Murray-Darling Basin water markets
Trends and drivers 2002-03 to 2018-19

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Summary

The Murray-Darling Basin (MDB) water market is complex and influenced by a range of factors, including weather, commodity markets and water policy. The objective of this report is to shed some light on changes in water markets (water prices and water trade flows) in the MDB over the past 15 to 20 years, and to explain the main factors driving these changes.

A key feature of the MDB water market is that the total volume of water available for use is capped, with changes in the supply and demand for water reflected in the price of water and movements in water between farms, industries and regions.

Historical data shows that water allocation prices are mainly driven by changes in water supply (Figure 1), and that the main factor influencing water supply in the MDB is rainfall. Rainfall was around 17% lower than the long run average in the southern MDB (sMDB) during the Millennium drought, and has been 5% lower since 2000. This has led to significantly lower inflows into rivers and dams. Allocation prices increased to unprecedented highs during the peak of the Millennium drought before declining to near zero following the 2011, 2012 and 2016 floods. Prices have risen substantially again during the latest drought.

Figure 1 Monthly allocation prices and storage volumes, southern MDB, July 2005 to May 2019

Note: Data was cleaned using ABARES price cleaning methods as described in Sanders et al. (2019) and adjusted for inflation.
Source: Price data is sourced from the BOM national water register, various market reports and broker websites; ABS Consumer Price Index (2019) (cat. 6401.0). Storage data is from Water NSW, SA Water, Goulburn-Murray Water, and the MDBA.

The other factors influencing supply tend to be institutional, and include recovering water for the environment, restrictions on interregional trade, changes in allocation rules in state water sharing plans and increased access to carryover. Commonwealth environmental recovery contributes to higher prices by reducing the volume of water available for irrigation (Figure 2) while trade restrictions can lead to differences in prices between regions in connected systems. Changes in the way water is allocated in state water sharing plans can change the timing of supply. For example, new water storage policies and more conservative forecasts for future inflows can change the timing of allocations, both within and between years.
There has been significant interest in the impact that Commonwealth environmental water recovery has had on water supply and water prices in recent years. While Commonwealth environmental water recovery has reduced consumptive supply, the effect has been relatively small compared to the effect rainfall had on supply over the same period.

The effect of increasing access to carryover on supply is more complex. Carryover allows irrigators to have more control over the timing of water use. The easing of restrictions on carryover that occurred in the late 2000s contributed to a significant increase in carryover balances during the high rainfall years that followed the Millennium drought. This was followed by a period of drawdown as rainfall declined. The increased use of carryover has important implications for the allocation market. In general, carryover will lead to slightly higher prices in years when carryover reserves are being accumulated (typically average or wetter years), and lower prices in years when carryover reserves are drawn down (typically drier years). It also has implications for where water is used and what it is used for. For example, in the absence of carryover, most of the water accumulated in carryover accounts in wetter years would have been used for lower value activities or sold on the allocation market.

There have also been significant changes in the demand for irrigation water in the MDB since the early 2000s. This is particularly the case in the sMDB where genetic advances and movements in commodity prices have led to an increase in the demand for water for cotton and almonds and a decrease in demand for rice, dairy pastures and grapevines (Figure 3). ABARES modelling suggests that this change in the composition of demand away from some of the more flexible lower value activities such as pastures and rice to higher value annual activities such as cotton and perennial activities such as almonds means that the demand for water will be higher at most water prices. The exception is when prices are very low, in which case demand is estimated to be similar.
This shift in demand has led to changes in the location of water use and interregional trade flows in the sMDB. For example, the increase in demand for water for almonds has occurred mainly in the Victorian Murray below the Barmah choke, with this expansion facilitated by interregional trade, mainly from regions above the Barmah choke. Increased demand below the Barmah choke and tighter restrictions on interregional trade have resulted in trade limits binding more often in the sMDB. This was particularly the case in 2016–17, when these limits restricted trade into the downstream Murray trading zones, contributing to higher allocation prices in these zones, and lower allocation prices in the upstream trading zones (including in the Murrumbidgee, Goulburn and above Barmah choke trading zones). Research by Aither (2019) suggests that the demand for water for permanent plantings in the sMDB could increase from current levels as existing plantings mature. This could lead to an increase in the frequency restrictions on interregional trade are binding.

Gupta & Hughes (2018) modelled future water prices in the sMDB assuming 2016-17 levels of water demand, 2016-17 institutional arrangements and a repeat of the historical climate between 2002-03 and 2016-17. The estimates suggest that there could be a change in the distribution of future allocation prices in the sMDB, with fewer years with low prices and more years with moderate to high prices.
Introduction

The objective of this research is to analyse trends in irrigated agriculture and water markets in the MDB, and to consider the factors driving changes in these markets.

The findings from this analysis will feed into a wider body of research investigating the socioeconomic effects of the Murray-Darling Basin Plan, as part of the 2020 review of the plan. While other projects in the monitoring and evaluation program will use economic models and statistical analysis to estimate the effects of the Commonwealth’s water recovery programs on irrigated agriculture and regional economies in the MDB, this project will provide context for this other research, identifying the range of factors influencing the supply and demand for irrigation water. This project is also confined to reporting and analysing trends in irrigated agriculture rather than for the broader economy, and while it does identify the main factors influencing irrigated agriculture, it does not attempt to attribute the effects of specific factors to changes in irrigated agriculture.

The key metrics considered in this study include:

- water allocation prices
- interregional water trade flows
- water availability (allocations, carryover, environmental water)
- irrigation area (by activity)
- irrigation water use (by activity)
- irrigation production (GVIAP by activity)
- water use per hectare (by activity).

This report will focus on the southern connected Murray-Darling Basin (sMDB), although it will include some analysis for the northern Basin (see Map 1 for catchments and rivers in the southern and northern MDB). Many of the factors influencing irrigated agriculture and water markets in the northern Murray-Darling Basin (nMDB) are similar to those in the sMDB, including rainfall and inflows, changes in water sharing plans, Commonwealth water recovery programs and the relaxation in carryover rules. One of the main differences between the sMDB and nMDB is that there is very little interregional trade in the nMDB due to the disconnected nature of most of these catchments. The sMDB is also much more reliant on regulated surface water, where it accounts for 87% of entitlements. In the nMDB, 53% of entitlements are for

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1 Schedule 12 of the Basin Plan specifies that the Murray-Darling Basin Authority and the Commonwealth department responsible for water policy (the Department) are jointly responsible for monitoring and evaluating the socioeconomic effects of the plan. The department responsible for water policy is the Department of Agriculture, Water and the Environment.
regulated surface water, 26% are for unregulated surface water and 21% are for groundwater (AWMR 2018). In terms of water use, the sMDB is much more diverse than the nMDB, where most water is used to irrigate cotton.

Map 1 Murray-Darling Basin catchments and major rivers

Chapter 1 identifies factors contributing to changes in the supply of irrigation water, while Chapter 2 identifies factors influencing the demand for irrigation water. Chapter 3, in turn, analyses the likely impacts of these changes on water prices and interregional trade flows in the MDB since the early 2000s.
1 Supply factors

Water prices and the level and mix of irrigated activities are a function of the supply and demand for irrigation water. The main factors that have altered the supply of irrigation water in recent years include:

- Water allocations—the total volume of surface water available for use in a particular year (determined by storage volumes - mainly a function of rainfall - and state water sharing plans).
- Environmental water—water rights transferred to environmental agencies effectively reduce the supply of water allocations available for irrigation.
- User carryover decisions—decisions by individual water right holders to hold water allocations in storage within or between years (rather than using or selling allocations).

The type of entities that own water have not been included as determinants of water supply. While there are concerns that speculators in the water market are manipulating the supply of water available for irrigation, this issue is beyond the scope of this project. The Australian Competition & Consumer Commission (ACCC) inquiry into water markets in the MDB will examine this claim in more detail (ACCC 2019). For context, the Victorian Department of Environment, Land, Water and Planning (DELWP) released a report in 2019 showing that only 12% of privately held high reliability water shares in northern Victoria were not linked to land, and that much of this water was likely to be owned by farmers (DELWP 2019). It also found that only 8% of allocations to these shares were carried over in 2018-19, suggesting that there is little evidence of hoarding.

The analysis presented in the remainder of this chapter draws heavily on Hughes, Gupta & Rathakumar (2016) and the Australian Water Markets Report 2016-17 (ABARES 2018).

1.1 Water allocations

Water storages

The supply of water allocations in regulated systems is primarily a function of the volume of water held in storage, which is mainly a function of rainfall (in unregulated systems allocations are largely a function of rainfall and inflows).

Figure 4 and Figure 5 show historical changes in rainfall in the southern and northern MDB. They show that rainfall can be volatile, has been lower than the long-run average (defined here as 1911-12 to 1999-2000) since 2000-01, and was significantly lower during the Millennium drought (2000-01 to 2008-09) (17% lower in the sMDB and 11% lower in the nMDB).

Figure 6 shows historical inflows into the sMDB (defined as modelled flows in the River Murray at Euston assuming historical weather and no extractions). Inflows have been 40% lower than the long run average since 2000-01, and were 49% lower during the Millennium drought.
Figure 4 Annual rainfall, southern MDB, 1911-12 to 2017-18

Note: Annual rainfall is calculated as the sum of average monthly rainfall in the sMDB.
Source: Bureau of Meteorology, ABARES estimate

Figure 5 Annual rainfall, northern MDB, 1911-12 to 2017-18

Note: Annual rainfall is calculated as the sum of average monthly rainfall in the nMDB.
Source: Bureau of Meteorology, ABARES estimate
Figure 6 Annual inflows, southern MDB, 1911-12 to 2017-18

Note: Modelled ‘without development’ inflows at Euston on the River Murray. Model estimates assume no water storages, no irrigation and pre-development land use where the impact of land use change on inflows is considered to be significant, and where data is available.
Source: Murray Darling Basin Authority

Movements in rainfall and inflows have been reflected in water storage levels (Figure 7 and Figure 8) and allocations (Figure 9 and Figure 10), with storage levels and allocations falling to historic lows at the peak of the Millennium drought, and rising rapidly following high rainfall events in 2010-11, 2011-12 and 2016-17.

Figure 7 Monthly storage volumes, southern MDB, October 2002 to May 2019

Note: The sMDB storage volume is the sum of storage volumes in the Hume Dam, Dartmouth Dam, Yarrawonga Weir, Lake Victoria, Menindee Lakes, Blowering Dam, Burrinjuck Dam, Lake Eildon, Lake Eppalock, Cairn Curran Reservoir, and Laanecoorie Reservoir.
Source: Water NSW, SA Water, Goulburn-Murray Water, and MDBA.
Figure 8 Water storage percentages, northern MDB, July 2007 to November 2019

Source: Bureau of Meteorology

Figure 9 Total regulated surface water allocations for irrigation and environmental use, southern MDB, 2000-01 to 2018-19

Note: Total water supply is defined as the sum of allocations, carryover, and uncontrolled flows, minus within year forfeits.
Source: ABARES estimate
Figure 10 Total regulated surface water allocations for irrigation and environmental use, NSW northern MDB, 2000-01 to 2018-19

Note: Total water supply is defined as the sum of allocations, carryover, and uncontrolled flows, minus within year forfeits. No allocation data was collected for Queensland.
Source: ABARES estimate

Research by Cai & Cowan (2008) suggests that in addition to lower annual rainfall, other climatic factors may have contributed to lower inflows into rivers and dams in recent years. These include increasing temperatures and changes in the seasonal distribution of rainfall.

Cai & Cowan found the reduction in rainfall in the MDB was greatest in autumn (BoM data shows that autumn rainfall was 37% lower than the long-run average during the Millennium drought and has been 16% lower since 2000-01). Autumn rainfall plays an important role in wetting the soil, which then has a delayed impact on runoff and inflows in winter and spring.

Cai & Cowan also found a relationship between inflows and fluctuations in temperature in the MDB. Figure 11 shows that annual mean temperatures in the MDB were well above average during the Millennium drought, and continue to rise. While this research is somewhat dated, it suggests that a 1 degree Celsius increase in maximum temperature in winter and spring (relative to the long term average) could lead to a 15% reduction in annual inflow in the MDB.
The supply of water allocations is also a function of how water is allocated between different users in water sharing plans prepared by state governments. There have been significant changes in some water sharing plans over the past 20 years, including new storage reserve policies and more conservative forecasts for future inflows (Hughes et al. 2013; New South Wales Government 2009). More conservative storage policies and forecasts for future inflows can change the timing of allocations, both within years and between years.

1.2 Environmental water recovery

The total supply of water allocations includes allocations to entitlements acquired by Commonwealth and state governments for the environment. These acquisitions reduce the total volume of water allocated to irrigation. They do not, however, reduce the volume of water allocated to entitlements retained by irrigators.

The main programs funded by the Commonwealth in the MDB as part of the Basin Plan include:

- Water recovery programs
  - Water purchases: purchase of water entitlements from irrigators (‘buybacks’) including the ‘Restoring the Balance in the Murray-Darling Basin’ program.
  - Irrigation infrastructure improvement projects: Government investments in on and off-farm irrigation infrastructure in return for water entitlements, including programs under the Sustainable Rural Water Use and Infrastructure Program (SRWUIP).

- SDL adjustment mechanism measures
  - Supply measures: environmental works and measures that allow Basin Plan environmental objectives to be achieved with less water, leading to an increase in the SDLs (a reduction in water recovery volumes).
  - Efficiency measures: infrastructure projects that achieve water savings, leading to a decrease in the SDLs (an increase in water available for the environment).
These programs influence the supply of irrigation water in different ways. For example, water purchases reduce the volume of entitlements and allocations available for irrigation, while investments in environmental works (supply measures) reduce the volume of water that needs to be diverted from irrigation to achieve environmental objectives (that is, avoided recovery). Water savings from investments in off-farm irrigation infrastructure increase the volume of water available for the environment but do not affect the volume of water available for irrigation. The impact of investments in on-farm irrigation infrastructure on the supply of irrigation water is more complex. On the one hand they involve exchanging entitlements for irrigation infrastructure, leading to a reduction in entitlements and allocations to irrigation. However, the impact of these investments on production is less than the purchase of an equivalent volume of water because they increase water use efficiency, increasing the effective supply of irrigation water. In addition, irrigators retain some of the savings from these investments.

As at 30 September 2019, 2,105.7 GL of surface water had been recovered for the environment under the Basin Plan. This comprised 1,942.2 GL recovered by the Commonwealth and 163.5 GL recovered by the states. Commonwealth recovery included 1,232.1 GL from purchases, 695.2 GL from investments in infrastructure and 15 GL of gifted water. The regional distribution of total acquisitions includes 349.6 GL from the nMDB and 1,756.1 GL from the sMDB.

Figure 12 and Figure 13 show Commonwealth water recovery volumes by catchment. They show that environmental purchases have accounted for the bulk of recovery in most systems, with most purchases occurring in the Victorian Murray, NSW Murray, Goulburn-Broken and Murrumbidgee systems in the southern Basin, and in the Condamine-Balonne, Gwydir, Lachlan and Barwon-Darling systems system in the northern Basin.

**Figure 12 Total Commonwealth surface water recovery in the southern MDB, 30 September 2019**

![Bar chart showing Commonwealth water recovery in the southern MDB, 30 September 2019.](chart)

Note: The total volume of water recovered is expressed in terms of the long term average annual yield (LTAAY).

Source: Department of Agriculture, Water and the Environment
The Commonwealth has been recovering entitlements for the environment since 2007-08. Figure 14 shows that this recovery has reduced the total volume of water allocated to irrigation in the sMDB by over 10% since 2010-11, and by over 18% since 2017-18.

1.3 Carryover

The supply of allocations to irrigation includes ‘carryover’ water (the supply of allocations to the environment also includes carryover). Carryover water is unused water that users are allowed to hold in dams between years. This allows irrigators to smooth out annual variations in water
availability. There have been significant changes to carryover rules since 2000, and particularly since 2007-08. Key changes in the sMDB since 2007-08 include:

- 2007-08: South Australia and Victoria introduce temporary carryover arrangements
- 2008-09: Victorian annual carryover limit increased from 30% to 50%
- 2009-10: Murrumbidgee annual carryover limit increased from 15% to 30%
- 2010-11: South Australia removes carryover, while Victoria introduces permanent carryover arrangement in the form of spillable water accounts, with no limit on annual carryover volumes
- 2012-13: South Australia adopts a permanent carryover arrangement
- 2013-14: Victoria applies a 100% limit on annual carryover volumes.

Net changes in irrigation carryover in the sMDB are shown in Figure 15. A net increase in carryover indicates that irrigators are using less than their current allocation, transferring some of this allocation for future use, whereas a decrease indicates irrigators are using more than their current allocation, with this additional water being sourced from irrigators carryover accounts (that is, irrigators are running down carryover balances).

There were significant increases in net carryover in the sMDB in 2009-10 and 2010-11. These increases coincided with the relaxation in restrictions on carryover and high rainfall events that followed the Millennium drought. These carryover balances were drawn down as rainfall declined, particularly in 2012-13.

There were also significant increases in carryover in northern NSW following the Millennium drought (Figure 16).

**Figure 15 Net change in irrigation carryover in regulated systems, southern MDB, 2000-01 to 2018-19**

![Net change in irrigation carryover in regulated systems, southern MDB, 2000-01 to 2018-19](image)

*Note: The net change in carryover is equal to carryover into next year minus carryover from the previous year.*

*Source: ABARES estimate*
Figure 16 Net change in irrigation carryover in regulated systems, NSW northern MDB, 2000-01 to 2017-18

Note: The net change in carryover is equal to carryover into next year minus carryover from the previous year.
Source: ABARES estimate
2 Demand factors

The demand for irrigation water in the MDB has changed significantly over the past 20 years. In cap and trade systems like the MDB, these changes are reflected in changes in water prices and in movements in water between farms, industries and regions. The main factors influencing the demand for irrigation water in the MDB include:

- The profitability of irrigated activities—changes in water demand often arise from shifts in the relative prices of inputs and outputs (for example, milk, cotton, rice).
- Seasonal conditions—on-farm rainfall is a substitute for irrigation water, so when rainfall in irrigation areas is higher or lower than expected, the demand for irrigation water also changes.
- Investments in on-farm infrastructure (public or private)—including expansion or rationalisation of irrigation areas, changes in the mix of irrigation activities or investments in on-farm water use efficiency—all influence the demand for water allocations.

Each of these drivers is considered in this chapter. As context for this analysis, it is important to recognise that measuring long-term changes in irrigation water demand is difficult given fluctuations in seasonal conditions and water prices. This is particularly the case for annual activities (annual crops and pastures), where irrigated area and water use can vary dramatically between wet and dry years. Given this complexity, understanding long run changes in demand typically requires the use of a model.

ABARES has estimated changes in the demand for irrigation water in the sMDB using a water trade model. The model assumes that the demand for water is a function of allocation prices, on-farm rainfall, commodity prices and time. By holding allocation prices fixed at $200 per ML and rainfall fixed at average values, changes in the demand for water between 2005-06 and 2018-19 were estimated. The results primarily reflect net changes in capital investment (including disinvestment) over time.

Figure 17 shows the results for individual irrigation activities. The 'Actual plantings' scenario reflects the actual maturity of almond trees in the sMDB in 2005-06 and 2018-19. It shows a significant increase in the demand for water for cotton and almonds in the sMDB between 2005-06 and 2018-19. It also shows a reduction in the demand for water for rice and irrigated pastures (including dairy) at $200 per ML.

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2 Similar to the supply chapter, the analysis in this chapter draws heavily on Hughes, Gupta & Rathakumar (2016) and the Australian Water Markets Report 2016-17 (ABARES 2018). In addition, it draws on Gupta & Hughes (2018).
The 'Full maturity plantings' scenario assumes all current plantings of almond trees are fully mature in 2018-19, and hence demand more water. It has been run to see what could happen to the demand for water when current plantings reach full maturity (there has been a significant expansion in almond plantings in recent years). The estimates suggest that this expansion could lead to a 165 GL increase in the demand for water in the sMDB.

**Figure 17** Long run change in water demand (2005–06 compared with 2018–19) at a price of $200/ML, by activity, southern MDB

### 2.1 Profitability

The model estimates appear to be consistent with some of the more significant movements in commodity prices and profitability in the irrigation sector. For example, Figure 18 shows that cotton prices have been relatively stable since 2006-07, while rice prices were volatile, increasing early on before falling substantially in the late 2000s. Dairy prices increased initially before trending down over much of this period. There was also a significant and extended decline in wine grape prices, although they have recovered to some extent. Almond prices have also been volatile, falling by just over 50% between 2006-07 and 2011-12, and more than doubling between 2011-12 and 2015-16. They have moderated since then.

Figure 19 shows that the returns to cotton farming have been greater than to irrigated dairy and rice farming over most of this period. It is worth noting that the cotton estimates were derived using survey data for cotton farms in the Condamine-Balonne region in the nMDB due to a lack of data on cotton farms in the sMDB. It is quite possible that the returns to cotton farms in the sMDB differ from those in the nMDB.
Figure 18 Commodity price indexes, selected industries, 2006-07 to 2018-19

Note: Prices have been indexed to 2006-07 and adjusted for inflation using the ABS consumer price index. 2018-19 almond price is an ABARES forecast.
Source: ABARES estimate; ABS Agricultural Commodities (cat. 7121.0), ABS Value of Agricultural Commodities Produced (cat. 7503.0), ABARES Agricultural Commodities Database (AG764, AG3671, AG817), QLD Cotton Prices, ABARES 2018-19 almond price forecast, and ABS Consumer Price Index (2019) (cat. 6401.0).

Figure 19 Rate of return, selected industries, 2006-07 to 2018-19

Note: Data for 2018-19 are provisional estimates. No data is available for cotton in 2018-19. Rate of return is defined as farm business profit with interest, lease and rent payments added (adjusted to full equity basis) expressed as a percentage of total farm capital (excluding capital appreciation). It represents the ability of the farm business to generate a return to all capital used by the business, including that which is borrowed or leased.
Source: ABARES Murray–Darling Basin Irrigation Survey

The model estimates (Figure 17) are also broadly consistent with estimates of historical movements in irrigation area and water use by activity in the MDB (these estimates were
derived by ABARES using ABS and industry data). Figures 20 to 23 show that there has been a significant increase in area irrigated and water use by cotton and almonds. They also show a decrease in water use by pastures and grapevines.

The reduction in demand for water for irrigated pastures for dairy and other grazing activities is reflected in water use by these activities remaining significantly lower in the high allocation years of 2011-12 and 2012-13 than in 2005-06, which was a relatively normal year. And while irrigated rice did recover to 2005-06 levels (around 100,000 hectares), it has not recovered to the levels recorded in the late 1990s and early 2000s, when around 150,000 hectares were planted.

**Figure 20 Irrigated area, selected broadacre industries and dairy, southern MDB, 2005-06 to 2017-18**

![Graph of irrigated area, selected broadacre industries and dairy, southern MDB, 2005-06 to 2017-18](image)

Source: ABARES estimate

**Figure 21 Irrigation water use, selected broadacre industries and dairy, southern MDB, 2005-06 to 2017-18**

![Graph of irrigation water use, selected broadacre industries and dairy, southern MDB, 2005-06 to 2017-18](image)
The data also shows that irrigation in the nMDB is much less diverse than in the sMDB, with cotton dominating in most catchments, and irrigated pasture and cereals accounting for much of the remainder (Figure 24). Figure 25 shows that irrigated agriculture in the nMDB is highly variable (the nMDB has smaller dams than the sMDB and is more reliant on unregulated water).
Changes in the demand for water by activity have also been reflected in regional trends in water use in the sMDB. For example, there has been a significant expansion in water use and area planted to irrigated almonds in the Victorian Murray below the Barmah choke between 2005-06 and 2017-18 (Figure 26 and Figure 27).
Research by the Almond Board of Australia (ABA) indicates that almonds are highly suitable for production in southern Australia, delivering high returns, not being affected by fruit fly, are durable and have a long shelf life compared to fruit and vegetables (ABA 2019). ABA data indicates that the area planted to almonds in Australia has increased from 3,500 hectares in 2000 to around 45,000 hectares in 2018 (ABA, 2019). The data also shows that 53% of these plantings are in the Victorian Sunraysia (located in the Victorian Murray below the Barmah choke), 24% are in the NSW Riverina and 20% are in the SA Riverland. It also shows that many of these plantings are not yet fully mature. Overall, these changes appear to have increased horticultural water demand in the sMDB.
Similarly, the shift away from rice toward cotton is likely to have been driven by a mix of the superior profitability of cotton and genetic advances that allow cotton to be grown in the sMDB. Much of the expansion in cotton has occurred in the Murrumbidgee system, where cotton plantings have increased from 3,000 hectares in 2005-06 to over 56,000 hectares in 2017-18 (Figure 28). The volume of water used for cotton has also increased, from 26 GL in 2005-06 to 536 GL in 2017-18 (Figure 29).

**Figure 28 Irrigated area, rice and cotton, Murrumbidgee, 2005-06 to 2017-18**

![Irrigated area, rice and cotton, Murrumbidgee, 2005-06 to 2017-18](chart1)

**Figure 29 Irrigation water use, rice and cotton, Murrumbidgee, 2005-06 to 2017-18**

![Irrigation water use, rice and cotton, Murrumbidgee, 2005-06 to 2017-18](chart2)
2.2 Seasonal conditions

The demand for irrigation water is also influenced by water application rates, which are influenced by on-farm rainfall and temperature, irrigation technologies, the mix of irrigated activities, and for perennial horticulture, the age of plantings. Farmers can also adjust application rates within and between seasons based on expectations about allocation and commodity prices.

Seasonal conditions influence both the supply and demand for irrigation water. Figure 4 and Figure 5 show that rainfall in the MDB was lower than average during the Millennium drought, and has been lower since 2000-01, while Figure 11 shows that temperatures have been increasing over the past 20 years. The reduction in rainfall and increase in temperature is likely to have increased the volume of irrigation water needed to sustain a hectare of crop during the Millennium drought.

Seasonal conditions can also influence the source of water used for irrigation. For example, irrigators who use surface water and groundwater would be expected to increase their use of groundwater in years when surface water availability is constrained. This would appear to be reflected in Figure 30, which shows that groundwater use was relatively high between 2006-07 and 2008-09, which was the peak of the Millennium drought, and decreased as seasonal conditions improved.

Figure 30 Farm groundwater use, MDB, 2005-06 to 2017-18

Note: No data available for 2007-08.
Source: ABS

2.3 Investments in on-farm irrigation infrastructure

Investments in on-farm irrigation infrastructure can influence the demand for water in several ways. For example, they can increase water use efficiency, reducing the volume of water needed
to irrigate a hectare of crop. They can also increase the productivity and profitability of irrigated activities, which can lead to an increase in the demand for water.

Farmers have made substantial investments in on-farm irrigation infrastructure over time, while the Commonwealth has invested heavily in irrigation infrastructure aimed at increasing water use efficiency, with some of the savings transferred to the Commonwealth for the environment. Some examples of investments in on-farm infrastructure include:

- installing new or upgrading existing irrigation infrastructure, including automated water management systems and sensing equipment
- improving irrigated area layout to increase on-farm irrigation efficiency (for example, laser grading, bank-less irrigation channels, decommissioning old irrigation infrastructure)
- converting flood irrigation systems to surface or sub-surface drip systems or overhead spray systems (such as lateral move or centre pivots)
- installing ancillary equipment needed to operate new or upgraded irrigation systems (for example, computers and pumps).

Figure 31 and Figure 32 show water use per hectare for a range of irrigated broadacre and horticulture crops in the Murray-Darling Basin between 2005-06 and 2017-18. With the exception of almonds and cotton, there appears to be no consistent trend in water use per hectare for most activities when looking at the raw data. This is not necessarily surprising, with any improvements in water use efficiency from investments in more efficient irrigation technologies likely to have been offset by lower rainfall and higher temperatures.

The increase in water use per hectare for almonds is likely to reflect the expansion in almond plantings and the age profile of these plantings. Almonds use around 14 ML per hectare when fully mature (ABA 2019), which is high compared to most other irrigated activities. Almond trees take three years to bear a crop and seven years to reach maturity, with water application rates increasing as plantings mature. The decline in water use per hectare in 2006-07 is likely to reflect the substantial expansion in new plantings in the mid-2000s (younger trees require less water), while the upward trend after that is likely to reflect the maturing of these plantings. Similarly, the recent dip in water use per hectare is likely to reflect to some extent the increase in new plantings since 2014-15. Data supplied by the Australian Almond Board shows that as of 2018, 30.5% (13,763 hectares) of almond plantings are not yet bearing a crop, and that 7% of bearing trees are not fully mature (ABA 2019).
Figure 31 Irrigation water use per hectare, selected irrigated broadacre industries and dairy, MDB, 2005-06 to 2017-18

Source: ABARES estimate

Figure 32 Irrigation water use per hectare, selected irrigated horticulture industries, MDB, 2005-06 to 2017-18

Source: ABARES estimate
3 Water prices and trade flows

The total volume of water available for use in the MDB is capped, with changes in the supply and demand for water reflected in the price of water and movements in water between farms, industries and regions. The disconnected nature of most river systems in the nMDB means that most water market activity in the nMDB is between farmers within a region. In contrast, the high degree of hydrological connectivity in the sMDB allows for relatively unconstrained trade in water entitlements and water allocations between systems. The sMDB is Australia’s most significant water market, and is widely regarded as one of the most sophisticated water markets in the world (ABARES 2018).

This chapter contains analysis of water prices and trade over time, and considers the key drivers of these changes.

3.1 Entitlement prices

The price of water entitlements essentially reflect the discounted returns irrigators expect to earn from water allocated to entitlements. Figure 33 shows that there has been a significant increase in entitlement prices in the sMDB in recent years.

While more research is needed to identify the factors driving this increase, they are likely to reflect to some extent an increase in the demand for water for higher value crops such as almonds and cotton, and the reduction in supply to irrigation associated with Commonwealth water recovery.

Higher water prices may also reflect a growing recognition of long-term trends in climate, including lower average rainfall and increasing temperatures. These climatic factors affect the supply and demand for water. For example, lower on-farm rainfall and higher temperatures are likely to increase the demand for water. The supply side effects are more complex, with lower rainfall likely to reduce the reliability of water entitlements, especially lower security entitlements. The net effect on entitlement prices will depend on the extent to which any reduction in reliability is offset by an increase in allocation prices. Figure 33 shows that the price of high security entitlements in the Murrumbidgee increased (in real terms) by 195% between 2012-13 and 2018-19, while the price of general security entitlements increased by 143%.

The remainder of this chapter focuses on the drivers of change in annual water allocation prices and trade.
Historical data shows that water allocation prices are mainly driven by changes in water supply. The main factors influencing water supply in regulated systems are the volume of water held in storages and inflows into these storages. Figure 34 shows the historical relationship between allocation prices and storage volumes in the sMDB. It shows allocation prices rising to unprecedented highs during the peak of the Millennium drought before declining to near zero following the 2011, 2012 and 2016 floods. Prices have also risen during the latest drought.

Figure 34 Monthly allocation prices and storage volumes, southern MDB, July 2005 to May 2019

Note: Data was cleaned using ABARES price cleaning methods as described in Sanders et al. (2019) and adjusted for inflation.
Figure 8 in Chapter 1 shows that trends in water storage volumes in the nMDB have been similar to those in the sMDB. This is reflected in changes in allocation prices in most catchments in northern NSW (note, no price data is available for southern Queensland) (Figure 35), with prices relatively high during the Millennium drought and low during the high rainfall events in 2011, 2012 and 2016. The disconnected nature of catchments in the nMDB means that there can be larger differences in prices between catchments compared with the sMDB.

**Figure 35 Annual allocation prices, NSW northern MDB, 2007-08 to 2018-19**

Note: Data was cleaned using ABARES price cleaning methods as described in Sanders et al. (2019) and adjusted for inflation.

While allocation prices have always been lower in wet years and higher in dry years, there have been significantly more dry years over the past 20 years. This is particularly the case in the sMDB (see Figure 4 in Chapter 1). This has led to lower inflows into rivers and dams, with inflows being around 50% lower than the long-run average in the sMDB during the Millennium drought and 40% lower since 2000-01 (Figure 6). Research by Cai & Cowan (2008) suggests that in addition to lower annual rainfall, increasing temperatures and changes in the seasonal distribution of rainfall may have also contributed to lower inflows over this period.

### 3.3 Institutional factors

In addition to weather and climate, there have been a number of institutional changes that have led to:

- reductions in the supply of allocations to irrigation
- changes in the timing of allocations and the volume of allocations used in a particular year.

These changes include changes in allocation rules in state water sharing plans, changes in carryover rules and Commonwealth water recovery. In addition, the supply of allocations in
some catchments in the sMDB has been influenced by restrictions on interregional trade, leading to higher prices in some systems and lower prices in other systems.

**Water sharing plans**

There have been a number of changes in the way water is allocated in some state water sharing plans, including new storage reserve policies and more conservative forecasts for future inflows. More conservative storage policies and forecasts for future inflows can change the timing of allocations, both within years and between years, which can influence the price of water within and between years.

**Commonwealth water recovery**

One factor that is likely to be contributing to higher allocation prices in the MDB is Commonwealth water recovery. One of the main elements of this recovery is the acquisition of entitlements from irrigators for the environment, with these acquisitions reducing the total volume of water allocated to irrigation (note, they do not reduce the volume of water allocated to entitlements retained by irrigators). These acquisitions have reduced the volume of water allocated to irrigation in the sMDB by over 10% since 2010-11 and by 18% since 2017-18.

By reducing supply, water recovery was always expected to increase water prices. While the effects of water recovery on supply are significant, they are relatively small compared with the effects of changes in seasonal conditions on supply over the same period (see Figure 14 in Chapter 1).

Measuring the precise effect of water recovery on prices is difficult. Water buybacks are straightforward and have been modelled by ABARES and others. For example, research by Hughes, Gupta & Rathakumar (2016) and Aither (2016) show that buybacks have increased the average price of allocations in the sMDB. However, estimating the effects of infrastructure programs on water prices is more difficult.

**Carryover**

The introduction or easing of restrictions on carryover coincided with a significant increase in the use of carryover, with substantial increases in carryover occurring in the high rainfall years that immediately followed the Millennium drought, and in 2016-17. Much of this water was used in later years as rainfall declined (Figure 15 and Figure 16).

The increased use of carryover has important implications for the allocation market. The expectation is that irrigators will increase carryover balances in average to wet years, increasing the price of irrigation water in those years. In dry years, users are expected to draw down these balances, which helps to limit the increase in allocation prices in dry years. The motivation behind carryover is the expectation that the benefits of lower prices in dry years will, in the long run, outweigh the costs of slightly higher prices in wetter years (Hughes et al. 2016). Changes in carryover rules also have implications for where water is used and what it is used for. For example, in the absence of carryover, most of the water accumulated in carryover accounts in wetter years would have been used for lower value activities or sold on the allocation market.

Gupta & Hughes (2018) modelled the effect of increasing access to carryover on water prices in the sMDB assuming a repeat of the historical climate between 2002-03 and 2016-17. They showed that allocation prices would have been slightly higher in the lead up to the Millennium drought, and significantly lower during the peak of the drought (2006-07 and 2007-08).
Overall effect of institutional changes

Figure 14 in Chapter 1 shows how environmental water recovery has reduced the volume of water available for irrigation. This recovery is likely to have contributed to higher allocation prices in the MDB. Figure 15 and Figure 16 show how increased access to carryover reduced the volume of water used for irrigation in the high rainfall years that followed the Millennium drought as irrigators increased their carryover balances, and how this carryover water added to supply as irrigators ran down these balances as rainfall declined. As explained in the previous section, these changes are likely to have contributed to higher allocation prices in wetter years as irrigators increased their carryover balances and lower prices in dry years as they ran down these balances.

3.4 Demand

ABARES modelling estimated a significant increase in the demand for irrigation water in the sMDB between 2005-06 and 2018-19, with this increase being driven mainly by an expansion in the cotton and almond industries (Figure 17). It also estimated a decrease in the demand for water for irrigated pastures and rice.

In addition to estimating the demand for irrigation water at $200 per ML, ABARES modelled the demand for water assuming a range of water prices (from $0 to $1,000 per ML) (Figure 36). The estimates suggest that changes in the composition of demand away from some of the more flexible lower value activities such as pastures and rice to higher value annual activities such as cotton and perennial activities such as almonds means that the demand for water will be higher at most water prices. The exception will be when prices are very low, in which case demand is estimated to be similar.

Figure 36 Demand for irrigation water as a function of water allocation price, southern MDB, 2005-06 compared with 2018-19, holding rainfall fixed at average values

3.5 Trade

The ability to trade water between activities and regions has helped facilitate the transfer of water to higher value uses in the short and long term. For example, trade significantly reduced the cost of the Millennium drought, with GVIAP in the MDB only falling by around 14% between
2005-06 and 2007-08, while water use fell by 57% (Figure 37). Figure 37 shows that there was relatively little variation in permanent horticulture over this period while there was significant variation in broadacre activities such as cotton and rice. This suggests that water was traded away from lower value activities to higher value activities where there was potential for irrigators to incur significant losses in the event permanent plantings were not watered (that is, fruit, nuts and grapes).

**Figure 37 Gross value of irrigated agricultural production (real terms) and water use, MDB, 2005-06 to 2017-18**

Note: GVIAP for Dairy included in ‘Other’ in 2012-13. No GVIAP data available for almonds.


The longer term shift in the demand for water in the sMDB has also had significant implications for the location of water use and interregional trade. As mentioned in Chapter 2, the increase in demand for water for almonds has occurred mainly in the Victorian Murray below the Barmah choke, while the increase in demand for cotton has occurred mainly in southern NSW, and particularly in the Murrumbidgee. The expansion in almonds has been facilitated by interregional trade, with the increase in water use in the Victorian Murray below the Barmah choke (Figure 38) being supported by transfers out the Murrumbidgee (Figure 39) and NSW Murray systems (see appendix A for net allocation trade in other major sMDB systems). It is worth noting that the expansion in irrigated cotton in the Murrumbidgee system is likely to reduce the volume of water traded out of the Murrumbidgee in the future.
Figure 38 Net interregional trade, surface water allocations, Victorian Murray below Barmah Choke

Note: Excludes environmental transfers. A positive number denotes net trade in and a negative number denotes net trade out.
Source: ABARES estimate

Figure 39 Net interregional trade, surface water allocations, Murrumbidgee

Note: Excludes environmental transfers. A positive number denotes net trade in and a negative number denotes net trade out.
Source: ABARES estimate

Trade restrictions
The increase in interregional trade and tighter trade restrictions in some regions have resulted in trade limits binding more often. Historically, allocation prices across different trading zones in the sMDB have generally moved in unison (Figure 40). However, prices in some systems occasionally diverge because of restrictions on interregional trade. For example, the Barmah
choke, the Goulburn inter-valley transfer (IVT) export limit, the Murrumbidgee IVT export limit and the New South Wales to Victoria trade constraint were all binding at various points in 2016–17.

**Figure 40 Surface water allocation prices, selected regions, southern MDB, 2008-09 to 2018-19**

![Surface water allocation prices, selected regions, southern MDB, 2008-09 to 2018-19](image)

Note: Price data was cleaned using ABARES price cleaning methods as described in Sanders et al. (2019) and adjusted for inflation.

Source: BOM national water register, various market reports and broker websites; ABS Consumer Price Index (2019) (cat. 6401.0).

The 2016–17 water year was exceptional because more restrictions were binding than in previous years. In 2016–17, these limits restricted trade into the downstream Murray trading zones in Victoria, NSW and South Australia, contributing to higher allocation prices in these zones (ABARES 2018). These limits also contributed to lower allocation prices in the upstream trading zones (including in the Murrumbidgee, Goulburn and above Barmah choke trading zones). The divergence in prices was most evident in the Murrumbidgee, where the 100 GL IVT trade balance was binding for most of 2016–17. Figure 41 compares allocation prices in the Murrumbidgee and Victorian Murray below the Barmah choke systems. It shows that allocation prices were noticeably lower in Murrumbidgee in 2016-17. The 100 GL Murrumbidgee IVT limit has started to bind again recently, contributing to a significant increase in the differential in prices between the Murrumbidgee and the Victorian Murray below Barmah trading zones.
Figure 41 Surface water allocation prices, Victorian Murray below Barmah and Murrumbidgee systems, 2012 to 2019

Note: Data was cleaned using ABARES price cleaning methods as described in Sanders et al. (2019) and adjusted for inflation. Source: Price data prior to June 2019 is sourced from the BOM national water register, various market reports, and broker websites; price data after June 2019 is obtained from Waterflow; ABS Consumer Price Index (2019) (cat. 6401.0).

3.6 Future allocation prices

Gupta & Hughes (2018) estimated future water prices in the sMDB assuming 2016-17 levels of water demand, 2016-17 institutional arrangements and a repeat of the historical climate between 2002-03 and 2016-17. They compared this scenario to what actually occurred between 2002-03 and 2016-17.

The model estimates suggest that there could be a change in the distribution of future allocation prices in the sMDB, with fewer years with low prices and more years with moderate to high prices (Figure 42).
Figure 42 Water price histogram, southern MDB

Source: Gupta & Hughes (2018)
Appendix A: Interregional trade flows

Figure 43 Net interregional trade, surface water allocations, NSW Murray

Note: Excludes environmental transfers. A positive number denotes net trade in and a negative number denotes net trade out.
Source: ABARES estimate

Figure 44 Net interregional trade, surface water allocations, SA Murray

Note: Excludes environmental transfers. A positive number denotes net trade in and a negative number denotes net trade out.
Source: ABARES estimate
Figure 45 Net interregional trade, surface water allocations, Goulburn-Broken

Note: Excludes environmental transfers. A positive number denotes net trade in and a negative number denotes net trade out.
Source: ABARES estimate
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