer recharge operating with a high level of community acceptance.

In addition, there was major investment in desalination as a rainfall-independent water source. Prior to the drought, there had been very few desalination plants in Australia; by the end of the drought, Perth, Melbourne, Brisbane, Sydney and Adelaide had all built desalination plants at a collective cost of over AUD10 billion. Many of augmentation projects had to be completed quickly and were costly and, in some cases, highly controversial. Most were funded through water pricing. Water prices rose rapidly as a result, for example doubling in Melbourne over five years, adding to the controversy.

As a result of the Millennium Drought, most Australian towns and major cities now have augmented their water supplies to ensure a greater degree of drought resilience and to avoid having to rely on taking additional water from the environment during times of water scarcity. Their supply portfolios now have a more diverse range of water sources and are less reliant on rainfall. Behavioural change programs have reduced demand and the new behaviours appear to have been hardwired in, not changing much after the drought broke. Drought-planning has become far more sophisticated, with multi-year scenarios and contingency planning. Water authorities have put much greater emphasis on the levels of service they provide, and they consult with the community on the frequency, duration and severity of restrictions and what that may mean for water costs and prices. Water planning is now informed by better understanding of system reliability and resilience, including the potential impacts of future climate scenarios.

## *3.4 Environment*

In Australia, water is provided for the environment through water planning and allocation processes. In these processes, for each major water system, the major stakeholders representing the various water-use interests (such as local irrigator groups, irrigation industry associations and environmental non-government organisations) and their local communities work together with water managers to negotiate outcomes that recognise the rights of existing water users, establish resource limits and identify an initial share of water for the environment. This negotiated process ensures the sustainability of the water system and underpins the water entitlement and trading regimes. In over-committed water systems, the initial share may not be sufficient to maintain environmental values over the longer term, and programs may be established to improve this situation over time.

Water for the environment is provided as a legally recognised share of the available water in the water system. Rules have been established for all rivers, governing when and how water can be taken for consumptive uses. In some highly developed regulated systems the rules providing passing flows for the environment are supplemented with specific water entitlements for the environment (with the same characteristics as for irrigators and other water-using industries). In 2000, at an early stage of the

drought, most water systems had established 'passing flow' (minimum flow) rules for the environment and a number of regulated systems, had, in addition, specific environmental entitlements. The volumes of these entitlements increased over time as government investment in irrigation efficiencies provided more water for environmental use in the over-allocated MDB water systems. At the same time, seasonal and annual water allocations were declining because of the persistent drought conditions.

From an environmental perspective, several important issues arose during the drought.

- In situations of extreme water scarcity, ministerial interventions to supply essential human needs generally reduced 'passing flows' in rivers, thereby exacerbating the impacts of the drought in those environments.
- In regulated water systems where water is provided to environmental entitlements (in the same way as for irrigators), environmental water managers had to choose the most effective and efficient ecological use of that water and be able to justify its use to the community.
- There was considerable community concern about using water for the environment during extreme water scarcity, with some sectors calling for environmental water to be transferred to irrigators and others questioning the basis for decisions on its use.

Responses of environmental water managers during the drought included:

- ensuring environmental protection was considered in the development of rules for water sharing during extreme water scarcity;
- developing a 'seasonally adaptive framework' for deciding on the best use of available environmental water and providing a clear and transparent rationale for decisions;
- using environmental water efficiently.

### Providing environmental protection in water sharing in extreme water scarcity

As described in Section 3.1, all Australian jurisdictions had legislation that enabled ministerial intervention during extreme water scarcity when water resources were so depleted that existing sharing arrangements were no longer adequate to supply all basic needs. Generally, when this occurred, passing flows in rivers were reduced to provide for essential human needs. In addition, along the River Murray, floodplain wetlands and large lakes were deliberately disconnected from river flows, by closing 'regulators' and by other means, to save water for critical human needs. Although there was nothing else that could be done, these actions meant that the impacts of water sharing during extreme scarcity were disproportionately borne by the environment.

When governments later began to codify the rules governing the triggering of such actions and how they should be managed, they included mechanisms to minimise the impacts to the environment as far as possible. In Victoria, the mechanisms ensured that the ministerial intervention would only be triggered when all other reasonable contingency measures had been demonstrably exhausted. When intervention was triggered, 'critical environmental needs' was included as a category in the 'heirarchy of supply'. Similar arrangements were put in place in New South Wales. Across the MDB, the new Murray-Darling Basin Plan included three water sharing tiers as a framework for adjusting water sharing arrangements during extremely dry conditions. In addition, in Victoria, a further requirement was added – that the water authority benefiting from the extra water had to pay to manage and mitigate the negative impacts on any parties whose rights had been affected, including the environment. Under this condition, some water authorities 'paid back' water when conditions improved. Others paid for complementary environmental restoration works to mitigate the impact of further reductions in flow.

Whilst most of this policy development occurred only towards the end of the drought, it did mean that ministerial interventions, when required, considered and mitigated as far as possible their impacts on the environment. Moreover, there has since been significant investment in augmenting water supplies, which should reduce the need for the scale of ministerial interventions that occurred in the Millennium Drought.

## Using environmental water in drought

In regulated systems where water entitlements have been provided for the environment, seasonal allocations are made as for all other water users. Just like irrigation farmers, environmental water managers make the decisions about how that water should be used. In highly regulated and interconnected water systems like the MDB, environmental water managers have considerable discretion in how, when and where to use environmental water. They may focus on particular parts of the flow regime (for example, releasing water for summer baseflows or to augment spring flushes), or decide to water particular river reaches or wetlands, and they may have a choice of river systems that can receive the environmental water. They can decide how much allocated water to use in any one year and how much to carry over in storages for the next or later years, and how much, if any, should be traded to consumptive users. In making these decisions, environmental water managers aim to achieve the *greatest environmental benefit for the volume of water applied*. They have a clear policy framework that enables them to evaluate a range of competing environmental uses for the water, on the basis of six criteria:

- extent and significance of expected benefit;
- certainty of achieving the benefit;
- ability to provide benefits over the long term;
- implications of not undertaking watering actions;
- feasibility; and
- overall cost-effectiveness.

Using these criteria, environmental water managers can justify their allocations and use of environmental water, and explain them to local communities. However, in the depths of the Millennium Drought, the situation was so dire that the 'greatest environmental benefit' actually became 'the avoidance of the greatest environmental loss'. It became clear that the framework for decision making needed to be expanded to deal more effectively with water scarcity and climate variability.

To revise the framework, environmental water managers considered how Australia's natural freshwater systems cope with variability in water supply. Based on that knowledge, the framework was expanded to include a new broad policy goal: that is, ensure that the most important environmental assets have the best chance of surviving water scarcity, and ensure that river and wetland systems are resilient enough to recover in wetter years.

The additional goal did not change the framework's long-term objectives for river and wetland health, and it was a valuable guide in annual planning for the use of environmental water and complementary river restoration activities under different water resource scenarios. The policy framework became seasonally adaptive: that is, in extremely dry years, priority would be given to protecting drought refuges, avoiding irreversible loss and catastrophic events. In dry years, priority would be given to maintaining ecological functioning. In average and wetter years, priority could be given to recruitment and recovery (Figure 5). This approach provided a rationale for decision-making which made sense to local communities. It showed that the environment was like everyone else in needing to make hard decisions during drought. It helped defuse some of the controversy around using environmental water during severe drought, and improved the 'social licence' under which environmental water managers operate. This approach has since been adopted universally in Australia and governs the use of both state and national environmental water.

**Figure 5. Environmental watering objectives under different climatic scenarios.**


(Source: http://www.vewh.vic.gov.au/__data/assets/pdf_file/0010/340003/VEWH0020_SeasonalWateringPlan_2016_Book_v8accessibility.pdf)

Using this framework, each year, environmental managers identify environmental watering priorities for a range of potential climate scenarios. Decisions are then made according to how the year actually turns out.

## Efficient environmental water delivery

During the drought, all sectors were encouraged to become as efficient as possible, and this included environmental water management. The aim, just as for every other sector, was to get the best outcomes possible with the least volume of water and to demonstrate this to the community.

Environmental water managers set about achieving this outcome in two ways. First, they worked with system managers to allow consumptive water to be delivered to end-users in such a way that it could benefit the riverine environment along the way; that is, the consumptive water could have positive environmental outcomes with no negative impacts to its target water users. One method was to negotiate 'piggy-back' delivery of environmental water, applying it to augment the peak or extend the duration of consumptive flows to achieve environmental outcomes. In other situations, negotiations enabled consumptive water to be delivered via routes that provided better environmental outcomes, but also resulted in greater system losses, which were compensated for using environmental water. Some very innovative solutions were found which produced significantly greater environmental benefits than would have otherwise been possible using environmental water alone.

Secondly, environmental water managers applied engineering to supply water to floodplain lakes, wetlands and forest areas which under natural conditions could only be reached when there was widespread over-bank flooding. Solutions included the use of pumps, temporary weirs and pipes, and using irrigation channels to deliver environmental water. Many of these solutions started as temporary measures to provide some relief during the drought. They were found to be so effective that large-scale permanent works have now been built in a number of locations to water important areas of floodplains. This should mean these areas can be maintained even if climate change brings a future with deeper and longer droughts.

The provision of environmental water entitlements, the development of the 'seasonally adaptive' approach to managing environmental water, and the application of environmental works and measures to make the most efficient use of environmental water were all advances that resulted from experience in the Millennium Drought. These, coupled with complementary river and wetland restoration activities, are aimed at building both environmental resistance and environmental resilience to drought.

## *3.5 Rebalancing the Murray-Darling Basin*

The sections above describe responses of Australia's governments and their water managers to the Millennium Drought in relation to water allocation processes and the management of urban, irrigation and environmental water. All responses were intended to manage water supplies through that drought and to build resilience to water shortages in the future. However, one of the most significant responses to the Millennium Drought was the decision of the Australian Government to rebalance use of the water resources of the MDB.

Under the agreed governance model for the management of the MDB, key decisions require the collective agreement of the partner governments of the MDB: that is, the national and the five state and territory governments.

This governance model based on consensus decision-making was challenged in the Millennium Drought. The emergency MDB drought summit called by the Prime Minister in November 2006 was the trigger for the states to temporarily modify their water sharing arrangements, to manage through extreme water scarcity. However, drought conditions coupled with the predictions of a climate change study clearly showed that the water resources of the MDB were still over-committed, even after previous initiatives by the partner governments to increase water for the environment.

In 2007, because of the national significance of the MDB, the Australian Government intervened in management of the basin. The Government announced a major and comprehensive AUD13 billion program to reset the balance between environmental use and consumptive use, and put the MDB onto a sustainable footing over the longer term. In doing so, the Government aimed to significantly improve the health of rivers and wetlands of the basin, while maximising the benefits for irrigators and local communities. The program involved the passing of new national legislation, and the development of a Basin Plan that set a new lower 'sustainable diversion limit' (that is, a new upper limit for water use) for the MDB.

Significant funding programs were provided to reduce the volumes of water used for consumptive purposes to the new sustainable diversion limit, and to support irrigators and their communities in adjusting to the new balance. Programs included purchase of water entitlements from willing irrigation farmers via the water market, and investment in water-efficient irrigation (see Section 3.2). In some cases, the adjustment involved irrigation communities making collective decisions about their future viability, closing their entire irrigation system and selling the water to the Australian Government. Whilst these programs were opportunities for irrigators to gain substantial funding assistance, they required irrigators to make difficult decisions about their future: that is, whether they would continue to be irrigators, and if so what their business model would be. Despite the levels of funding available, the rebalancing initiative has met significant opposition from irrigation communities and industries, given that it requires considerable adjustment, over time, to adapt to the reduced volume of water available for irrigation.

The water recovered for the environment is managed by a new national entity, the Commonwealth Environmental Water Holder, whose role is to use the recovered water entitlements to achieve new environmental objectives for the MDB. As at February 2016, the Commonwealth Environmental Water Holder held a total volume of 2410 GL of water entitlements of varying reliability in the MDB. State governments also have adopted similar statutory or regulatory positions to manage environmental water delivery within their state borders.

The initiative to rebalance the MDB has fundamentally altered governance over water allocation in the MDB – from the 90-year old partnership model to one in which the national government sets the sustainable diversion limits and the states are required to comply, assisted by the funding programs. The partnership model is retained for other matters, such as environmental and river management.

The Australian government's MDB rebalancing initiative was conceived in response to the Millennium Drought, which revealed clearly the impacts of extreme water scarcity over a long period on the MDB's urban and rural communities, irrigation industries and environments. Although some of the funding programs were of significant assistance to irrigators through the drought, helping them lift their efficiency and providing opportunities to sell their water entitlements for cash, the rebalancing program overall is a much longer-term investment. It is forward-looking, moving the MDB towards sustainable water resource management in the basin, adjusting irrigation to a lower diversion limit and building drought resilience for a drier future.

# 4 Lessons learnt

All parts of the Australian water sector learnt a number of lessons from the experience of the Millennium Drought, including government policy makers, urban water authorities, water system managers, the irrigation industry, irrigation farmers and the community in general. As a result, changes have been made to water allocation frameworks, urban and environmental water management and use, irrigation systems and practices. New augmentations have been undertaken, all of which have built greater resilience to water scarcity and drought. These are now embedded in the way water is managed, used and valued across Australia.

Among the many changes made here, eight key lessons may be of interest to other countries confronting water scarcity.

1. Understanding that minimum rainfall records can be broken.
2. Importance of drought planning as a normal part of water resource planning and management.
3. Importance of the water market.
4. Enabling entitlement holders to manage their own risk.
5. Pursuing water use efficiency in all areas: household, commercial, industrial, mining, irrigation, environment.
6. The need for a diverse portfolio of water supplies, encompassing direct use, reuse and desalination options.
7. Understanding community impacts and providing good communication and support.
8. The need for improved climate and stream-flow forecasting.

## Records can be broken

Australian water managers thought they were prepared for drought. They had drought plans in place. They had worked through plans for their next augmentation. They understood how their systems would run and how water would be shared in dry years. All this had been developed with reference to historical records of inflows to storages and rivers. However, the length, extent and depth of the Millennium Drought, including the sequence of extremely dry years 2006, 2007 and 2008, created conditions that were beyond all previous planning horizons.

A key lesson learnt was that, in the context of global climate change, the past can no longer be regarded as a reliable indication of the future, particularly with the prospect of climate change. A more sophisticated approach, using a range of climate scenarios and demand scenarios, has now been adopted for most aspects of planning for water management in Australia.

## Importance of drought-planning

Drought-planning needs to be undertaken at all scales, by all sectors and with a multi-year horizon. The dry years 2006–08 showed that drought-planning must include scenario planning that is multi-year and long-term in its outlook.

This means, at the water-system scale, understanding the impacts of extreme low flows on various users, how those impacts will be distributed and how they could change under different scenarios. It also means understanding the issues that will arise, and ensuring there are plans to mitigate these with either infrastructure or policy rules that are known in advance and can allow entitlement holders to then undertake their own planning.

All holders of water entitlements, whether they are urban water authorities providing town water supply, irrigation farmers managing their own businesses, or environmental water managers managing environmental water entitlements, need to undertake their own drought-planning to identify their issues under a range of climate scenarios and work through their actions and priorities.

For urban authorities, drought plans need to identify triggers for water restrictions and community water conservation programs; they need to identify contingency supplies and specify conditions for their use. They also need to link with long-term water supply–demand planning and identify criteria triggering the next stages of augmentation.

Irrigation farmers need to understand the impacts of drought on seasonal water allocations and the likely availability of water for their entitlements, for a range of climate scenarios. That understanding can be built into their business plans and influence their decisions to crop or not, and whether to use, buy, sell and/or carry-over water.

Environmental managers also need to do drought-planning, understanding where their drought refuges are and how much water they need to meet their priorities for environmental water under a range of climate scenarios. They need to plan where to water, how much to carry over for the next year or years, and how to use the water market.

Effective drought-planning allows all sectors to cope better through periods of water scarcity, minimising its negative impacts as far as possible and building long-term resilience to drought.

### Importance of water trading and the water market

The water market became a critical tool during the Millennium Drought, enabling the scarce water that was available to be applied where it had highest value. Because of the market, irrigators survived consecutive years of drought, though with varying levels of impact. As mentioned above, they could decide whether to crop and potentially buy more water or instead to sell their seasonal water allocation to realise cash.

Market utilisation 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. For the most part, water moved to support high value perennial plantings and vegetable crops. 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 the Goulburn River system (in Victoria) and in South Australia would not have survived the extremely low allocations. In addition, many mixed farms survived the dry years by selling water on the temporary market, thus making more money than they would have done by growing crops. Where farms became unviable, those farmers could permanently sell their water entitlements in the water market and leave farming with more money than they would have had otherwise. The market provided flexibility for irrigators to adapt their businesses to water scarcity and enabled irrigation industries like horticulture to survive.

Water prices revealed the economic value of water, which then drove irrigators' decisions to invest in water efficiency. As a result, production became more efficient during the drought. 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%.

The water market was used by urban water authorities to buy permanent water entitlements to augment their water supplies and increase their diversity of supply options. The Australian Government used the water market to buy water entitlements from willing irrigators, to provide more water for the environment, as part the MDB rebalancing initiative – an additional way for irrigators to gain cash and ease their personal situations.

The Millennium Drought showed that water markets and, in particular, the mature water market in the MDB, are essential in managing through drought and in building resilience to drought.

### Providing entitlement holders with tools to manage their own risk

The important decision to extend water 'carryover' to a much broader suite of entitlement holders gave them the option to 'bank' water from one year's seasonal allocation for use in the next. Although offered first as a temporary measure, carryover became so successful that it has now been adopted permanently in the MDB and in other regulated systems in southern Victoria (beyond the MDB).

Carryover gives entitlement holders real flexibility and allows them to mitigate their own risk – choosing whether to use, buy or sell or bank all or part of their seasonal allocation. They can buy water at the end of the season to use early in the next season. Some irrigators have chosen to sell most of their water entitlement and to run their businesses by buying water each year from the market and using carryover provisions. Apart from irrigators, carryover provisions are used by urban water authorities and environmental water managers. Carryover is a significant addition to the options available to individual entitlement holders in building their own resilience to drought.

### Pursuing efficiency in all areas

The drought created a drive for water efficiency wherever water is used – in domestic, industrial, irrigation or environmental management situations. The aim across all sectors was to get the best outcomes for the least volume of water used – an aim supported by governments via incentives, large-scale investment and a range of community education and supporting programs. Many improvements were made with the intention not just of managing through the drought but of building a new culture of water-use efficiency in all sectors. There is evidence this has succeeded, with some cities reporting that residential water use has remained approximately at the levels achieved during the drought rather than increasing once water restrictions were lifted.

As noted above, irrigation has become more efficient. Having seen the levels of production achieved through the worst period of the drought, irrigators' long-term aspiration has become 'twice the production from half the water'.

Environmental water managers develop their watering programs to realise the best environmental outcomes possible from the water available and use ecological engineering works to simulate floods where natural flooding is not possible or where there is insufficient water for overbank flooding.

In addition, at the largest scales, water systems have been connected and water grids have been created which enables greater optimization in using available water supplies to meet a wider range of demands, enables water markets to be extended over time and promotes greater efficiency at the systems scale.

The focus on efficiency certainly helped communities manage through the drought but the hard-wiring of water efficient practices and infrastructure lessens their vulnerability to drought and builds greater resilience for the future.

## The need for a diverse portfolio of water supplies

The Millennium Drought coupled with the climate change predictions of a drier future meant that urban water managers all over southern and eastern Australia needed to bring forward planned augmentations, in some cases by 30 years. However, experience showed that adding new rainfall-dependent water supplies would not be effective in future extreme water scarcity.

Water managers looked for ways to diversify their water supply portfolios to include a mix of rainfall-dependent and climate independent supplies to buffer against climate change. The drought drove decisions to use non-potable water supplies for uses which did not require water of such high quality such as irrigation and some industries, reserving existing potable supplies for potable purposes. Urban water supply portfolios included desalination, increased use of recycled water and stormwater. Also, as new housing developments were designed, alternative water sources were included as a feature to support the developments' sustainable liveability and green spaces. Whilst these initiatives have built real resilience to drought and climate change, it did cause significant rises in water prices, making governments and communities aware of the trade-off between reliability of water supply and cost.

## Understanding community impacts – providing good communication and support

Communities were vitally interested, extremely concerned and frequently affected economically during the Millennium Drought. Therefore, it was fundamentally important to establish good communication between governments, water managers and communities through this period.

Good communication included accurate and timely water information, available to all water users. Urban water users were told regularly and frequently about available water supplies and the success of their water saving efforts, ensuring these efforts were sustained. Irrigators were given all available information they needed to make their own business decisions, often about their long-term future.

Good communication also included processes for input by stakeholders and community members, especially where policy changes were proposed to deal with water scarcity. This communication helped ensure policy changes were effective under extreme water scarcity and that people understood them as they were being implemented. However, even though there was a reasonably good level of water information flowing to the community on the status of water supplies and use, decisions on augmentations were still highly controversial.

For extreme droughts, the national, state and territory governments provided support to affected communities. In urban communities support is through rebates and incentives. In rural communities, support is through drought relief and welfare programs, intended to assist both with managing through the drought and in dealing with the structural adjustment that follows long periods of extreme water scarcity.

## The need for improved forecasting

The drought showed the value of improved climate and streamflow forecasting for short, medium and long-term time scales. It enables improved predictions of water demands and provides the basis for better planning and preparation by all parts of the water sector – urban water authorities, irrigators and environmental managers, which can reduce the damage and economic shocks caused by drought and build greater resilience to water scarcity.

# 5 Conclusions

The Millennium Drought severely tested the water management framework that had already been 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 harsh as a result of water reforms that had been put in place. Trading on the water market enabled many irrigation enterprises to survive the drought and improve their production efficiency. Most urban water systems augmented their supply options, mostly factored into water prices. The need for efficiency in water use in all sectors – urban, rural, industrial and environment – became obvious and has now been embedded in community attitudes. Refinements and improvements, made so that Australian enterprises and communities could function better in extreme water scarcity, have increased the water sectors' resilience to drought and are enabling them to adapt to climate change.

Whilst the Millennium Drought accelerated and embedded much of the Australian water reform agenda, there is still ongoing work to do. The prospect of climate change continues to put a sharp focus on water-use efficiency and drought resilience in all sectors.

# 6 Further reading

## *(For Section 2)*


Murray Darling Basin Authority (2014). *A path to water reform: Timeline of water resource management in the Murray-Darling Basin*. Murray Darling Basin Authority, Canberra. http://www.mdba.gov.au/sites/default/files/pubs/MDBA-Historical-Timeline.pdf and http://www.mdba.gov.au/publications/products/river-management-timeline-poster/.

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

AWP (2016). *The Australian water reform journey: An overview of three decades of policy, management, and institutional transformation*. Australian Water Partnership, Canberra. http://waterpartnership.org.au/.

South Eastern Australian Climate Initiative (2011). *The Millennium Drought and the 2010/11 Floods*. http://www.seaci.org/publications/documents/SEACI-2Reports/SEACI2_Factsheet2of4_WEB_110714.pdf

van Dijk A.I.J.M. et al. (2013). The Millennium Drought in southeast Australia (2 001–2009): Natural and human causes and implications for water resources, ecosystems, economy, and society. *Water Resources Research* 49(2): 1040–1057. http://onlinelibrary.wiley.com/doi/10.1002/wrcr.20123/full

Murray Darling Basin Commission (2008). *Murray System Drought Updates*. Murray-Darling Basin Commission, Canberra. http://www.mdba.gov.au/sites/default/files/archived/mdbc-drought-updates/MDBC_Drought_Update_Issue_12_March_2008.pdf and http://www.mdba.gov.au/sites/default/files/archived/mdbc-drought-updates/Drought_Update_Issue_13_-_May_2008.pdf

DELWP (2016). *Managing extreme water shortage in Victoria: Lessons from the Millennium Drought*. Victoria Department of Environment, Land, Water and Planning, Melbourne. http://www.delwp.vic.gov.au/__data/assets/pdf_file/0017/330551/DELWP-MillenniumDrought-web-SB.pdf.pdf

Bureau of Meteorology (2015). *Recent rainfall, drought and southern Australia's long-term rainfall decline*. Australian Government Bureau of Meteorology, Melbourne. Webpage. http://www.bom.gov.au/climate/updates/articles/a010-southern-rainfall-decline.shtml

CSIRO (2008). *Water availability in the Murray-Darling Basin. A report from CSIRO to the Australian Government*. CSIRO, Canberra. https://publications.csiro.au/rpr/download?pid=legacy:530&dsid=DS1

Steffen W. (2015). *Thirsty Country: Climate Change and Drought in Australia*. Climate Council of Australia Limited, Canberra. https://www.climatecouncil.org.au/droughtreport2015

Water Corporation (WA) (2016) Historical streamflow. Webpage last accessed 22 Aug 2016. http://www.watercorporation.com.au/water-supply-and-services/rainfall-and-dams/streamflow/streamflowhistorical/

## *(For Section 3)*

Turner A. et al. (2016). *Managing drought: Learning from Australia*. Institute for Sustainable Futures, University of Technology Sydney. http://waterpartnership.org.au/tag/drought/

Department of the Environment (2014). *Water Recovery Strategy for the Murray-Darling Basin*. Australian Government Department of the Environment, Canberra. http://www.environment.gov.au/system/files/resources/4ccb1c76-655b-4380-8e94-419185d5c777/files/water-recovery-strategy-mdb2.pdf

Department of Sustainability and Environment (2007). *Our water our future: the next stage of the Government's Water Plan*. Victoria Department of Sustainability and Environment: Melbourne. http://images.theage.com.au/file/2011/12/09/2828453/water_policy.pdf

DELWP (2016). *Managing extreme water shortage in Victoria: Lessons from the Millennium Drought*. Victoria Department of Environment, Land, Water and Planning, Melbourne. http://www.delwp.vic.gov.au/__data/assets/pdf_file/0017/330551/DELWP-MillenniumDrought-web-SB.pdf.pdf

Office of Living Victoria (2013). *Melbourne's water future*. Department of Environment, Land, Water and Planning, Melbourne.

Victorian Environmental Water Holder (2016). *Seasonal Watering Plan 2016-17*. Victorian Environmental Water Holder, Melbourne. http://www.vewh.vic.gov.au/__data/assets/pdf_file/0020/342515/4.4.01-Seasonal-Watering-Plan_01_Introduction.pdf

## *(For Section 4)*

National Water Commission (2011). *Water markets in Australia: A short history*. National Water Commission, Canberra. http://archive.nwc.gov.au/library/topic/markets/water markets-in-australia-a-short-history

Productivity Commission (2010). *Market mechanisms for recovering water in the Murray-Darling Basin. Final report*. Productivity Commission, Melbourne. http://www.pc.gov.au/inquiries/completed/murray-darling-water-recovery/report

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*The Australian Water Partnership is an Australian Government aid initiative bringing together public and private organisations from the Australian water sector with development partners in the Asia-Pacific.*

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