Murray-Darling Basin:
Status and Trends of Key Socio-Economic Indicators and The Economic and Social Effects of Water Reforms

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Abstract

The Murray-Darling Basin (MDB) has been the focus of major water reforms over the past two decades aimed at improving water use efficiency, improving transparency, establishing long-term sustainability, and redressing over-allocation affecting many of the Basin's rivers. These water reforms were expected to have social-economic impacts on the Basin, compounded by the broader changes occurring across the Basin, and indeed Australia, as agriculture adapted to changing market conditions, new technologies and climate conditions. In this paper, we document trends in social-economic indicators in the MDB, as a whole and for selected communities (Deniliquin, Shepparton, Renmark, Griffith and Moree), and identify likely causes for these trends in key indicators. The socio-economic indicators include agricultural production, water use and efficiency, commodity prices, population size and density, labour force and population and employment of indigenous communities. Different towns fared quite differently across the MDB with some communities growing and prospering, while others declined. Drought was a major driver of changes in MDB communities and industries through the 2000s, but water reforms, water prices and other factors also played a role in more recent years. Socio-economic changes are still playing out in the MDB and ongoing assessment at multiple scales will be critical for understanding the nature and drivers of changes experienced by the industries and communities in the MDB.

Key findings

- Agricultural commodity production varied considerably throughout the period examined, with greater fluctuations in production of annual crops including cotton and rice, compared to grapes, a perennial crop which relies on water from higher security entitlements and water trade to sustain permanent plantings.

- The gross value of irrigated and total agricultural production (GVIAP and GVAP; in real terms) has grown in the MDB between 2000-01 and 2010-11 and has been maintained over the five years between 2011-12 and 2015-16, despite being interrupted by several years of decline during the Millennium drought. GVIAP in the MDB reached a record high of $7,135 million in 2013-14 ($5,442 million in 1997-98 price) while GVAP reached a record high of $20,588 million in 2014-15 ($13,634 million in 1997-98 price).

- Drought was probably the major factor driving reductions in GVIAP, but water recovered through buybacks and infrastructure (associated with limits on the quantity of water that can be taken from the Basin's water resources) and consequent pressure on water allocation price also possibly played a role. Drought influenced agricultural production (GVAP) in the MDB to a lesser degree, while effects of water reforms were not significant in our model.

- Total volume used for irrigation declined during the Millennium drought to 3,142GL in 2007-08, but increased to 8,273GL in 2012-13 following a wet period. Pastures and cotton were the highest overall water users, while rice had the highest water application rate (12.6ML/ha on average over the period 2001-2016).

- There was a declining but variable trend in land irrigated, from a high of 1,824,000ha in 2000-01 to 929,000 ha in 2008-09 then rising to 1,560,000ha in 2013-14, then slightly declining to 1,238,000ha in the dry year of 2015-16. Most land irrigated was used for pasture, cereals and cotton. Factors contributing to changes in land irrigated included agricultural commodity producer price index, drought period prior to 2007, water allocation price, and water recovery from buybacks and infrastructure.

- Water use efficiency (measured as the gross value of irrigated agricultural production in the Basin in 1997-98 price per megalitre of water used) increased from $486/ML in 2000-01 to $1,171/ML in 2007-08 during the Millennium drought, but subsequently declined to $704/ML by 2013-14. Significant drivers appear to be water allocation price and water recovery from buybacks and infrastructure.

- Water allocation price appeared to be driven by the volume of water allocation announced and the total water availability. Volumes of water extracted were affected by water allocation, water recovery and water allocation price.

- Increased water recovery was associated with reduced area of land irrigated, GVIAP and GVAP, but was associated with increased water use efficiency. Similar effects occurred with changes in water allocation price.

- Population of the MDB has increased since 1996 to about 2.2 million in 2016, or 9.5% of the population of Australia. However, the rate of population increase in the MDB was lower than the Australian rate. The average age appeared to increase, with an increase in the proportion of population who were 65 years or older in the MDB between 2006 and 2016.

- Indigenous population in the MDB increased from 3.5% of the Basin's population in 2006 to 5.4% in 2016. Between 2006 and 2016, the indigenous population growth rate in the MDB was 41%, nearly four times higher than the overall population growth rate in the MDB (10.1%), and more than double the national rate (18%). Labour force participation of the Indigenous community in 2016 (54%) was less than the MDB average (64%) while the unemployment rate of the Indigenous community (17%) was much higher than the MDB rate (5.6%).

- In 2016, there were almost one million people employed in the MDB, more than half (55%) of the Basin's population aged 15 years and over, similar to the national employment to population ratio (56%). Over the period 1996-2016, the number of employed persons in MDB increased, however, part-time employment increased faster than full-time employment, and the proportion of full time employment decreased from 67.9% to 62.2% over the period.

- In 2016, employment in agriculture in the MDB accounted for 34% of the national employment in agriculture. The decline of 15% in agricultural employment in the MDB between 2006 and 2016 was about twice of the Australia-wide decline in employment in agriculture of 7.4%.

- Between 2005 and 2016, there was a downward trend in the total number of agricultural businesses and the number of irrigating agricultural businesses in the MDB. This is consistent with the national downward trend. We found no evidence of any effect of water reforms on the number of agricultural businesses or irrigating agricultural businesses in the MDB.

- Deniliquin, Moree and Renmark experienced declines in population and economic activity, while Shepparton and Griffith grew strongly. Deniliquin has experienced the greatest decline, with the number of businesses almost halving between 2003 and 2015 with agriculture/forestry/fishing businesses being particularly hard hit with a decline from 498 to 128 over that period. Moree's population declined by 11% between 2000 and 2015 while its agricultural/forestry/fishing labour force dropped by 20% between 1996 and 2011. The Renmark district experienced only a small (6%) decrease in population between 2000 and 2015, although the labour force remained relatively stable.

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1 Introduction

The Murray–Darling Basin (MDB) region covers an area of over 1 million km^2, which is equal to 14% of mainland Australia. This includes 75% of New South Wales, more than 50% of Victoria, large portions of Queensland and South Australia, and all of the Australian Capital Territory. The region is defined by the catchment areas of Australia's two longest rivers: the Darling River (2,740 km) and the Murray River (2,520 km). The region has a population of over 2 million, and irrigated agriculture is a major industry.

The current water reforms in the MDB grew from a Basin-wide approach to water reform that started over 30 years ago, beginning with a development of water market and access to water trading. Water markets, where buyers and sellers can trade the right to receive either an ongoing share of the available water entitlement, or a specified volume of water allocation, are one of the major features of the water reforms.

Trade in water allocations was first allowed in New South Wales and South Australia in 1983 and then later in Victoria in 1987. Trade in water entitlements within an irrigation district was permitted in South Australia in 1983, New South Wales and Queensland in 1989, and Victoria in 1991 (Grafton & Horne 2014). In 1992, the Murray-Darling Basin agreement was established between Basin States to coordinate planning for the equitable, efficient and sustainable use of water, land and other environmental resources. In 1994, the Council of Australian Governments water reform agreement reformed water pricing and facilitated cross-border water trading.

In 1995, a limit on water diversions (called the 'cap') was first implemented in the MDB. The Cap was established to limit the total surface water extracted from the Basin's rivers and streams. In 2004, the National Water Initiative (NWI) was signed by all state governments and sought to establish a nationally consistent water market. Interstate water trade was expanded within the Southern MDB in 2006.

A new stage of institutional and market reforms started in 2007. The Australian Government committed to funding a number of measures to re-balance water between irrigation and environmental needs. In 2007, the Commonwealth government committed $10 billion over ten years under the National Plan for Water Security to facilitate the implementation of the NWI, of which $3.1 billion was committed to water buyback program to purchase water for the

environment and $4.4 billion was committed to the investment towards improving the efficiency and productivity of water use and management (Crase et al. 2009; ABARES 2011). The Commonwealth Water Act 2007 established the Murray-Darling Basin Authority with responsibility to develop a Basin Plan that would set enforceable sustainable diversion limits and rules to facilitate water trade. The reforms included critical basin-wide measures to improve competition within the water markets and availability of water information (Connell and Grafton 2011). In 2008, the government committed to a spending of almost $13 billion over ten years in water reforms (Crase et al. 2009; ABARES 2011).

In November 2012, the Murray-Darling Basin Plan was enacted. The central element of the Basin Plan is the introduction of a limit on surface and groundwater diversions. The Basin Plan sets limits on the quantity of water that can be taken from the Basin's water resources. It also includes a requirement for an environmental watering planning as the means to coordinate the delivery of environmental outcomes across the Basin. Water trading rules have also been introduced to further reduce restrictions on trade and improve market transparency and confidence.

As this history shows there have been a number of government-led initiatives – introduction of water trading, a limit on surface water abstractions, buying water entitlements back for environmental use, investments to upgrade irrigation water use efficiencies, and a basin-wide Plan for water resources - to both improve water use efficiency in the MDB and to return water from consumptive uses to the environment to redress over-allocation in some of the Basin's rivers. These water reforms are expected to have social-economic impacts on the basin. In addition, there are wider changes occurring across the Basin, and indeed across Australia, as agriculture adapts to changing market conditions and changes in technology. In this paper we attempt to see if the water reforms have led to significant economic and social changes across the Basin and within selected communities of the Basin.

We base our analysis on publically available data from various sources including data from MDB annual reports, MDBA water audit monitoring reports, agricultural commodity statistics in 2016 from ABARES, Murray Irrigation data, Department of Employment data, and ABS data (surveys on Agricultural Commodities, Gross Value of Irrigated Agricultural Production, Water Use on Australian Farms, Australian Census of Population and Housing 1996, 2001,

2006, 2011 and 2016, National Regional Profile). Depending on the series, the data extracted for the MDB for our analysis are only available between 11 and 16 years over the period 2001-2016. Before 2001, the data for these surveys published by the ABS do not provide information at geographical areas that enable us to extract the data for the MDB.

In Section 2, we report the status and trends of key socio-economic indicators in the MDB. Section 3 analyses the effects of water reforms on key social-economic indicators in the basin. Section 4 presents discussion of the modelling results and Section 5 summarizes key findings.

2 Status and trends of key socio-economic indicators in the MDB

This section reviews the status and trends of key socio-economic indicators in the MDB. The followings are key findings.

- The production of annual, water-dependent crops such as rice, cotton, cereals fell sharply during the drought period 2006-2009 and recovered in 2011 after the dry period. Between 2013 and 2015, the production of these crops experienced downward trends which are associated with a downward trend in natural water availability due to low rainfall levels over those years. Grape production remained stable over the period 2001-2015.
- Gross value of irrigating agricultural production as well as total value of agricultural production in the MDB was severely affected by the drought in 2006-07 and in 2008-10.
- Despite the reduction in severe drought years, the gross value of total agricultural production as well as gross value of irrigated agricultural production in the MDB has risen over the period 2001-2011, and has been maintained over the last five years between 2011-12 and 2015-16, after adjusting for inflation.
- Between 2005 and 2016, there was a downward trend in the total number of agricultural businesses and the number of irrigating agricultural businesses in the MDB. However, there was also a downward trend in these businesses at national level.
- The average water use efficiency in the MDB (measured as the gross value of irrigated agricultural production in 1997-98 price per megalitre of water used overall) increased

during the drought period 2006-2009, and then remained at higher level than before the drought.

- In the MDB, water availability, water allocation announcements and water diversions for consumptive use tended to move together.
- The water allocation price experienced a sharp increase during the period 2006-2009 when water availability dropped to a critically low level due to drought. This price then dropped significantly between 2011 and 2013 when water availability was again at high levels. Between 2013 and 2016, water allocation price experienced an increasing trend, corresponding to a downward trend in water availability over those years.
- Over the period 1996-2016, the MDB population increased by 16%, which is only half of the rate of the increase in national population (32%).
- Population declined in the outer regional and remote locations and increased in inner regional areas and major cities of the MDB between 2001 and 2011.
- The number of employed persons in MDB continued to increase over the period 1996-2016, and the unemployment rate in the MDB was lower than the national unemployment rate.
- Between 2006 and 2016, while the number employed in the MDB increased, the number employed in agriculture decreased by 15.5% in the MDB, and by 7.4% Australian wide.
- The proportion of the MDB community that is indigenous increased over time. The unemployment rate of the Indigenous community was much higher than the average basin unemployment rate. In 2016, it was 17% compared to 5.6% for whole Basin workforce.
- The average incomes from wage and salary in Deniliquin, Griffith, Moree, Shepparton, and Renmark were significantly less than the national average.
- Over the period 2002-2016, the unemployment rate in Deniliquin and Griffith was less than the national level; while the unemployment rates in Moree Plains, Greater Shepparton and Renmark were higher than the national average.

Details of the status and trends of the key socio-economic indicators in the MDB are presented below.

2.1 Agricultural production

The MDB is colloquially known as the nation's 'food bowl' because of the volume of agricultural products grown there, collectively generating a gross value of $19.4 billion, or 35% of Australia's total value of agricultural production in 2015-16. Although representing just 14% of Australia's total land area, in 2015-16 the Basin contains 23% of Australia's agricultural land.

A variety of crops and pasture are grown in the MDB for food and fibre for domestic consumption and export. These include: cereals (e.g. wheat, barley, rice, sorghum); cotton; fruit and nuts (e.g. apples, oranges, almonds); grapes; vegetables (e.g. tomatoes, onions); livestock fodder (e.g. pasture for grazing or hay/silage).

Irrigated agriculture is more common in the MDB than elsewhere in Australia. Irrigated agricultural land is a relatively small proportion of total agricultural land throughout Australia (less than 6%). However, in the MDB, 1.5% of agricultural land is irrigated. In 2015-16, the MDB's irrigation volume accounted for 59% of Australia's irrigation volume (ABS, Water Use on Australian Farms).

The change in agricultural production over time can be influenced by many factors. Climate, specifically rainfall and drought, significantly impacts water availability and farmers' ability to grow crops. Government policies can affect irrigated agricultural production and encourage or discourage the production of particular agricultural commodities (NWC 2008). Changes in commodity prices and input prices influence agricultural production by affecting their revenue and expenditure on farming inputs (such as water, fertiliser, fuels and labour). New technologies can improve productivity and reduce the quantity of inputs (e.g. water, fertiliser) required. These factors affect overall agricultural production in the MDB, and can instigate structural change in the industry, leading farmers to increase production of some commodities and reduce the production of others.

This section reports changes in agricultural activity between 2000–01 and 2015–16 in the MDB, including changes in agricultural commodity production, value of agricultural and irrigated agricultural production, water use on Australian farms, irrigated agricultural area, irrigation application rate, water use efficiency and agricultural commodity prices.

2.1.1 Agricultural commodity production

Cereals: cereals for grain and seeds account for 24% of the gross value of agricultural production in the MDB, most of it is dryland cropping. Nearly half (47%) of all Australian agricultural land dedicated to producing cereals for grain in 2014-15 was located in the MDB, accounting for 45% of all cereals for grain production in Australia (Table 1).

Figure 1 shows the cereals for grains and seed production (excluding rice) in the period 2001-2015 for Australia and the MDB. Cereals production dropped in the years 2006-07 and 2007-08. This reduction could be explained by the impacts of the Millennium Drought (Qureshi et al. 2013). After 2008, cereals production increased and reached a peak in 2010-11. Between 2012 and 2015, there was a downward trend in cereal production in the MDB which is associated with a downward trend in water availability over this period.

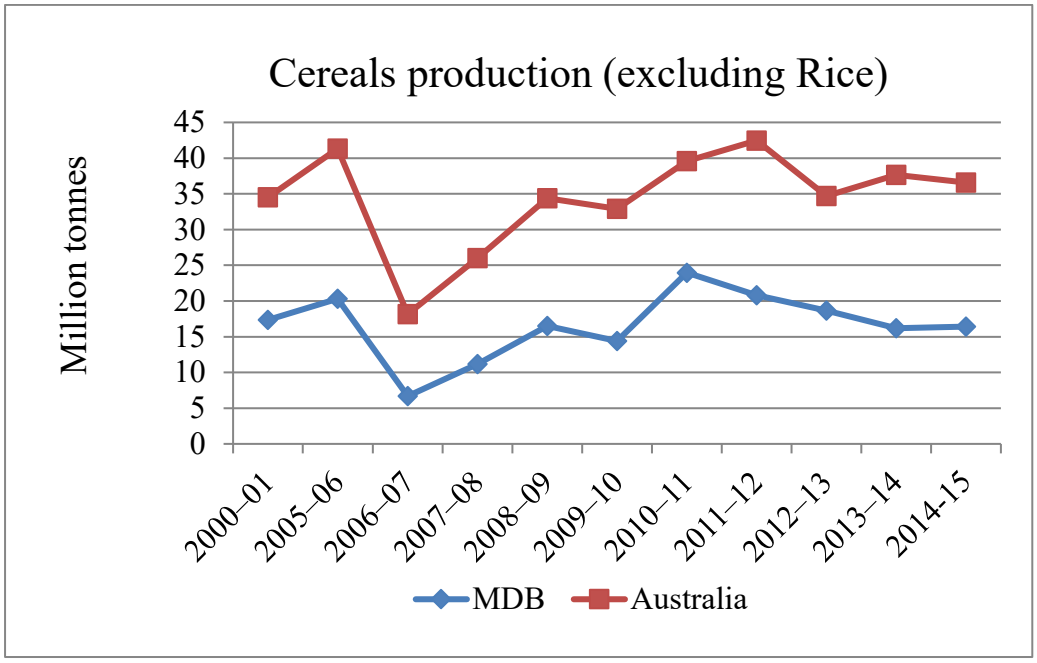
Table 1: Agricultural commodity production in MDB

Year	MDB (Million tonnes)				MDB as proportion of Australia (%)			
	Cereals (excl. rice)	Rice	Cotton	Grapes	Cereals (excl. rice)	Rice	Cotton	Grapes
2000–01	17.36	1.64	0.60	1.12	50.3	99.7	90.7	72.1
2005–06	20.31	1.00	0.52	1.51	49.2	99.9	92.2	76.1
2006–07	6.69	0.16	0.25	1.00	36.8	99.9	88.3	65.3
2007–08	11.19	0.02	0.11	1.45	43.0	100.0	93.4	73.9
2008–09	16.52	0.06	0.27	1.26	48.0	100.0	90.6	70.1
2009–10	14.41	0.19	0.33	1.22	43.8	99.0	93.6	72.2
2010–11	23.96	0.71	0.67	1.29	60.5	98.6	96.1	75.3
2011–12	20.80	0.92	0.77	1.30	49.0	99.9	94.5	78.5
2012–13	18.64	1.16	0.81	1.40	53.7	100.0	96.5	79.7
2013–14	16.17	0.82	0.81	1.25	42.9	99.8	94.8	80.0
2014-15	16.42	0.69	0.37	1.42	44.9	99.9	92.4	82.4

Source: ABS, Agricultural Commodities, cat. No. 7121.0

Note: Grape production figures are not available for the years 2006-07 and 2008-09: the figures here are calculated as GVIAP/price (source: Kirby et. al. 2012)

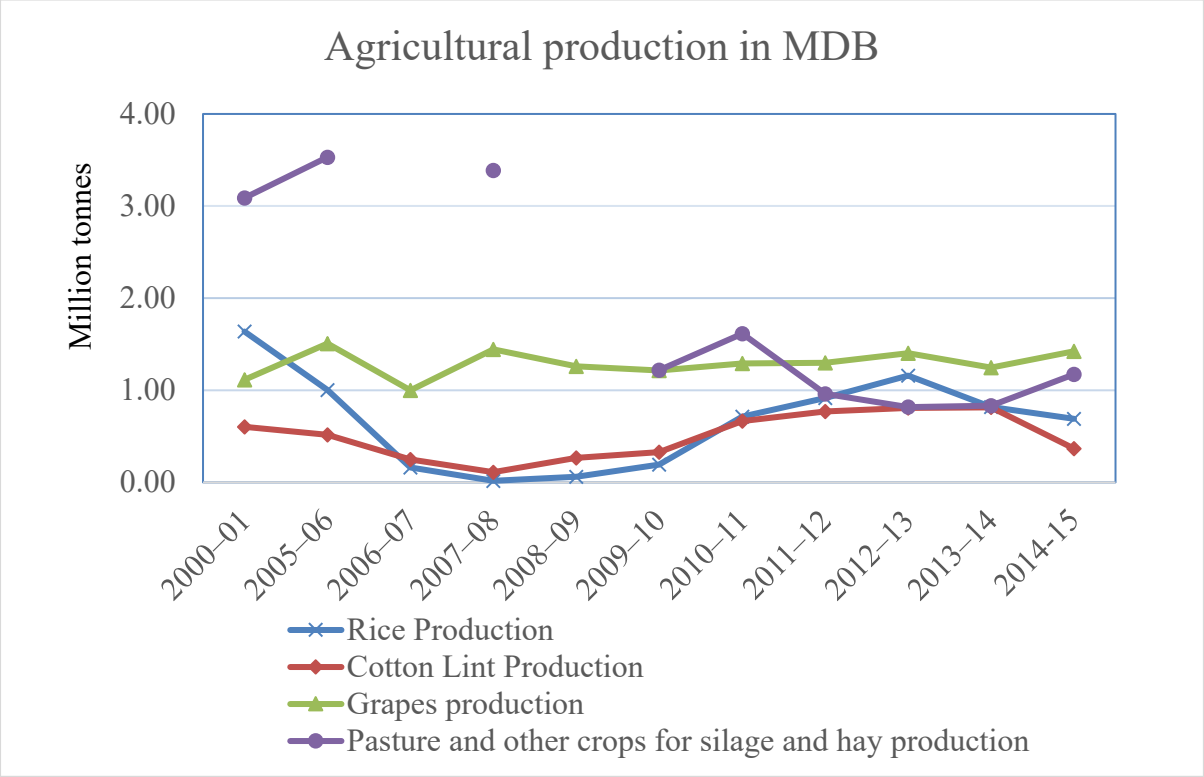
Figure 1: Cereals for grains and seeds production, 2001-2015



Source: ABS, Agricultural Commodities, cat. No. 7121.0

Other selected commodities: Figure 2 shows the production of heavily-water dependent crops including rice, cotton lint, grapes, and pasture and other crops for hay and silage in the MDB for the period 2001-2015. The Figure shows that rice and cotton lint production fell sharply in the Millennium Drought period 2007-2009. Production levels for those commodities recovered in 2009-2010 and showed an increasing trend in the period 2010-2013. However, corresponding to the reduction in water availability between 2013 and 2015, rice production again decreased between 2013 and 2015 and cotton production decreased in 2014-15. Pasture and other crops for hay and silage production fell sharply between 2006 and 2010 and remained at low levels between 2010-2015. Grape production, in terms of volume, remained stable in the period with the level of production being between 1 and 1.5 million tonnes during the period 2001-2015. The stability of grape production might be due to grape being a perennial crop. Because of their relatively fixed water demand, grape farmers tend to hold high-security entitlements. They also bought additional water during droughts. These purchases helped maintain grape production (National Water Commission 2011).

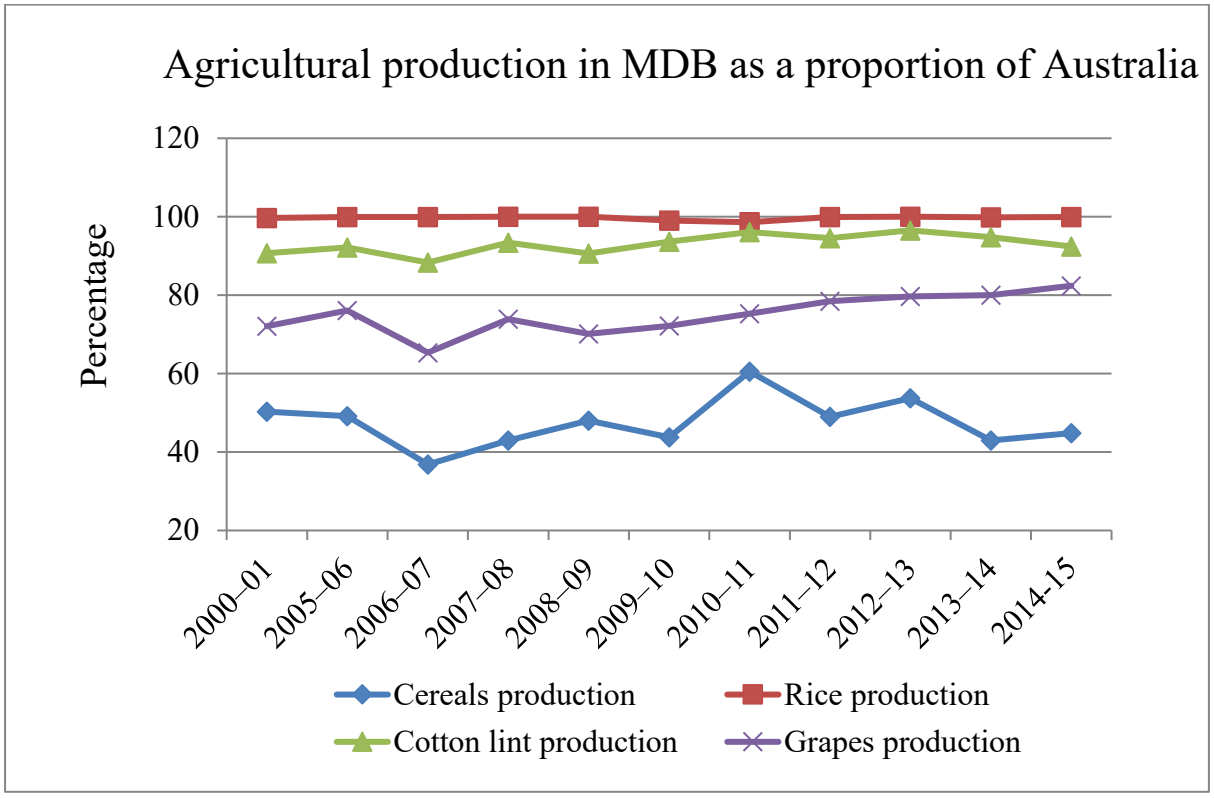
Figure 2: Rice, cotton lint, grapes, and hay and silage production in MDB, 2001-2015



Source: ABS, Agricultural Commodities, cat. No. 7121.0

Figure 3 represents the share of cereals, rice, cotton lint and grapes production in the MDB as the percentage of Australian production. It shows that, over the period 2001-2015, rice production in MDB accounted for almost all of the Australian rice production. The share of cotton lint production remained stable and accounted for more than 90% of Australian cotton lint production. The share of grapes production in the MDB as a proportion of Australia was more than 70% and showed an increasing trend during the period 2007-2015. The share of cereals production is between 40-60% and there is a downward trend in the share of cereals production in MDB between 2011 and 2015.

Figure 3: Agricultural production in MDB as a proportion of Australia, 2001-15



Source: ABS, Agricultural Commodities, cat. No. 7121.0

2.1.2 Gross value of total and irrigated agricultural production

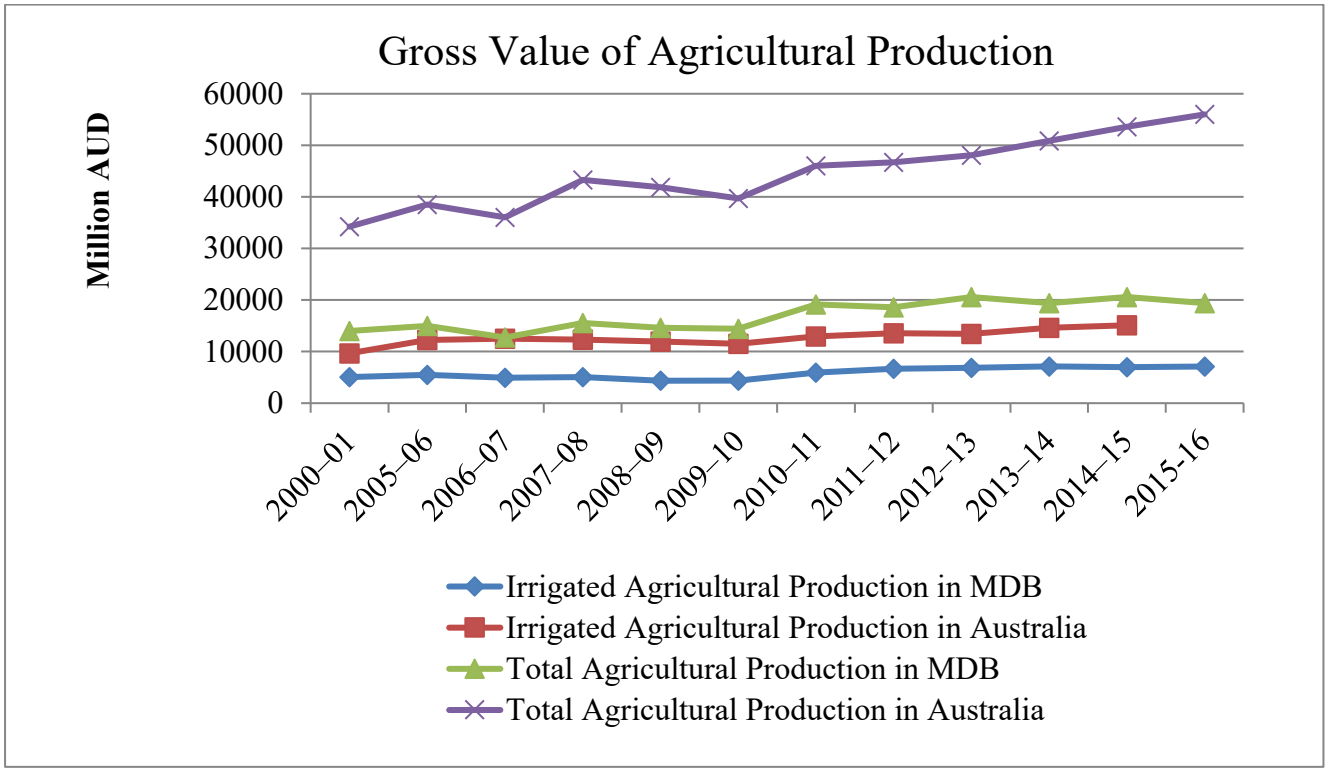
Table 2 shows the gross value of total and irrigated agricultural production in the MDB and Australia for the period 2001-2016. In 2015-16, the gross value of all agricultural production in the MDB was $19.4 billion and represented 36% of Australia's total value of agricultural production. Out of this $19.4 billion, the gross value of irrigated agricultural production (GVIAP) in the MDB was $7.1 billion, representing 37% of the gross value of agricultural production (GVAP) in the MDB. Figure 4 shows a variable, but growing trend in the values of total and irrigated agricultural production in the MDB, as well as in Australia.

Table 2: Gross value of total and irrigated agricultural production in Australia and MDB, 2001-16

Year	Irrigated agricultural production				Total agricultural production		
	Irrigated agricultural production in MDB (million AUD)	Irrigated agricultural production in Australia (million AUD)	MDB as proportion of Australia (%)	Irrigated agricultural production as proportion of total agricultural production in MDB (%)	Total agricultural production in MDB (million AUD)	Total agricultural production in Australia (million AUD)	MDB as proportion of Australia (%)
2000–01	5085	9669	52.6	36.3	14001	34237	40.9
2005–06	5522	12257	45.1	36.8	14991	38527	38.9
2006–07	4922	12488	39.4	38.6	12739	36060	35.3
2007–08	5079	12311	41.3	32.6	15576	43270	36.0
2008–09	4349	11953	36.4	29.7	14637	41849	35.0
2009–10	4386	11485	38.2	30.4	14423	39707	36.3
2010–11	5944	12946	45.9	31.0	19163	46020	41.6
2011–12	6691	13546	49.4	35.9	18620	46687	39.9
2012–13	6837	13431	50.9	33.2	20568	48048	42.8
2013–14	7135	14599	48.9	36.8	19402	50866	38.1
2014–15	6962	15108	46.1	33.8	20588	53625	38.4
2015-16	7100			36.6	19400	55994	35.6

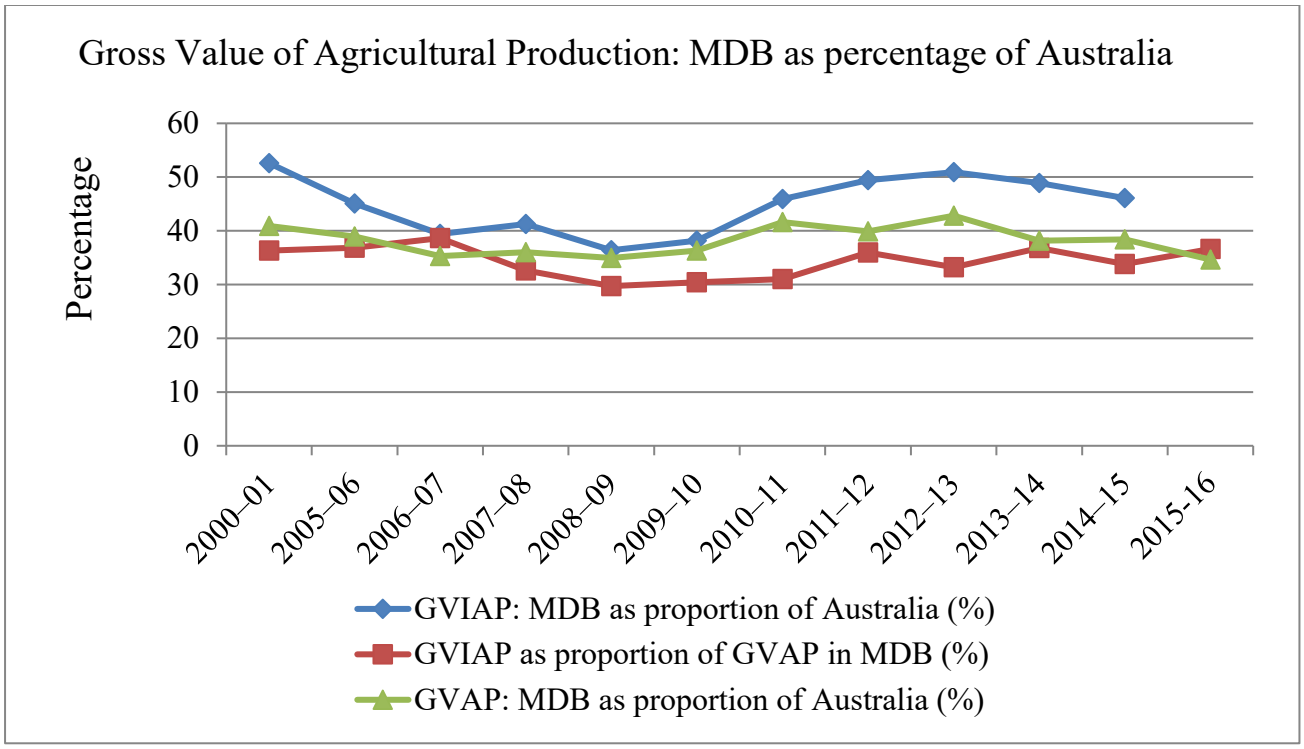
Source: ABS, Gross Value of Irrigated Agricultural Production, cat. No. 4610.0.55.008; MDBA Annual Report 2015-16

Figure 4: Gross value of agricultural production in MDB and Australia (nominal value)



Source: ABS, Gross Value of Irrigated Agricultural Production, cat. No. 4610.0.55.008

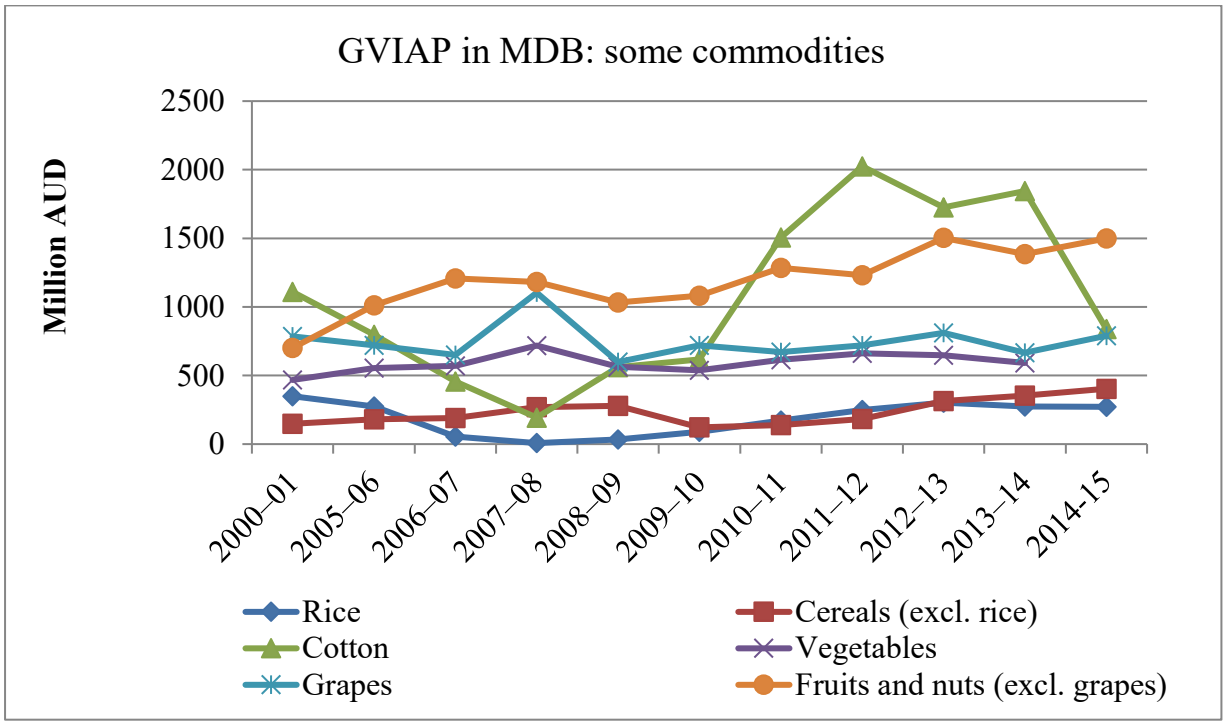
Figure 5: Gross value of agricultural production: MDB as percentage of Australia



Source: ABS, Gross Value of Irrigated Agricultural Production, cat. No. 4610.0.55.008

Figure 5 includes trends in the share of the gross values of total and irrigated agricultural production in MDB as a percentage of the gross values of those in Australia and the share of the gross value of irrigated agricultural production in the MDB as proportion of the gross value of agricultural production in the MDB. It shows that the share of the gross value of irrigated agricultural production to the value of total agricultural production in the MDB declined in the period 2007-2011. This could be partly the result of the Millennium Drought where typically, irrigated crops demand more water than non-irrigated crops, therefore, droughts where there are large reductions in the water available for extraction can have large negative impacts on seasonal irrigated agricultural production. This share of the GVIAP to GVAP in the MDB recovered during the period 2011-14. The share of the GVIAP in the MDB as a percentage of GVIAP in Australia also decreased during the period 2006-2010 and recovered after 2010. The proportion of the GVAP in MDB to GVAP in Australia exhibited no noticeable trend between 2001 and 2016.

Figure 6: GVIAP in MDB: some commodities



Source: ABS, Gross Value of Irrigated Agricultural Production, cat. No. 4610.0.55.008

Figure 6 represents the nominal GVIAP for rice, cereals (excluding rice), cotton, vegetables, grapes, and fruits and nuts (excluding grapes) in the MDB. It shows that GVIAP for rice and

cotton both of which depend on irrigation fell sharply during the years 2006-10 and recovered (rice) or increased (cotton) between 2011 and 2015. GVIAP for cereals, vegetables and grapes fluctuated slightly while GVIAP for fruits shows a slightly increasing trend over the period. The fluctuations of the GVIAP for these crops caused by both the changes in production and prices over the period.

2.1.3 Water use on Australian farms

Table 3 and 4 show the water use and water application rate for main crops in the MDB as well as the total irrigation water volume applied and the application rate in the MDB and Australia over the period 2001-2016. The volume of water applied in both the MDB and Australia fell in the period 2006-2011 and recovered back to pre-drought levels during the years 2012-2016 (Figure 7). In 2015-16, the volume of water applied for irrigation in the MDB accounted for 59% of the total water applied for irrigation in Australia. As shown in Table 4, the water application rate is highest for rice production; the next crops that depend heavily on irrigation are cotton and fruits and nuts, while the water application rate is relatively low for other cereals. Generally, over the period 2001-2016, the average water application rate in MDB was higher than the average in Australia. However, average water application rate in MDB was lower than the national average level in 2014-15 (Figure 8). This might be the result of a low water allocation in 2014-15 combined with the government buy-back program in the MDB. With the exception of pasture, there is no discernible reduction in the water application rate over the period. After the drought period, water application rates for cotton and fruits and nuts increased between 2011 and 2016.

Table 3: Irrigation volume for main crops in the MDB

	Irrigation volume (GL)									
Year	Pastures	Rice	Cereals (excl. rice)	Cotton	Grapes	Fruits and nuts (excl. grapes)	Vegetables	MDB	Australia	MDB as % of Australia
2000–01	3227	2418	751	2599	469	372	166	10002		
2001–02	2971	1978	1015	2581	479	389	152	9565		
2002–03	2343	615	1230	1428	492	424	143	6675	10404	0.64
2003–04	2549	814	876	1186	489	382	194	6491	10442	0.62
2004–05	2371	619	844	1743	510	399	152	6640	10085	0.66
2005–06	2571	1252	782	1574	515	413	152	7260	10737	0.68
2006–07	1559	239	690	819	534	417	125	4458	7636	0.58
2007–08	997	27	805	283	434	356	124	3142	6285	0.50
2008–09	842	101	707	793	439	374	121	3492	6501	0.54
2009–10	998	247	469	764	428	450	129	3564	6596	0.54
2010–11	766	755	234	1789	303	379	115	4507	6645	0.68
2011–12	1271	1134	511	1906	365	475	120	5875	8174	0.72
2012–13	2042	1434	701	2735	463	566	114	8273	11060	0.75
2013–14	1941	912	808	2676	415	713	134	7736	10731	0.72
2014-15	2025	876	692	1114	431	502	108	5869	8950	0.66
2015-16	1438	299	535	1294	428	664	149	4938	8381	0.59

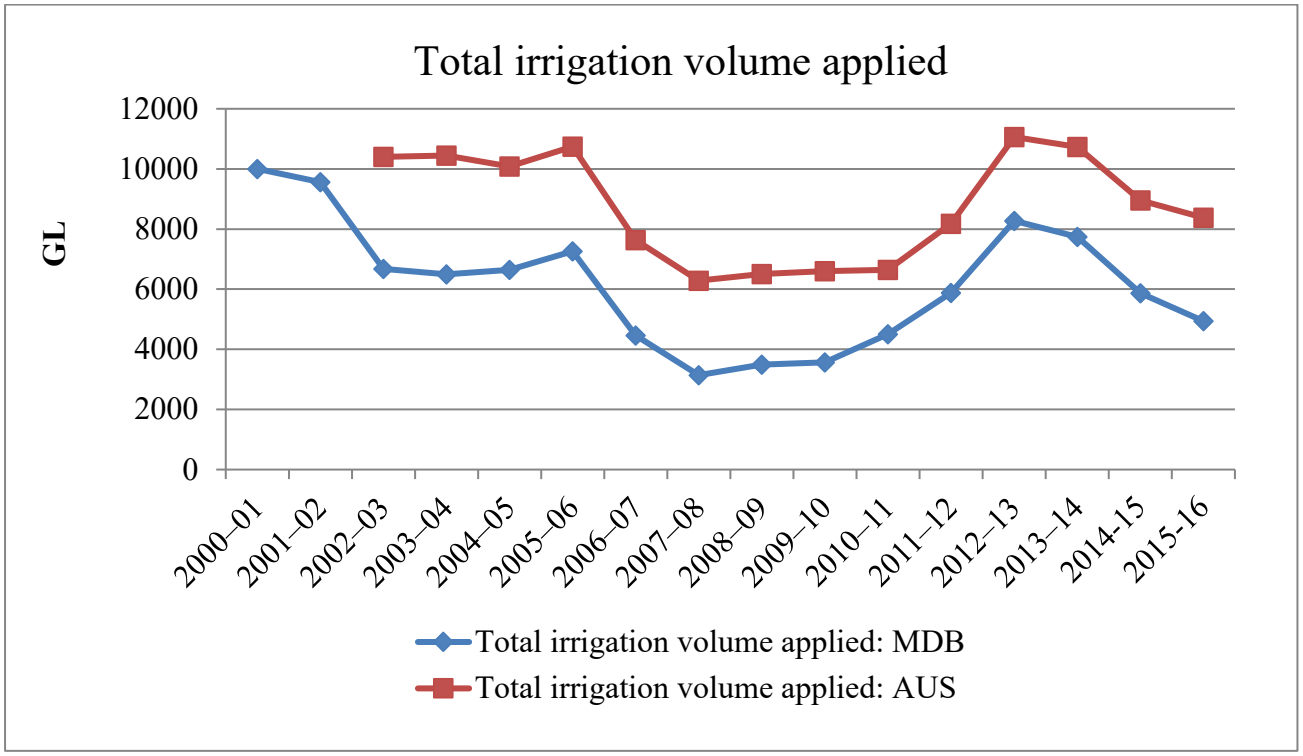
Source: ABS, Water Use on Australian Farms, cat. No. 4618.0

Table 4: Water application rate for main crops in the MDB

Year	Water application rate (ML/ha)								
	Pasture for dairy and other livestock farming	Rice	Cereals (excl. rice)	Cotton	Grapes	Fruits & nuts (excl. grapes)	Vegetables	MDB	Australia
2000–01	4.2	13.6	2.9	6.4	5.6	6.3	4.5	5.5	
2001–02	4.1	13.6	2.9	6.6	5.6	6.3	4.4	5.3	
2002–03	4.2	14.1	3.0	6.5	5.5	5.7	4.6	4.6	4.4
2003–04	3.8	12.4	2.6	6.8	5.6	6.5	4.9	4.5	4.3
2004–05	3.3	12.1	2.6	6.8	5.5	6.3	4.3	4.3	4.2
2005–06	3.5	12.3	2.4	6.4	4.9	5.5	4.7	4.5	4.2
2006–07	3.5	12.2	2.6	6.5	4.8	5.3	4.8	4.1	4.0
2007–08	2.7	12.9	2.8	5.3	4.1	5.0	4.4	3.3	3.4
2008–09	2.8	14.1	2.8	6.2	4.3	5.4	4.8	3.8	3.7
2009–10	2.5	13.0	2.5	5.6	4.5	5.7	5.1	3.7	3.6
2010–11	2.1	10.1	1.7	5.4	3.2	4.7	3.9	3.8	3.4
2011–12	2.6	11.0	2.4	5.2	4.1	6.1	4.2	4.2	3.8
2012–13	3.4	12.6	2.7	7.9	5.3	7.4	4.8	5.2	4.7
2013–14	3.1	12.0	3.0	8.0	5.0	9.0	5.0	5.0	5.0
2014-15	3.0	13.0	2.0	8.0	5.0	8.0	5.0	4.0	4.2
2015-16	2.9	12.3	2.0	6.9	5.4	8.4	4.6	4.0	3.9

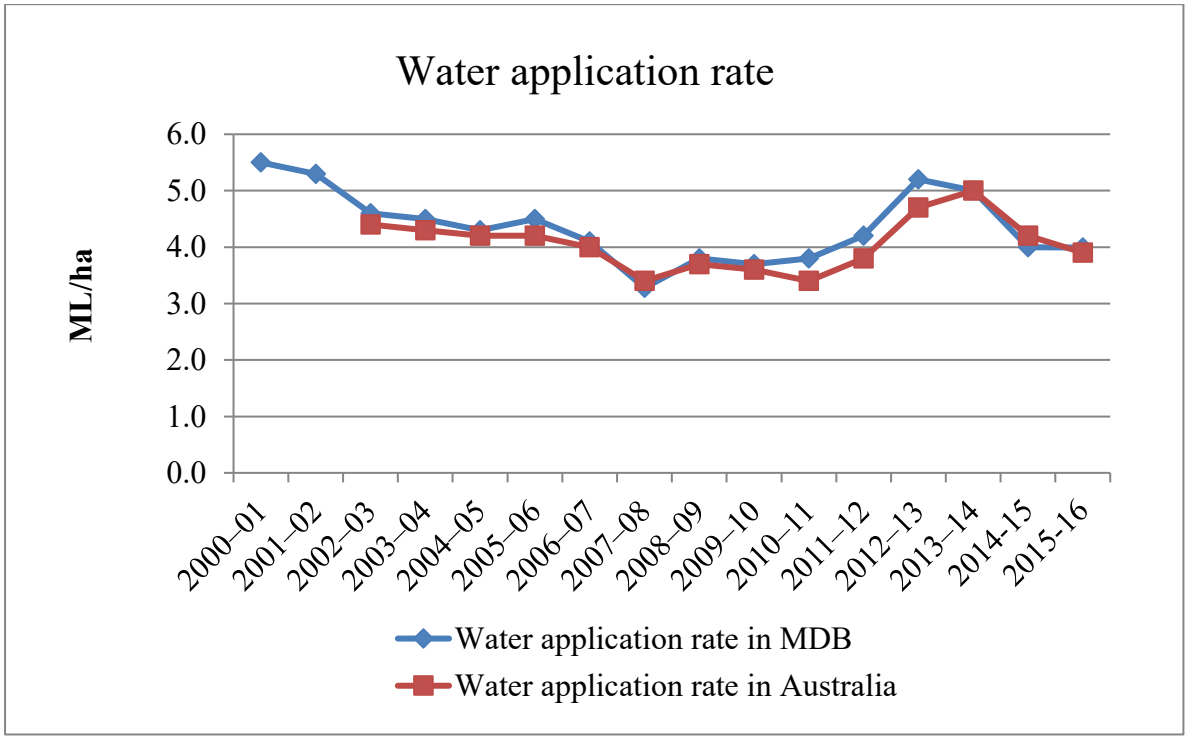
Source: ABS, Water Use on Australian Farms, cat. No. 4618.0

Figure 7: Total irrigation volume applied in MDB and Australia



Source: ABS, Water Use on Australian Farms, cat. No. 4618.0

Figure 8: Water application rate in MDB and Australia



Source: ABS, Water Use on Australian Farms, cat. No. 4618.0

2.1.4 Area irrigated

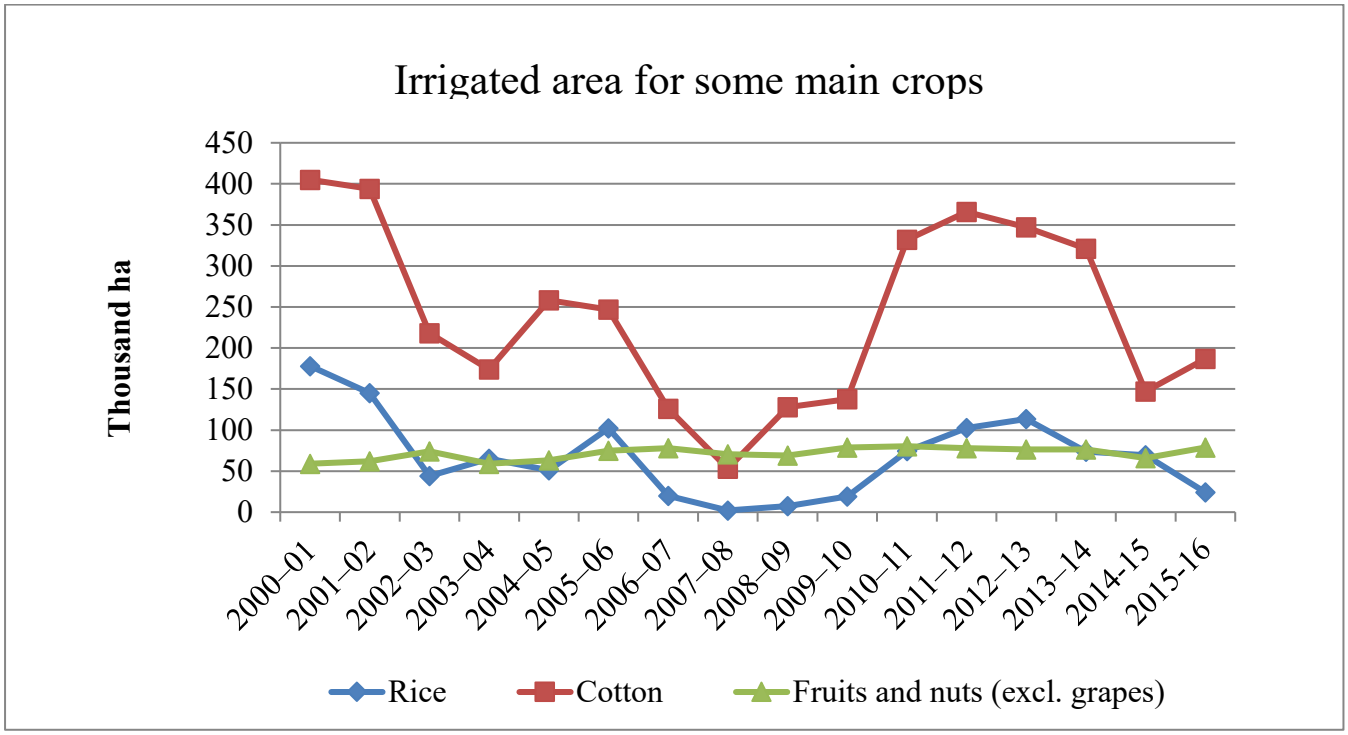
Table 5 and Figure 9 represent the irrigated area for some main crops in the MDB. The irrigated areas for rice and cotton, which are crops that have a high water application rate, fell substantially during the period 2006-2010, but after the Millennium Drought recovered between 2011 and 2015. However, irrigated area for rice in 2014-15 remained significantly below its level in 2001 before the drought, and dropped significantly in 2015-16 compared to its level in 2014-15. Irrigated area for cotton decreased sharply from 321,000 ha in 2013-14 to 147,000 ha in 2014-15 and 187,000 ha in 2015-16 as a result of the persisting drought between 2014-2016. Irrigated areas for cereals (excluding rice) decreased significantly during the period 2007-2011, but had recovered by 2012-13. Irrigated areas for fruits and nuts, grapes and vegetables fluctuated much less than other crops over the period 2001-2016.

Table 5: Irrigated Area in the MDB

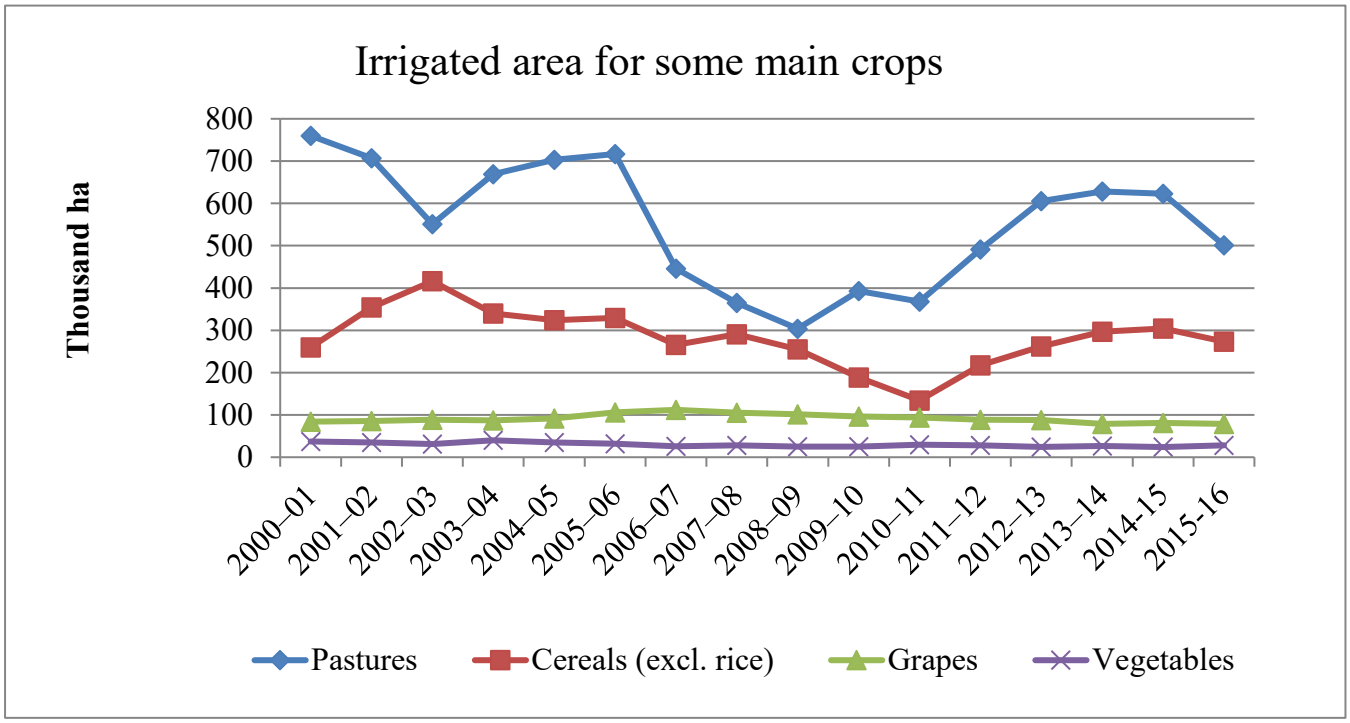
Year	Irrigated Area (thousand ha)							
	Pasture for dairy & other livestocks	Rice	Cereals (excl. rice)	Cotton	Grapes	Fruits & nuts (excl. grapes)	Vegetables	Total agriculture
2000–01	760	178	260	405	84	59	37	1824
2001–02	707	145	354	394	86	62	35	1817
2002–03	551	44	416	218	89	74	31	1466
2003–04	669	65	340	174	87	59	40	1501
2004–05	703	51	324	258	92	63	35	1588
2005–06	717	102	329	247	106	75	32	1654
2006–07	446	20	266	126	112	78	26	1101
2007–08	365	2	291	53	106	71	28	958
2008–09	304	7	255	128	102	69	25	929
2009–10	393	19	189	138	96	79	25	976
2010–11	368	74	134	332	94	80	29	1189
2011–12	491	103	217	366	89	78	28	1412
2012–13	605	113	262	347	88	77	24	1592
2013–14	628	74	296	321	79	76	26	1560
2014-15	623	70	304	147	81	66	24	1367
2015-16	501	24	273	187	79	79	28	1238

Source: ABS, Water Use on Australian Farms, cat. No. 4618.

Figure 9: Irrigated area for some main crops in MDB



(a) *Source: ABS, Water Use on Australian Farms, cat. No. 4618.0*



(b) *Source: ABS, Water Use on Australian Farms, cat. No. 4618.0*

2.1.4 Water use efficiency

As the data for production costs, and therefore data for net returns, of agricultural crops in the MDB are not available over the period, we calculated water use efficiency of agricultural crops using the gross value of agricultural crops. Table 6 and Figure 10 show the water use efficiency (WUE) defined as a ratio of value of production in fixed price of the year 1997-98 (A$; adjusted for inflation) per ML of water used for main crops in the MDB. The water use efficiencies for rice, and cereals have fluctuated, but generally exhibit a growing trend. WUE is lowest in rice production equal to about $228 per ML in 2013-14. The crops with relatively low value of WUE compared to others are cereals and cotton, with the levels $293 and $663 per ML, respectively, in 2013-14. Vegetable has the highest value of WUE, achieving a level of $2,546 per ML in 2013-14. Fruits and nuts are the second highest water efficient crops, achieving a level of $1,224 per ML in 2013-14.

Figure 11 shows that the average water use efficiency in the MDB increased during the period 2000-2008 but showed a decreasing trend between 2008 and 2014, then increased between 2014 and 2016. The value of WUE reached a peak level of $1,171 per ML in 2007-08. The increase in WUE during the drought could arise from one or more of a number of factors: a more efficient use of water in response to water scarcity, a shift from higher irrigation requirement crops to lower irrigation requirement, and water trade that allowed the highest value horticulture to stay in production while crops with lower marginal value and higher demand for water were fallowed crops, as such, water was only being used on crops generating high returns in low water availability years (Kirby et al. 2012). By 2013-14, the average water use efficiency in the MDB had fallen to $704 per ML, although this level of efficiency is still higher than that prior to the drought. WUE increased to $1,117 per ML in 2015-16.

Table 6: Water use efficiency in MDB

Year	Value of WUE (A$/ML) (fixed price year 1997-98)					
	Rice	Cereals (excl. rice)	Cotton	Fruits & nuts (excl. grapes)	Vegetables	MDB
2000–01	174	182	403	1848	2621	486
2005–06	206	237	663	1770	2726	732
2006–07	175	215	676	1573	3233	865
2007–08	170	187	781	2237	3768	1171
2008–09	154	287	732	1861	3037	1039
2009–10	203	239	820	1638	2770	1135
2010–11	243	472	812	1863	3188	1082
2011–12	208	312	959	1429	3425	967
2012–13	208	303	643	1696	3277	637
2013–14	228	293	663	1224	2546	704
2014-15	202	390	721	1751		901
2015-16						1117

Source: ABS, calculated by the author using the GVIAP and producer price index (reference year 1997-98=100)

Figure 10: Water use efficiency in MDB

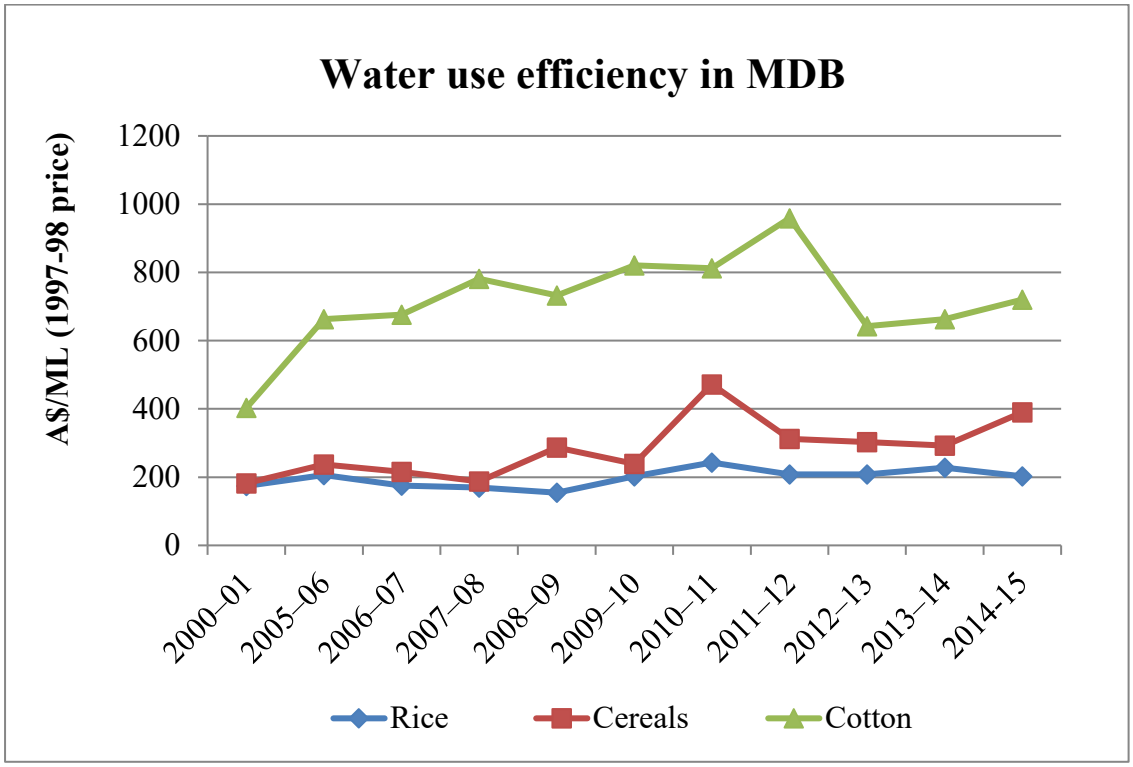
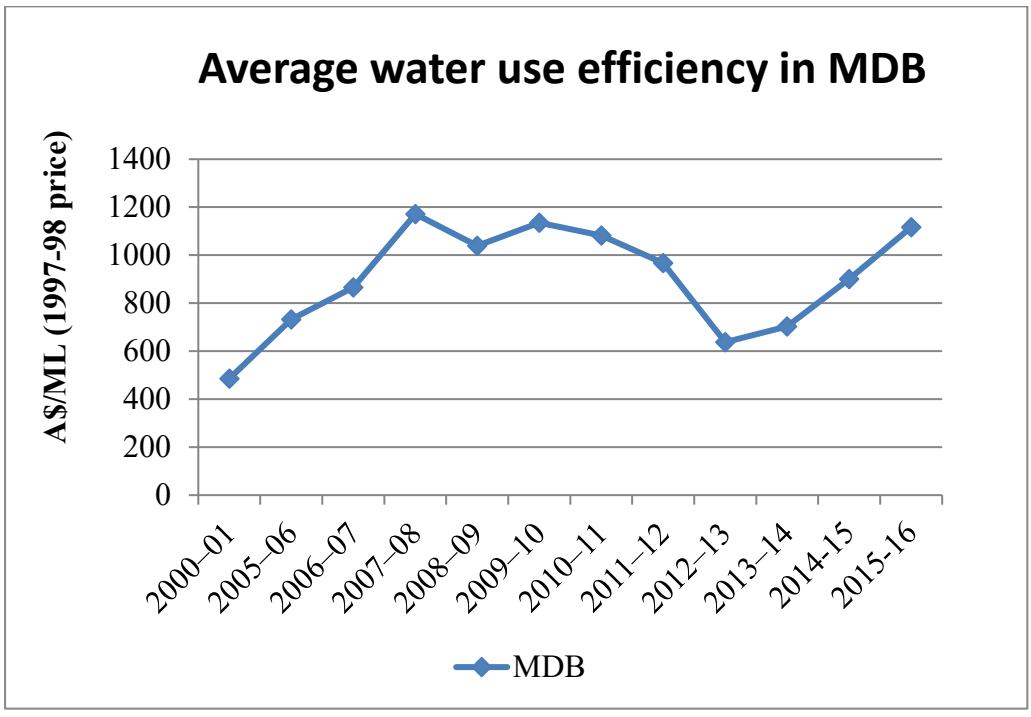


Figure 11: Average water use efficiency in MDB



Source: ABS, calculated by the author

2.1.5 Agricultural commodity prices

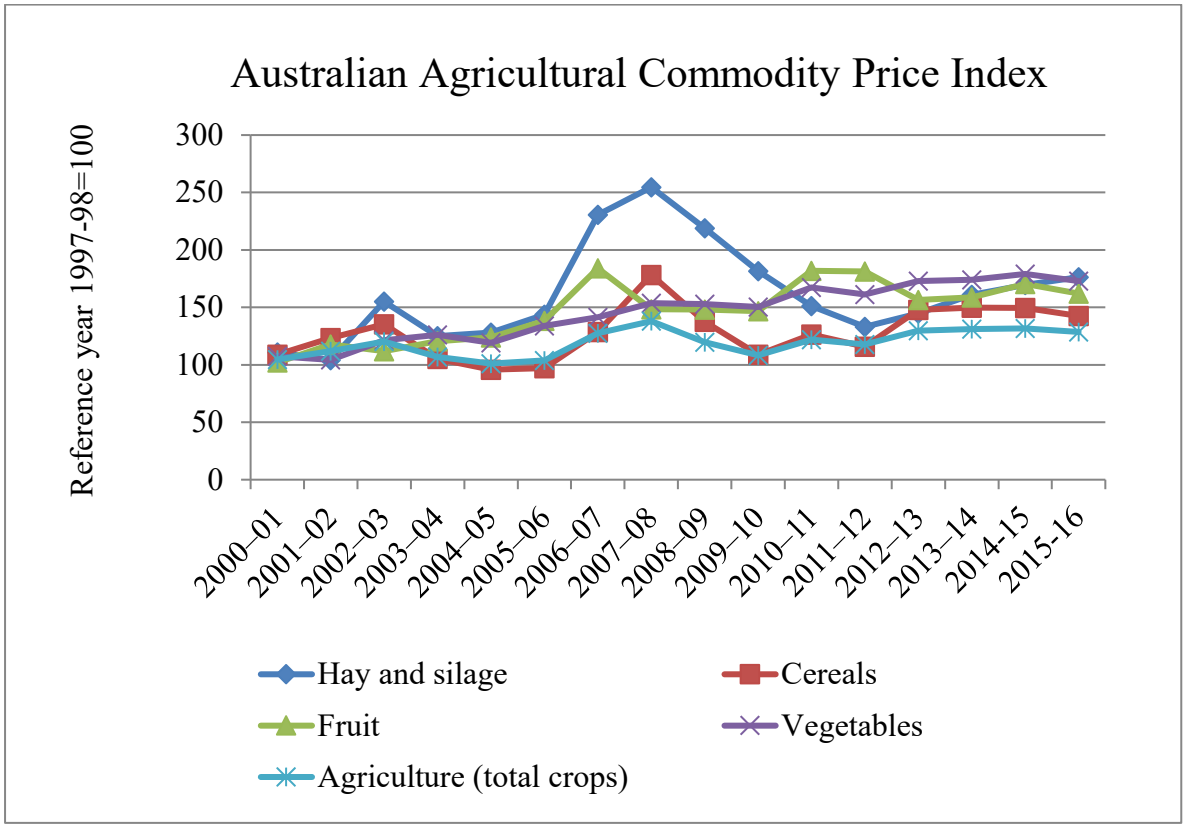
Table 7 and Figures 12 and 13 represent the Australian agricultural commodity price indexes and nominal prices received by farmers for some commodities and the average for Australian crops. Figure 12 shows that there has been an upward trend in the nominal prices of cotton, fruit, cereals, vegetables and the overall average price of Australian crops. Cereals, fruit and average price of Australian crops experienced a significant price spike in 2007-08. This is consistent with the price spike that year in global prices of cereals. Fruit experienced another price spike in 2011. After the price spike in 2007-08, the Australian agricultural commodity prices returned to the 2005-06 level in 2009-10 and showed an increasing trend between 2011 and 2016. Figure 13 shows a big price spike for rice between 2007 and 2010; for grapes in 2007-08; and for cotton in 2010-11.

Table 7: Australian agriculture commodity prices

Year	Australian agriculture commodity price index (97-98=100)					Commodity price		
	Hay and silage	Cereals	Fruits and nuts	Vegetables	Agriculture (total crops)	Rice price ($/tonne)	Raw cotton price (cents/kg)	Grapes price in warm climate ($/tonne)
2000–01	110.7	108.7	102.0	107.5	104.7	213.2	251.5	
2001–02	104.2	123.4	117.8	104.3	111.9	274.2	193.8	
2002–03	155.0	135.2	111.9	121.5	120.2	348.2	225.5	560.3
2003–04	125.0	105.2	120.6	126.0	107.0	325.1	225.9	536.2
2004–05	128.0	95.8	123.9	119.1	101.1	296.8	167.3	473.6
2005–06	143.7	97.2	138.3	133.8	103.9	272.9	177.8	379.3
2006–07	230.7	128.5	184.0	141.3	127.6	337.4	176.9	389.0
2007–08	254.6	178.3	148.4	153.7	138.0	415.0	190.8	546.0
2008–09	219.0	137.5	148.2	152.9	119.8	566.0	193.3	369.0
2009–10	181.5	108.9	146.6	150.3	108.4	457.1	205.1	298.0
2010–11	151.1	126.3	181.8	167.3	121.9	240.0	377.4	285.0
2011–12	133.0	115.7	181.4	161.3	117.8	270.0	225.1	339.0
2012–13	144.9	147.9	156.5	172.8	129.7	260.0	199.5	351.0
2013–14	160.9	149.8	158.8	174.1	131.1	340.0	228.6	300.0
2014-15	169.6	149.6	170.4	179.1	131.7	395.0	199.5	289.0
2015-16	176.4	142.6	162.0	172.9	128.7		226.1	

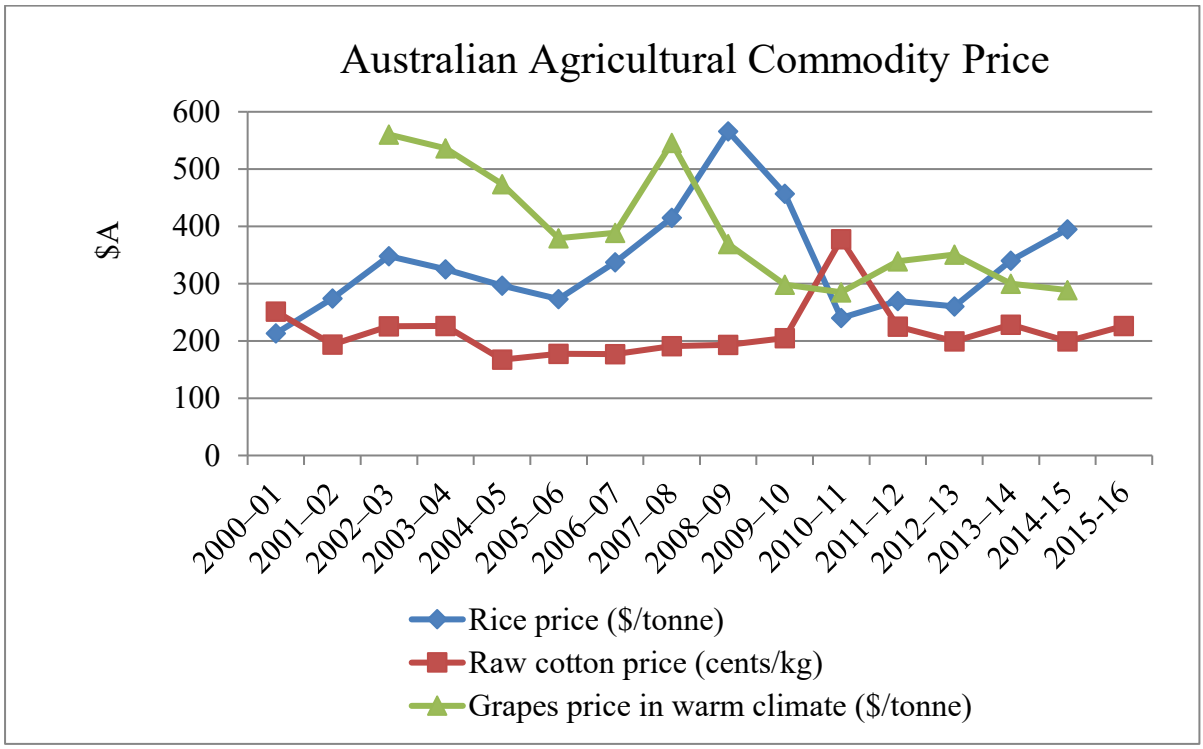
Source: ABARES, 2015, 2016

Figure 12: Australian agricultural commodity price index



Source: ABARES, 2016

Figure 13: Australian Agricultural Commodity Price



Source: ABARES, 2016

2.2 Water availability and extraction

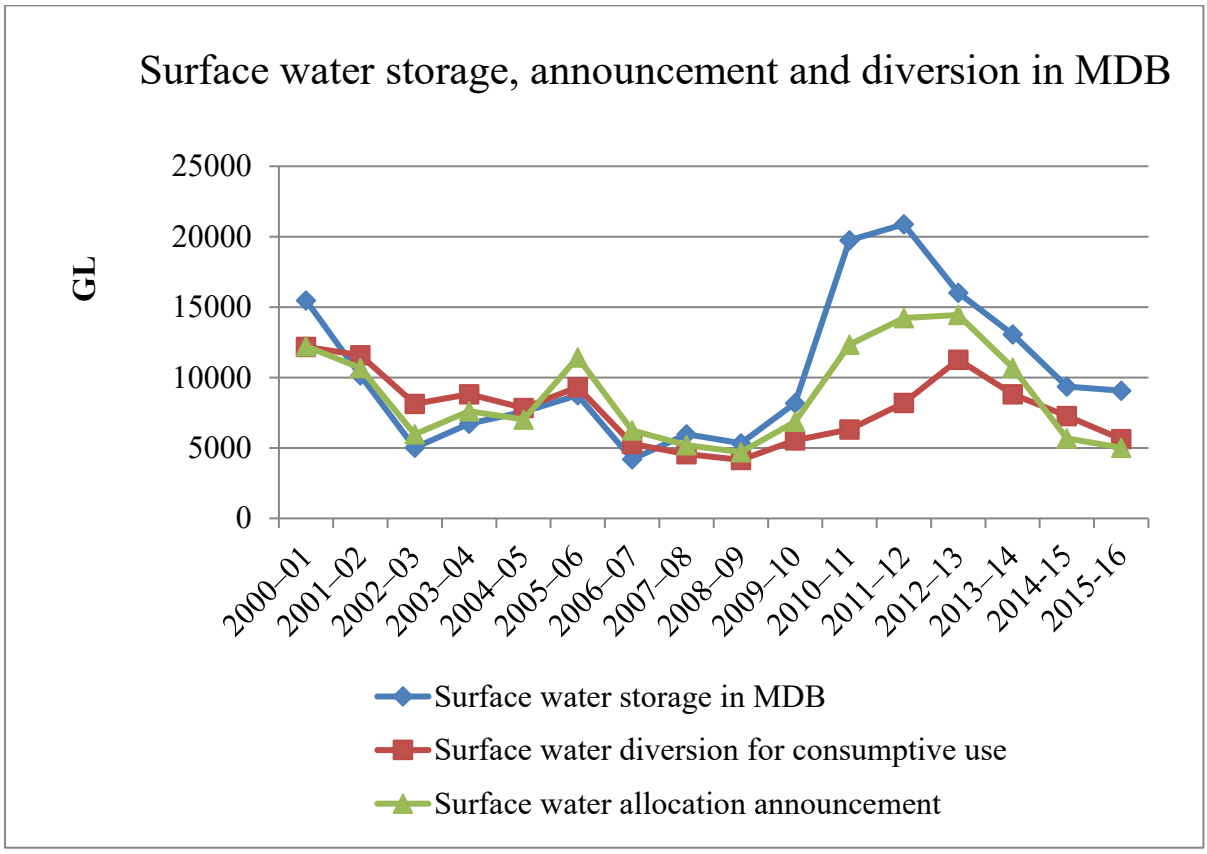
Table 8 and Figure 14 represents the surface water storage, surface water allocation announcement at the beginning of the season that includes net carryover water from the previous year, and surface water diversion for consumptive use in the MDB over the period 2000-2016. The Figure shows that there is a strong association between water storage, allocation and use. Especially, the path of water diversion is closely linked to the path of water allocation over the period. The excess of water storage compared to water allocation and use between 2010 and 2012 results from the significant increase in natural water availability due to high rainfall levels in those years and the cap that places a limit on water allocation and diversion. Water diversions were also significantly less than water allocations in those years. This reflects the effects of factors that affect demand for water such as water price, and area of irrigated land. A comparison between 2001-02 and 2015-16 shows that the water storages in the MDB were similar between those years, however, water allocation and extraction were much less in 2015-16 than in 2001-02.

Table 8: Surface water storage, allocation and extraction in MDB

Year	Surface water storage in MDB (GL)	Surface water diversion for consumptive use (GL)	Surface water allocation announcement (GL)
2000–01	15475	12175	12228
2001–02	10165	11587	10677
2002–03	5023	8136	5986
2003–04	6735	8824	7607
2004–05	7562	7842	7019
2005–06	8753	9327	11427
2006–07	4199	5286	6238
2007–08	5987	4556	5203
2008–09	5342	4154	4701
2009–10	8172	5553	6852
2010–11	19752	6311	12345
2011–12	20881	8214	14222
2012–13	16022	11278	14443
2013–14	13067	8812	10694
2014–15	9365	7281	5670
2015–16	9060	5644	5031

Source: water storage was sourced from MDBA water audit monitoring reports and the National Water Accounts, water diversion and allocation announcement were provided by the MDBA

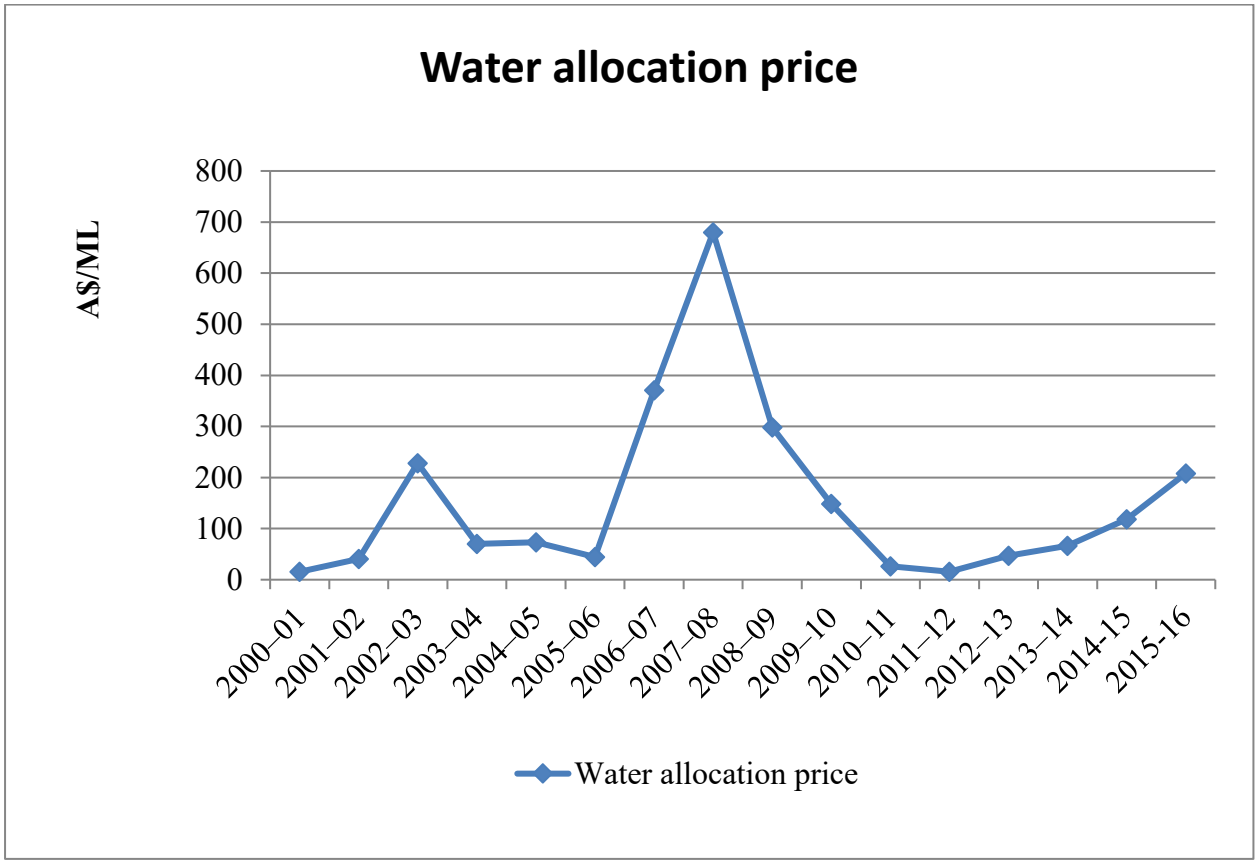
Figure 14: Surface water storage, announcement and diversion in MDB



Source: water storage was sourced from MDBA water audit monitoring reports and the National Water Accounts, water diversion and allocation announcement were provided by the MDBA

As the average water allocation price for the whole MDB is not publicly available, we used average water allocation price extracted from Murray Irrigation. Figure 15 represents water allocation price, which is the average price of temporary trades of water allocation at Murray Irrigation weighted by the amount of water traded at each price, over the period 2000-2016. It shows that water allocation price experienced a sharp increase during the period 2006-2009 when water availability dropped to a critically low level due to drought. This price dropped back to the pre-drought levels by 2010-2011 when water allocations rose again in 2010-2012. As a supply side impact, corresponding to the downward trend in the water availability over the years 2013-2016, water allocation price exhibited an increasing trend over this period.

Figure 15: Water allocation price



Source: Murray Irrigation

2.3 Social and Economic indicators

2.3.1 Population characteristics

Population size and density

In 2016, more than 2.2 million people were living within the MDB, around 9.5% of Australia's population (Census 2016). The largest shares of the Basin's population resided within the states of New South Wales (37%) and Victoria (28%) (Table 9). Over the period 1996-2016, the population increased in the MDB, but at a lower rate than the national population growth rate (Table 10 and Figure 16). Overall, the MDB is sparsely populated with an average density of 2 persons per square kilometre, well below the national rate of 3 persons per square kilometre. The Australian Capital Territory (comprising mainly the city of Canberra) had the highest population density of 169 persons per square kilometre. Besides Victoria (4.8 persons per square kilometre), the population density in the other Basin states were all below the national average.

Table 9: Population density in MDB

			Population	Population density (persons/km2)	Proportion of MDB population (%)
2006	MDB	NSW	777303.8	1.3	38.7
		Vic.	570948.4	4.4	28.7
		Qld	207450.4	0.8	10.8
		SA	110745.6	1.6	5.6
		ACT	322733.4	137.1	16.1
	MDB		2011243	1.9	100
	Australia		19948877	2.6	
2011	MDB	NSW	793769	1.3	37.8
		Vic.	597850	4.6	28.5
		Qld	236431	0.9	11.3
		SA	115897	1.7	5.5
		ACT	356586	151.5	17.0
	MDB		2100533	2.0	100
	Australia		21507719	2.8	
2016	MDB	NSW	823306	1.4	37.2
		Vic.	626975	4.8	28.3
		Qld	241993	0.9	10.9
		SA	126992	1.8	5.7
		ACT	396853	168.6	17.9
	MDB		2216117	2.1	100
	Australia		23401891	3.1	

Source: ABS, Australian Census of Population and Housing 2006, 2011 and 2016

The distribution of the MDB population by remoteness differs from that of Australia as a whole. In Australia, in 2011, the majority of people were located in the major cities (62% of the total population), while in the MDB the majority of people lived in inner and outer regional areas (78%) (Figure 17).[1]

Analysing population changes between 1996 and 2011 by remoteness area shows population declines in the outer regional (2.1% decrease between 1996 and 2011), and remote (29.6% decrease) locations. There were corresponding population increases in inner regional areas and

[1] The Remoteness Structure is defined by the ABS that includes five categories (major cities, inner regional, outer regional, remote, and very remote area) where the category is based on the distance that people are required to travel to the nearest urban centre

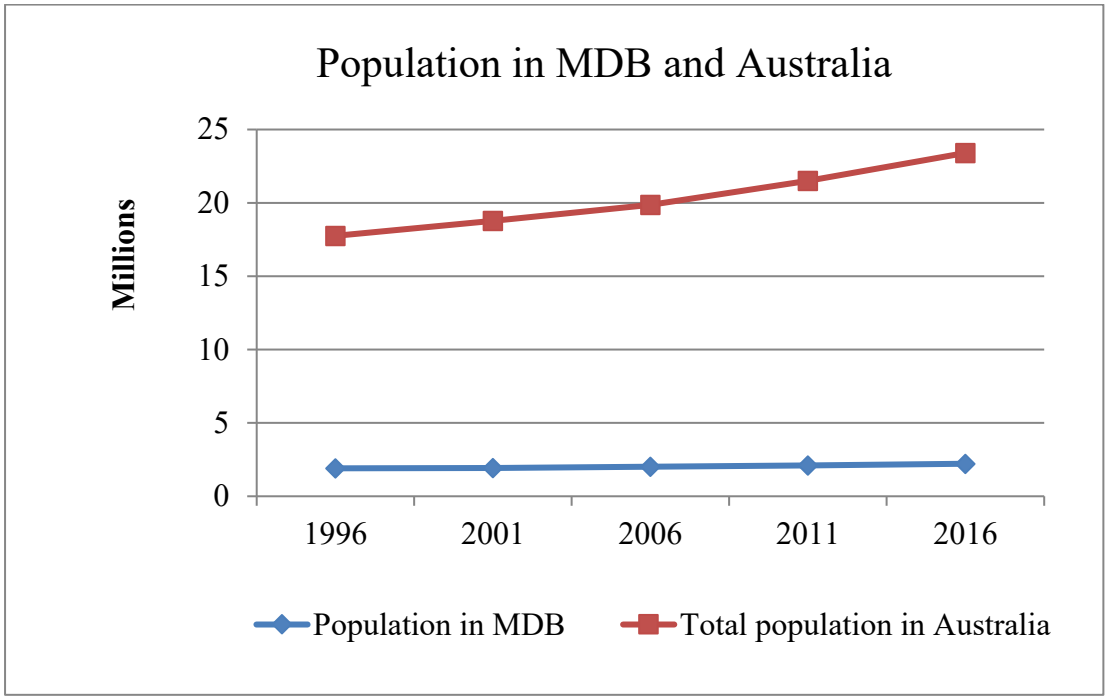
major cities (Table 10). In the very remote areas, population declined by some 43% between 2001 and 2006, but then increased 125% between 2006 and 2011.

Table 10: Population change by remoteness area in MDB, 1996-2016

		Population					Change				
		1996	2001	2006	2011	2016	1996-2001	2001-2006	2006-2011	2011-2016	1996-2016
MDB	Major Cities	324940	349370	358560	394004		7.5	2.6	9.9		
	Inner Regional	958530	975110	1059260	1109537		1.7	8.6	4.7		
	Outer Regional	548060	525180	527880	536486		-4.2	0.5	1.6		
	Remote	60580	58120	50910	42636		-4.1	-12.4	-16.3		
	Very Remote	13500	13890	7950	17869		2.9	-42.8	124.8		
Total: MDB		1905610	1921670	2004560	2100532	2216117	0.8	4.3	4.8	5.5	16.3
Total: Australia		17752830	18769250	19855287	21507719	23401891	5.7	5.8	8.3	8.8	31.8
MDB as proportion of Australia		10.7	10.2	10.1	9.8	9.5					

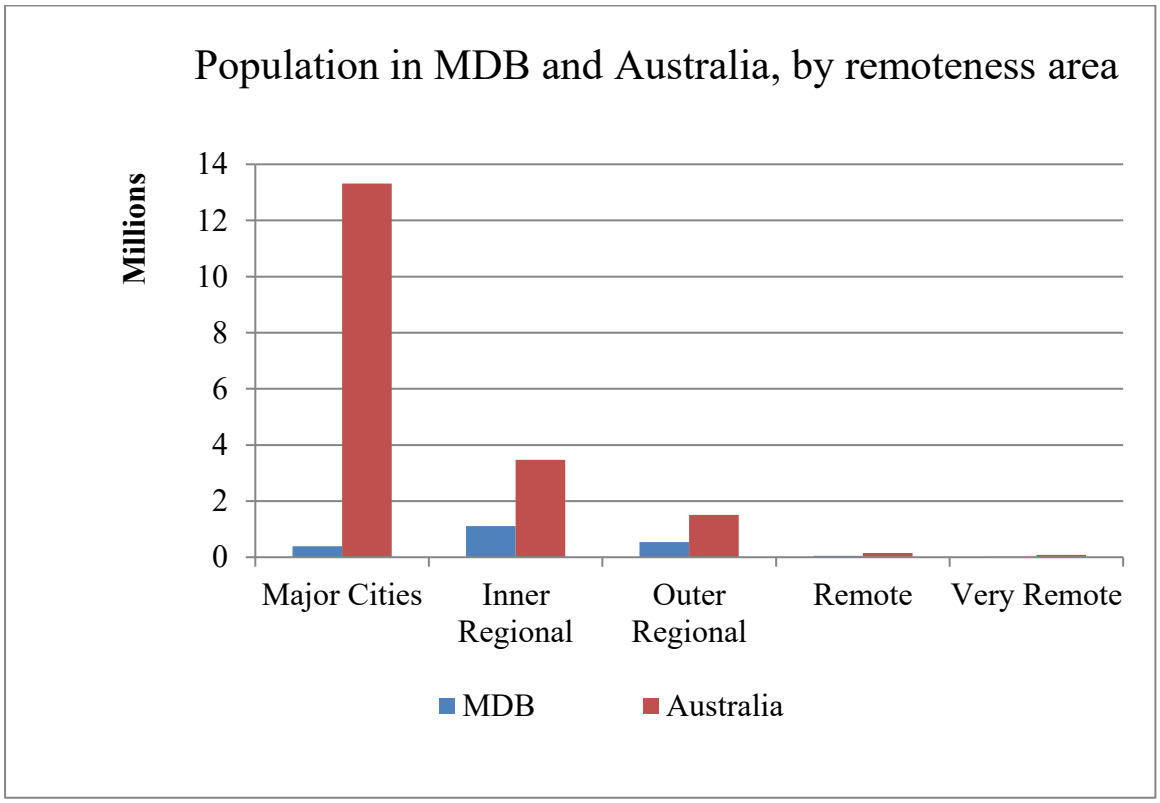
Source: ABS, Australian Census of Population and Housing 1996, 2001, 2006, 2011 and 2016

Figure 16: Population in MDB and Australia



Source: ABS, Australian Census of Population and Housing 1996, 2001, 2006, 2011, 2016

Figure 17: Population in MDB and Australia in 2011, by remoteness area



Source: ABS, Australian Census of Population and Housing 2011

Population by age and sex

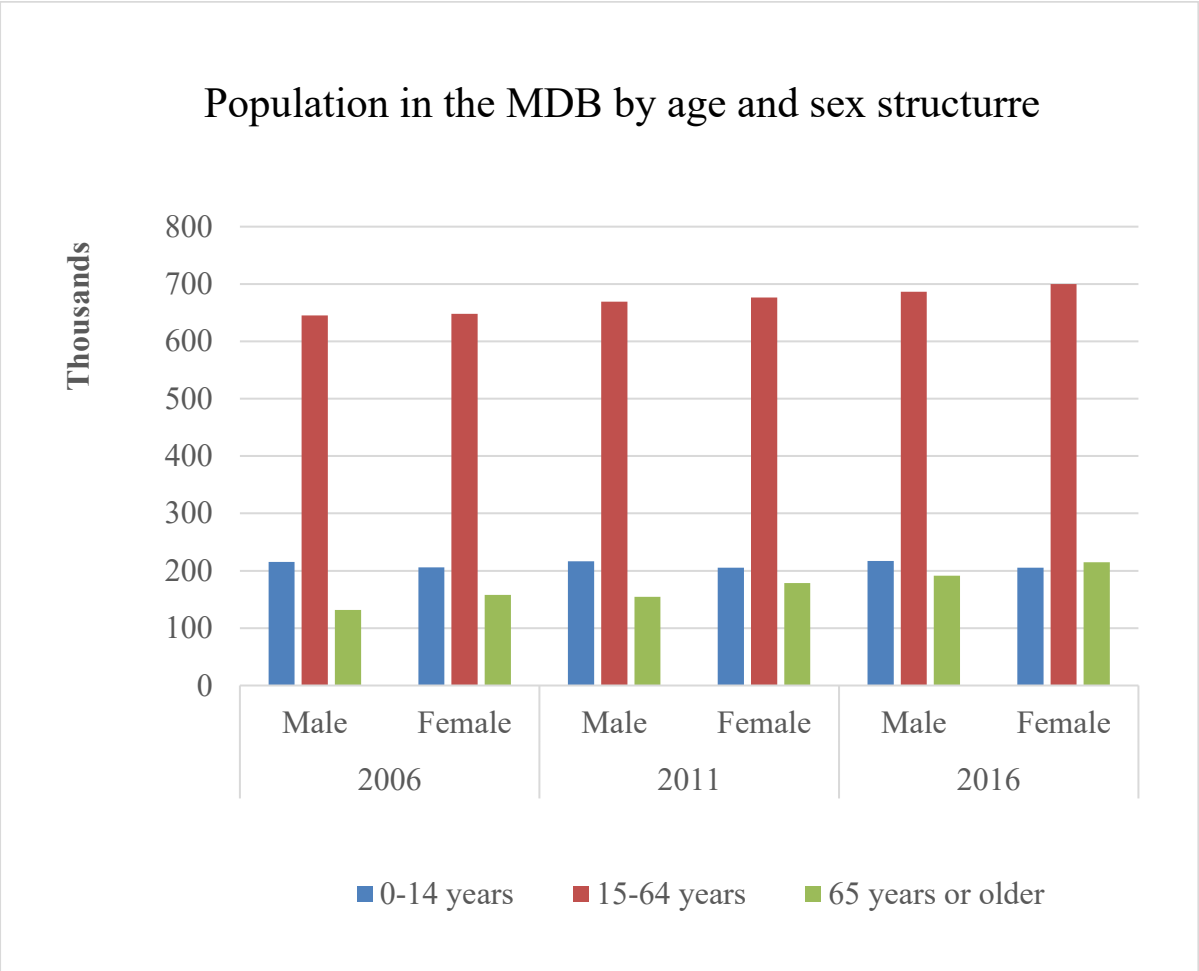
Table 11 and Figure 18 represent the population in the MDB by age and sex structure in 2006, 2011 and 2016. In those years, the female population is larger than the male population. The proportion of population which is 65 years or older increased from 14.5% in 2006 to 18.4% in 2016.

Table 11: Population in MDB, by age and sex

	Age	Male	Female	Total	% of MDB
2006	0-14 years	215488	205684	421172	21.0
	15-64 years	645227	648220	1293447	64.5
	65 years or older	131814	158122	289936	14.5
	Total	**992529**	**1012026**	**2004555**	**100**
2011	0-14 years	216473	205623	422096	20.1
	15-64 years	668950	676346	1345296	64.0
	65 years or older	154660	178480	333140	15.9
	Total	**1040083**	**1060449**	**2100532**	**100**
2016	0-14 years	217084	205643	422721	19.1
	15-64 years	686676	700018	1386688	62.6
	65 years or older	191577	215135	406714	18.4
	Total	**1095337**	**1120782**	**2216117**	**100**

Source: ABS, Australian Census of Population and Housing 2006, 2011 and 2016

Figure 18: Population in the MDB by age and sex structure



Source: ABS, Australian Census of Population and Housing 2006, 2011 and 2016

2.3.2 Labour Force

In 2016, there were almost one million people employed in the MDB (as reported in the Census). This represented more than half (55%) of the Basin's population aged 15 years and over, giving an employment to population ratio the same as the national level of 56%.

The number of unemployed people in the MDB decreased from 77,500 in 1996 to 59,021 in 2016, a decrease of 24% (Table 12). Over this period, the unemployment rate in the MDB dropped from 8.7% to 5.6% which is lower than the national figure of 6.9% in 2016. Over the entire period, the unemployment rate in the MDB was lower than the national unemployment rate.

Table 13 shows the employment status of employed persons in the MDB. Over the period 1996-2016, the number of employed persons in MDB increased, however, part-time employment increased faster than full-time employment, and the proportion of full time employment decreased from 67.9% to 62.2% over the period.

2.3.3 Employment by industry

Table 14(a) and (b) reports the number of persons employed by industry of employment for the MDB and for Australia, respectively. In 2016, employment in agriculture in the MDB accounted for 34% of the nation’s employment in agriculture. The proportion of employment in agriculture is much higher in MDB (7.7%) compared to national level (2.1%). The Table shows that although the number of persons employed in the MDB, as well as in Australia, increased between 2006 and 2016, the number of persons employed in agriculture decreased by 15.5% in the MDB, and by 7.4% in Australian wide.

In MDB, between 2006 and 2016, manufacturing industry also experienced a significant contraction (-23.7%); while employment in Health Care and Social Assistance, Education and Training, Public Administration and Defence, and Electricity, Gas, Water and Waste, increased by 31.5%, 19.3%, 14.9% and 14.7% respectively.

Table 12: Labour Force status in MDB and Australia

	MDB					Australia				
	1996	2001	2006	2011	2016	1996	2001	2006	2011	2016
Employed	810760	850900	921297	976272	992901	7636319	8298606	9104187	10058323	10683844
Unemployed	77500		48949	48565	59021	771970	660,709	503803	600133	787454
Labour Force (LF)	888260		970246	1024837	1051924	8,408,289	8,959,315	9607990	10658456	11471295
Not in Labour Force			529719	566179	604078	5174181	5265426	5271110	5729310	6297598
Unemployment rate	8.7		5.0	4.7	5.6	9.2	7.4	5.2	5.6	6.9
LF Participation			64.7	64.4	63.5	61.9	63.0	64.6	65.0	64.6

Source: ABS, Australian Census of Population and Housing 1996, 2001, 2006, 2011 and 2016

Table 13: Employment status in MDB

	Number employed					Change				
	1996	2001	2006	2011	2016	1996-2001	2001-2006	2006-2011	2011-2016	1996-2016
Employed										
Full-time	550760	552580	590890	619503	617249	0.3	6.9	4.8	-0.4	12.1
Part-time	239470	272900	268980	292338	315737	14	-1.4	8.7	8.0	31.8
Employed persons	810760	850900	921300	976272	992901	5	8.3	6.0	1.7	22.5
% working full time	67.9	64.9	64.1	63.5	62.2					

Source: ABS, Australian Census of Population and Housing 1996, 2001, 2006, 2011 and 2016

Table 14: Employment by industry in MDB

MDB	2006		2011		2016		Change 2006-2011 (%)	Change 2011-2016 (%)
	No.	% of total employed	No.	% of total employed	No.	% of total employed		
Agriculture	90840	9.9	80007	8.2	76801	7.7	-11.9	-4.0
Manufacturing	81850	8.9	75219	7.7	62465	6.3	-8.1	-17.0
Electricity, Gas, Water and Waste	9964	1.1	11848	1.2	11428	1.2	18.9	-3.5
Retail Trade	101909	11.1	100953	10.3	93410	9.4	-0.9	-7.5
Public Administration and Defence	105107	11.4	121904	12.5	120730	12.2	16.0	-1.0
Education and Training	73004	7.9	80030	8.2	87081	8.8	9.6	8.8
Health Care and Social Assistance	95133	10.3	112888	11.6	125120	12.6	18.7	10.8
Others	363490	39.5	393423	40.3	415866	41.9	8.2	5.7
Employed persons	**921297**	**100.0**	**976272**	**100.0**	**992901**	**100.0**	**6.0**	**1.7**

Source: ABS, Australian Census of Population and Housing 2006, 2011 and 2016

Table 15: Employment by industry in Australia

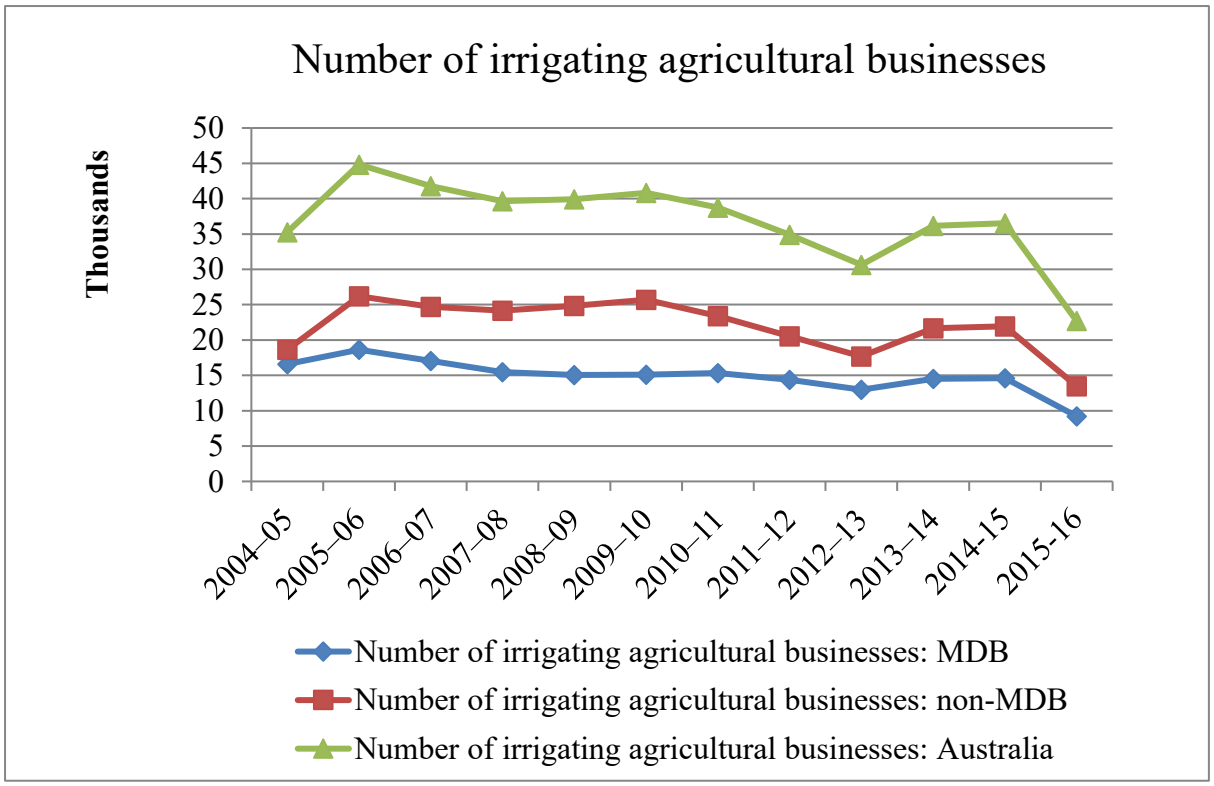
Australia	2006		2011		2016		Change 2006-2011 (%)	Change 2011-2016 (%)
	No.	% of total employed	No.	% of total employed	No.	% of total employed		
Agriculture	246603	2.7	219269	2.2	228372	2.1	-11.1	4.2
Manufacturing	952014	10.5	902830	9.0	683686	6.4	-5.2	-24.3
Electricity, Gas, Water and Waste	89449	1.0	115609	1.1	115753	1.1	29.2	0.1
Retail Trade	1033192	11.3	1057310	10.5	1053815	9.9	2.3	-0.3
Public Administration and Defence	608599	6.7	689929	6.9	713142	6.7	13.4	3.4
Education and Training	697805	7.7	804420	8.0	925890	8.7	15.3	15.1
Health Care and Social Assistance	956147	10.5	1167634	11.6	1351018	12.6	22.1	15.7
Others	4520378	49.7	5101322	50.7	5612168	52.5	12.9	10.0
Employed persons	**9104187**	**100.0**	**10058323**	**100.0**	**10683844**	**100.0**	**10.5**	**6.2**

Source: ABS, Australian Census of Population and Housing 2006, 2011 and 2016

2.3.4 Trend in agricultural employment

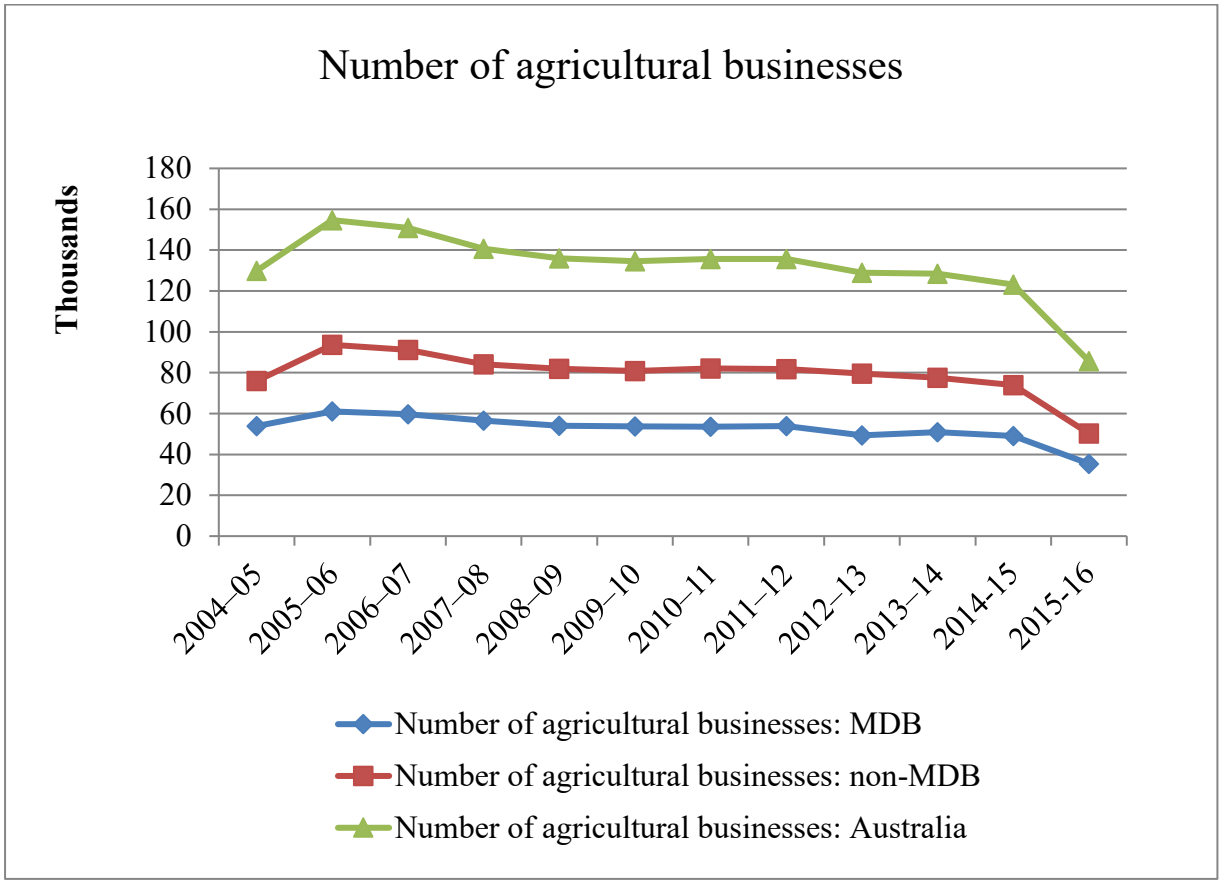
Figures 19 and 20 represent the number of irrigating and total agricultural businesses in the MDB and Australia between 2005 and 2016. In 2015-2016, there were 85,681 agricultural businesses in Australia, of which 35,464 businesses were located in the MDB. The number of irrigating agricultural businesses in MDB, as well as at the national level, peaked in 2005-06, but the number has declined in the 10 year period to 2015-16. In 2004-05, irrigating agricultural businesses in MDB accounted for 47% of the irrigating agricultural businesses in Australia and 32% of the agricultural businesses in MDB. In 2015-16 those numbers were 41% and 26%, respectively.

Figure 19: Number of irrigating agricultural businesses



Source: ABS, Water Use on Australian Farms, cat. No. 4618.0

Figure 20: Number of agricultural businesses



Source: ABS, Water Use on Australian Farms, cat. No. 4618.0

Table 15 reports the changes in employment in agriculture industry in the MDB between 2001 and 2016. Employment decreased in all sub-groups in the agriculture industry, except beef cattle farming and poultry farming which experienced an increase of 6.6% and 22.5% in employment, respectively. There was a large reduction in employment in cotton (-66%); other crops (-45%); horticulture and fruit growing such as grapes (-62%), plant, flower and seed growing (-22%); dairy cattle farming (-41%); sheep-beef cattle farming (-60%). In the MDB, total employment in agriculture decreased by 25.7% between 2001 and 2016.

Table 16: Trend in employment in agriculture in MDB

	Employed persons				Change (%)			
	2001	2006	2011	2016	2001-2006	2006-2011	2011-2016	2001-2016
Horticulture and fruit growing								
Plant, flower, seed growing	1450	1000	693	1126	-31.0	-30.7	62.5	-22.3
Vegetable growing	2540	2220	1959	1978	-12.6	-11.8	1.0	-22.1
Grape growing	7950	5540	3781	3013	-30.3	-31.8	-20.3	-62.1
Apple and pear growing	1180	970	751	596	-17.8	-22.6	-20.6	-49.5
Stone fruit growing	840	670	516	360	-20.2	-23.0	-30.2	-57.1
Other fruit growing	3370	3020	2481	2391	-10.4	-17.8	-3.6	-29.1
Other	1880	1830	1805	2086	-2.7	-1.4	15.6	11.0
Total	**19210**	**15250**	**11986**	**11550**	**-20.6**	**-21.4**	**-3.6**	**-39.9**
Grain, sheep and beef cattle farming								
Grain growing	10720	10680	10442	9824	-0.4	-2.2	-5.9	-8.4
Grain-sheep and grain-beef cattle farming	20120	16150	13726	7409	-19.7	-15.0	-46.0	-63.2
Sheep-beef cattle farming	8410	6170	5331	3374	-26.6	-13.6	-36.7	-59.9
Sheep farming	10690	9710	9130	9032	-9.2	-6.0	-1.1	-15.5
Beef cattle farming	12650	14660	13224	13481	15.9	-9.8	1.9	6.6
Other	1310	400	1028	1351	-69.5	157	31.4	3.1
Total	**63900**	**57770**	**52881**	**44471**	**-9.6**	**-8.5**	**-15.9**	**-30.4**
Dairy cattle farming	8860	6920	5065	5199	-21.9	-26.8	2.6	-41.3
Poultry farming	1690	1440	1558	2070	-14.8	8.2	32.9	22.5
Other livestock farming	3360	3690	3125	3073	9.8	-15.3	-1.7	-8.5
Other crop growing								
Cotton growing	2950	1700	1520	1007	-42.4	-10.6	-33.8	-65.9
Other crop growing	980	1110	575	525	-15.6	-48.2	-8.7	-45.3
Total	**3930**	**2810**	**2095**	**1532**	**-28.5**	**-25.4**	**-26.9**	-61.0

Other	2400	2960	3297	8906	22.8	11.4	170	269
Total Agriculture	**103360**	**90840**	**80007**	**76801**	**-12.4**	**-11.9**	**-4.0**	**-25.7**

Source: ABS, Australian Census of Population and Housing 2001, 2006, 2011 and 2016

2.4 Indigenous community: population and employment

Table 16 reports the status and demographic changes in indigenous community between 2006 and 2016. As a proportion of total population, the share of indigenous community in the MDB increased from 3.5% in 2006 to 4.4% in 2016. Between 2006 and 2016, the population growth rate of the Indigenous community in the MDB was 41%, which is nearly 4 times higher than the overall population growth rate in the MDB (10.6%), and 2.5 times higher than the national population growth rate (18%). Of note, the age structure of the Indigenous community is substantially different to the age structure in the MDB. In 2016, about 36% of the Indigenous population was aged less than 15 years; 59% was aged between 15 and 64, and only 5% of the Indigenous community was aged 65 or older.

Table 17 reports the employment status of the Indigenous community in the MDB. It shows that, in 2016, the labour force participation of the Indigenous community (54%) was less than the average labour force participation in the MDB (64%) while the unemployment rate of the Indigenous community (17.3%) was much higher than the average basin unemployment level (5.6%). While the Indigenous population accounts for 4.4% of the population in the MDB, 10% of the unemployed in the basin are Indigenous people.

Table 17: Indigenous community in MDB

Indigenous community in MDB					
	Age	**Male**	**Female**	**Total**	**Proportion of indigenous population in MDB**
2006	0-14 years	14071	13597	27668	39.8
	15-64 years	19040	20429	39469	56.8
	65 years or older	1061	1339	2400	3.5
	Total	**34172**	**35365**	**69537**	**100**
	% of MDB	**1.7**	**1.8**	**3.5**	
2011	0-14 years	16015	15645	31660	37.7
	15-64 years	23669	25256	48925	58.2
	65 years or older	1554	1876	3430	4.1
	Total	**41238**	**42777**	**84015**	**100**
	% of MDB	**2.0**	**2.0**	**4.0**	
2016	0-14 years	18078	17016	35090	35.7
	15-64 years	28039	29800	57838	58.9
	65 years or older	2460	2825	5281	5.4
	Total	**48571**	**49638**	**98206**	**100**
	% of MDB	**2.2**	**2.2**	**4.4**	
Growth rate of indigenous community in MDB between 2006-2016					41.2
Population growth rate in MDB between 2006-2016					10.6
Population growth rate in Australia between 2006-2016					17.9

Source: ABS, Australian Census of Population and Housing 2006, 2011 and 2016

Table 18: Employment status of Indigenous community

	2006			2011			2016		
	Indigenous community	**MDB**	**% of MDB**	**Indigenous community**	**MDB**	**% of MDB**	**Indigenous community**	**MDB**	**% of MDB**
Employed	16851	921297	1.8	21327	976272	2.2	27269	992901	2.7
Unemployed	4182	48949	8.5	4707	48565	9.7	5719	59021	9.7
Labour Force (LF)	21033	970246	2.2	26034	1024837	2.5	32986	1051924	3.1
Not in Labour Force	18651	529719	3.5	24032	566179	4.2	28348	604078	4.7
Unemployment rate	**19.9**	**5.0**		**18.1**	**4.7**		**17.3**	**5.6**	
LF Participation	**53.0**	**64.7**		**52.0**	**64.4**		**53.8**	**63.5**	

Source: ABS, Australian Census of Population and Housing 2006, 2011 and 2016

2.5 Livelihoods and status of key regional towns

2.5.1 Deniliquin

Population

For statistical purposes, Deniliquin covers a land area of about 140km^2 and had a population of 7,429 in 2015. Deniliquin is a service centre for the surrounding agricultural region. The region includes both dryland and irrigated areas. The dryland areas support grazing, in particular beef cattle and wool growing. The irrigated areas produce a range of high yield crops. Rice was a major crop until the recent drought. The largest rice mill in the southern hemisphere is in Deniliquin, producing large packs and bulk rice for export markets. Deniliquin is also the headquarters of Murray Irrigation Limited, an irrigator owned private company and one of the largest privately owned irrigation supply companies in the world.

Table 18 reports the population in Deniliquin between 2000 and 2015. The Table shows that between 2000 and 2015, the Deniliquin population decreased by about 9% from 8,170 to 7,429. Consequently, the population density in Deniliquin decreased from 63 persons/km^2 in 2000 to 52 persons/km^2 in 2015. Over this period, the working age population remained at about 60% of the total Deniliquin population.

Employment

Table 19 reports the employment status in Deniliquin between 2002 and 2011. In 2006, the unemployment rate was 6.1% which is higher than the average MDB level of 5%. However, in 2011, the Deniliquin unemployment rate was 4.6%, close to the average MDB level of 4.7%.

Table 20 shows that the number of businesses in Deniliquin between 2003 and 2015 almost halved from 1,128 in 2003 to 686 in 2015. Industries that experienced a large reduction in the number of businesses include Agriculture, Forestry and Fishing; Manufacturing, and the Retail Trade. The number of businesses in Agriculture, Forestry and Fishing decreased from 489 in 2003 to 128 in 2015.

Table 19: Population in Deniliquin between 2000 and 2015

Year	Population (no.)	Male (no.)	Female (no.)	Working age population (% of total)	Population density (persons/km2)	Indigenous community (%)
2000	8170	4006	4164	61.7	62.9	
2001	8333	4162	4171	61.2	64.1	2.8
2002	8314	4126	4188	60.9	64.0	
2003	8274	4107	4167	60.7	63.7	
2004	8201	3937	4012	60.4	63.2	
2005	7835	3871	3964	60.6	60.3	
2006	7731	3810	3921	60.6	59.4	3
2007	7708	3821	3887	60.7	59.3	
2008	7635	3798	3837	61.0	53.3	
2009	7446	3667	3779	60.9	52.0	
2010	7366	3611	3755	60.9	51.4	
2011	7303	3574	3729	60.4	51.0	3.6
2012	7336	3594	3742	60.2	51.2	
2013	7376	3620	3756	60.3	51.5	
2014	7432	3643	3789	60.4	51.9	
2015	7429	3637	3792	60.0	51.9	

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001; Data By Region

Table 20: Labour force status in Deniliquin

Year	Labour force	Employed	Unemployed	Unemployment rate	Unemployment rate in MDB
2002	4087	3899	188	4.6	
2003	4204	3998	206	4.9	
2004	4250	4063	187	4.4	
2005	4157	3945	212	5.1	
2006	4230	3972	258	6.1	5.0
2007	4450	4272	178	4	
2008	4450	4272	178	4	
2009	3800	3572	228	6	
2010	3895	3673	222	5.7	
2011	3169	3023	146	4.6	4.7

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Table 21: Number of businesses by industry in Deniliquin

Industry	2003	2004	2005	2006	2011	2012	2013	2014	2015
Agriculture, Forestry and Fishing	489	525	516	507	113	120	119	119	128
Manufacturing	45	42	45	45	28	28	27	24	22
Construction	90	81	84	93	87	88	90	86	93
Retail trade	111	117	102	93	63	59	54	47	44
Transport, postal and warehousing	87	72	69	69	59	64	63	67	65
Education and training	9	9	9	9	8	10	7	4	4
Health care and social assistance	24	27	24	27	18	20	22	22	23
Others	273	288	300	312	305	305	295	304	307
Total (no.)	**1128**	**1161**	**1149**	**1155**	**681**	**694**	**677**	**673**	**686**

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001; Data By Region

Drivers of population and employment changes in Deniliquin

The population growth of Deniliquin is intrinsically linked to economic conditions of the town. Over the last two decades, the population of Deniliquin declined as the area was in severe drought and due to consolidation of agricultural holdings and concentration of employment in larger towns and cities (Riverina Cities, 2015a). Due to prolonged drought, a number of businesses were shut down, the Deniliquin rice mill was temporarily closed in 2007 and this has had a major effect on Deniliquin's economy. Other reasons contributed to the reduction in agriculture employment and the migration of people out of the town include the mechanization in agriculture sector that substituted labour by machinery; and the ending of a number of government programs in 2001; in 2005, three government agencies for health and communities services were closed down. Between 2006 and 2015, 23 manufacturing companies, 49 retail trade companies and 4 health care and community services were closed down. The most mobile group in the population is young adults. They move out of the town to attend educational institutions, look for work and change a lifestyle. The town retains young family households and older age group people.

Income

Table 21 and Figure 21 show that the average wage and salary income as well as average taxable income[2] in Deniliquin increased steady over the period 2002-2013. In 2010, the average taxable income in Deniliquin was A$ 47,579 and the total taxable income was A$ 125 million. Between 2002 and 2013, average income from wage and salary in Deniliquin increased by 47%, which is significantly lower than the growth rate of 64% in the national average income from wage and salary. The income growth rate in Deniliquin between 2002 and 2013 was also less than that of other communities in the MDB such as Griffith (49%), Moree Plains (50%), Shepparton (52%) and similar to the income growth rate in Renmark Paringa 47%).

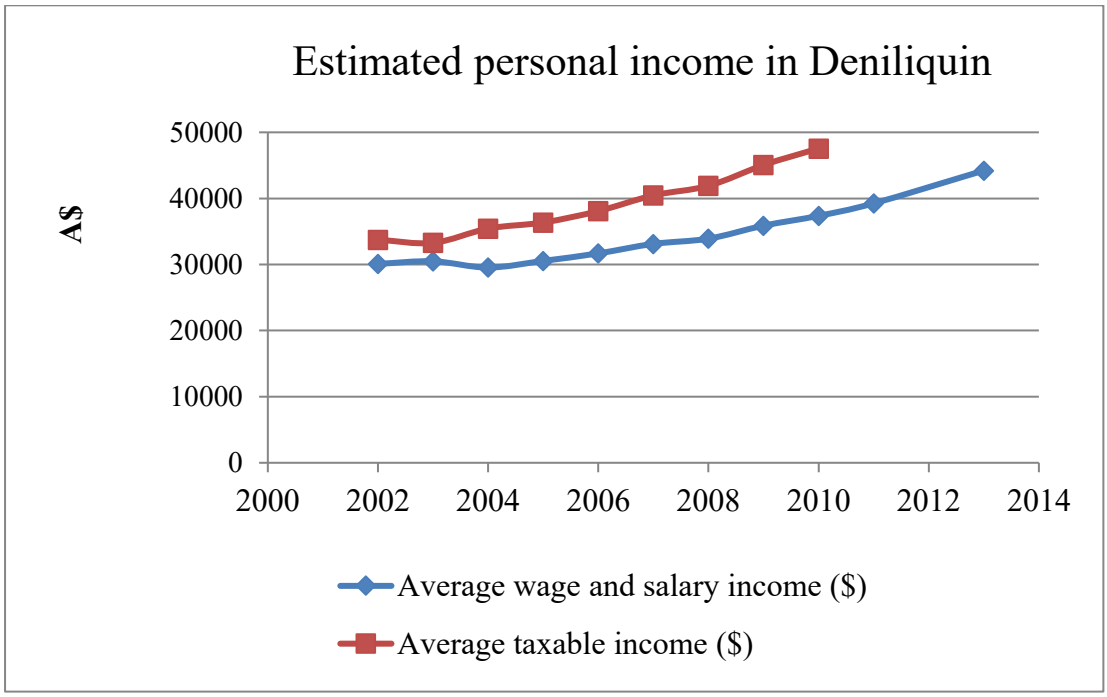
[2] Salary income includes income from salary and wages. Taxable income includes income from salary and wages, and all other taxable incomes such as interest from investment.

Table 22: Estimates of personal income in Deniliquin

Year	Average wage and salary income ($)	Average taxable income ($)	Total taxable income ($m)
2002	30094	33744	107.5
2003	30486	33280	103.9
2004	29542	35442	112
2005	30545	36354	112.7
2006	31682	38083	120.5
2007	33119	40461	122.3
2008	33911	41902	125.7
2009	35873	45 051	121.9
2010	37364	47560	125
2011	39252		
2013	44214		

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Figure 21: Estimates of personal income in Deniliquin



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Agricultural production

Table 22 reports the gross value of agricultural production in Deniliquin in 2001, 2006 and 2011. The Table shows that between 2001 and 2006, value of agricultural production in Deniliquin decreased from $11.2 million in 2001 to $6.1 million in 2006, and the gross value of crops decreased from 6.3 to 2.9 million. The reduction in agriculture production in Deniliquin between 2001 and 2006 was primarily caused by years of severe drought in the MDB which started in 2003. The total value of agricultural production increased to $38.8 million in 2011, of which the gross value of crops increased to $25.1 million. Crops were the major production in the agriculture industry of the region, accounting for 65% of total value of agricultural production in 2011.

Table 23: Gross value of agricultural production in Deniliquin

Gross value of agricultural production ($m)	2001	2006	2011
Gross value of crops	6.3	2.9	25.1
Gross value of livestock slaughtering	2.2	1.3	5.9
Gross value of livestock products	2.7	2	7.8
Total gross value of agricultural production	**11.2**	**6.1**	**38.8**

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001, Agriculture Census 2011

2.5.2 Griffith

Population

Griffith city covers an area of 1,640 square kilometres. In 2015, the Griffith population was 25,986. The agricultural industry and value added food and beverage manufacturing/ processing underpins the economy of the region. The area is a major wine grape growing area. The town also hosts other crops and mixed farming such as prune, rice and citrus with emerging industries such as nuts (almonds and walnuts), chicken breeding, growing and processing, cotton, cereals, fruit (melons, pumpkins, onions, cherries, tomatoes, olives) and aquaculture.

Table 23 reports the population in Griffith between 2000 and 2016. The Table shows that the Griffith population increased from 24,036 in 2000 to 26,125 in 2016 (increased by about 8.7%).

Population density in Griffith increased from 14.7 persons/km^2 in 2000 to 15.9 persons/km^2 in 2016. The working age population accounted for about 64% of the Griffith population. The share of the Indigenous community in total population increased from 3.9% in 2001 to 4.7% in 2016.

Table 24: Population in Griffith between 2000 and 2016

Year	Population	Male	Female	Working age population (% of total)	Population density (persons/km2)	Indigenous community (%)
2000	24036	12169	11867	63.9	14.7	
2001	24604	12461	12143	63.8	15.0	3.9
2002	24709	12549	12160	63.9	15.1	
2003	24758	12600	12158	63.6	15.1	
2004	24870	12661	12209	63.6	15.2	
2005	24705	12501	12204	63.7	15.1	
2006	24921	12579	12342	63.8	15.2	4
2007	24907	12585	12322	63.8	15.2	
2008	25107	12725	12382	63.9	15.3	
2009	25100	12748	12352	63.7	15.3	
2010	25264	12835	12429	63.6	15.4	
2011	25395	12875	12520	63.5	15.5	4.1
2012	25493	12999	12494	63.7	15.5	
2013	25417	12973	12444	63.7	15.5	
2014	25795	13193	12602	63.8	15.7	
2015	25986	13330	12656	63.7	15.8	
2016	26125				15.9	4.7

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001; Data By Region; Griffith City: Estimated Resident Population

Employment

Table 24 reports the labour force and unemployment rate in Griffith. Between 2002 and 2008, there was a growing trend in the labour force in Griffith. The overall labour force declined in 2009 and fluctuated between 2009 and 2016. The number of unemployed persons in Griffith fluctuated over the period and there was no obvious trend between 2002 and 2016. The unemployment rate in Griffith is slightly higher than the average unemployment rate of the basin.

Table 25: Labour force status in Griffith

Year	Labour force	Unemployed	Unemployment rate	Unemployment rate in MDB
2002	11978	551	4.6	
2003	13022	599	4.6	
2004	13514	500	3.7	
2005	13256	570	4.3	
2006	13473	741	5.5	5.0
2007	13921	529	3.8	
2008	14378	532	3.7	
2009	12900	645	5	
2010	13273	730	5.5	
2011	13339	981	7.4	4.7
2012	13422	728	5.4	
2013	14070	830	5.9	
2014	15130	814	5.4	
2015	14454	655	4.5	
2016	14234	507	3.6	5.6

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001 for period 2002-2010 Department of Employment: Small Area Labour Markets for period 2011-2016

Table 25 reports the number of employed persons by industry in Griffith between 2001 and 2015. Although employment slightly decreased between 2009 and 2011, there was an increasing trend in the number of persons employed in Griffith over the period 2001-2015 (Figure 22). The total employment in Griffith increased from 11,670 in 2000-01 to 13,700 in 2014-15.

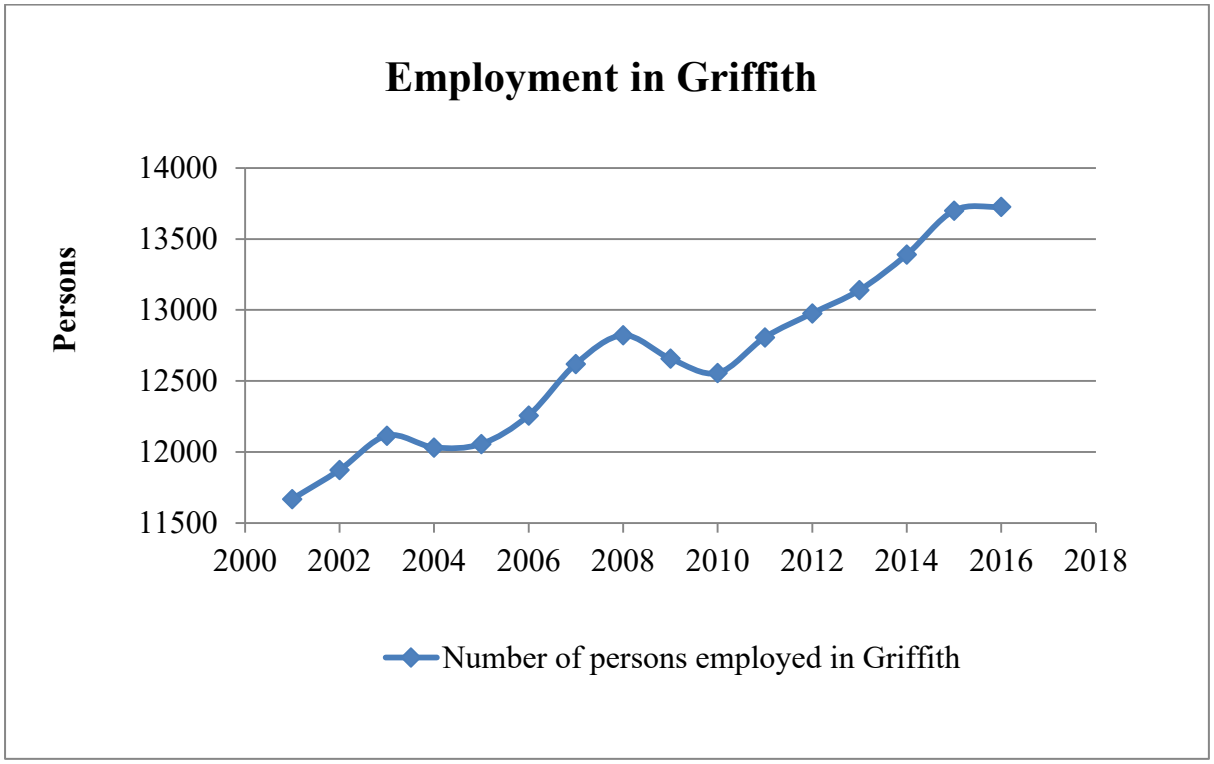
In Griffith, Agriculture, Manufacturing and Health Care and Social Assistance are the main industries in the region. Employment in agriculture declined between 2006 and 2012, but showed a large increase between 2013 and 2015. Manufacturing experienced a growing trend between 2001 and 2013, and then declined in 2014 and 2015. The Health Care and Social Assistance industry experienced a steadily increasing trend between 2001 and 2015 (Figure 23).

Table 26: Employment by industry in Griffith

Year	Employment by industry in Griffith									
	Agriculture	Manufacturing	Construction	Accommodation and Food Services	Wholesale and retail trade	Public administration and Safety	Education and training	Health care and social assistance	Others	Total
2001	1547	1725	911	708	2599	408	691	835	2246	11670
2002	1626	1750	882	667	2394	397	868	908	2382	11874
2003	1610	1908	909	677	2315	387	819	1009	2482	12116
2004	1934	2015	939	633	2112	381	792	949	2278	12033
2005	2087	2033	976	639	2035	403	827	904	2154	12058
2006	1952	2050	1047	599	2018	430	852	1026	2284	12258
2007	1887	2253	1121	491	2034	451	768	1175	2441	12621
2008	1731	2365	1088	570	2203	466	707	1258	2434	12822
2009	1504	2363	1063	737	2225	480	694	1237	2355	12658
2010	1372	2345	1120	870	2002	497	696	1179	2476	12557
2011	1183	2385	984	923	2147	513	813	1179	2681	12808
2012	1049	2370	891	833	2415	523	857	1342	2697	12977
2013	1349	2431	829	687	2545	534	762	1419	2584	13140
2014	2050	2174	785	709	2431	546	719	1452	2524	13390
2015	2673	1994	742	711	2268	557	729	1440	2586	13700

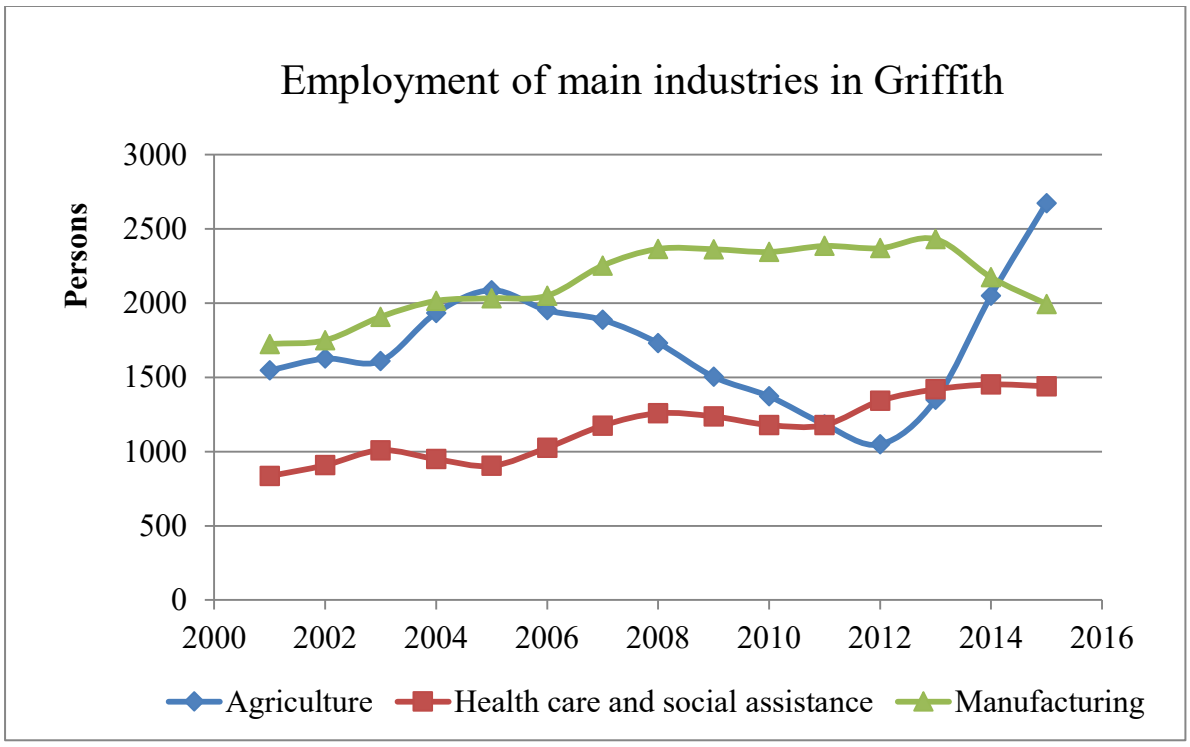
Source: Griffith City, Employment Report, 2016

Figure 22: Employment in Griffith



Source: Griffith City, Employment Report, 2016

Figure 23: Employment by industry in Griffith



Source: Griffith City, Employment Report, 2016

Drivers of population and employment changes in Griffith

Over the last two decades, while the Riverina region was in severe drought and the populations of some townships declined, the population and employment of Griffith increased and the economy of the Griffith remained strong and continued to grow. Griffith was one of the main centres that attracted most of the development in the Riverina area. Population and employment growth was driven by the increase in local investment in the town. Younger population is attracted to Griffith due to large employment bases, particularly the Bajada Group which is the Riverina's largest employer, the Riverina Institute of TAFE campuses, and the Regional University Study Centre which was established in 2004 in Griffith. Griffith has also experienced strong commercial growth with new shopping centre developments in recent years (Riverina Cities, 2015b). Between 2001 and 2015, Agriculture and Health Care and Social Assistance are the industries that experienced largest increase in employment. Employment in agriculture industry increased by 73% from about 1,500 in 2000-01 to approximately 2,700 in 2014-15. Number of people employed in Health Care and Social Assistance industry increased by 72% from about 800 in 2000-01 to 1,440 in 2014-15 (Griffith City, 2016). Significant new housing developments on the outskirts of Griffith, providing opportunities for households to relocate from other areas or new households to form locally (such as young people leaving the family home), is also a driver of population growth in the area.

Income

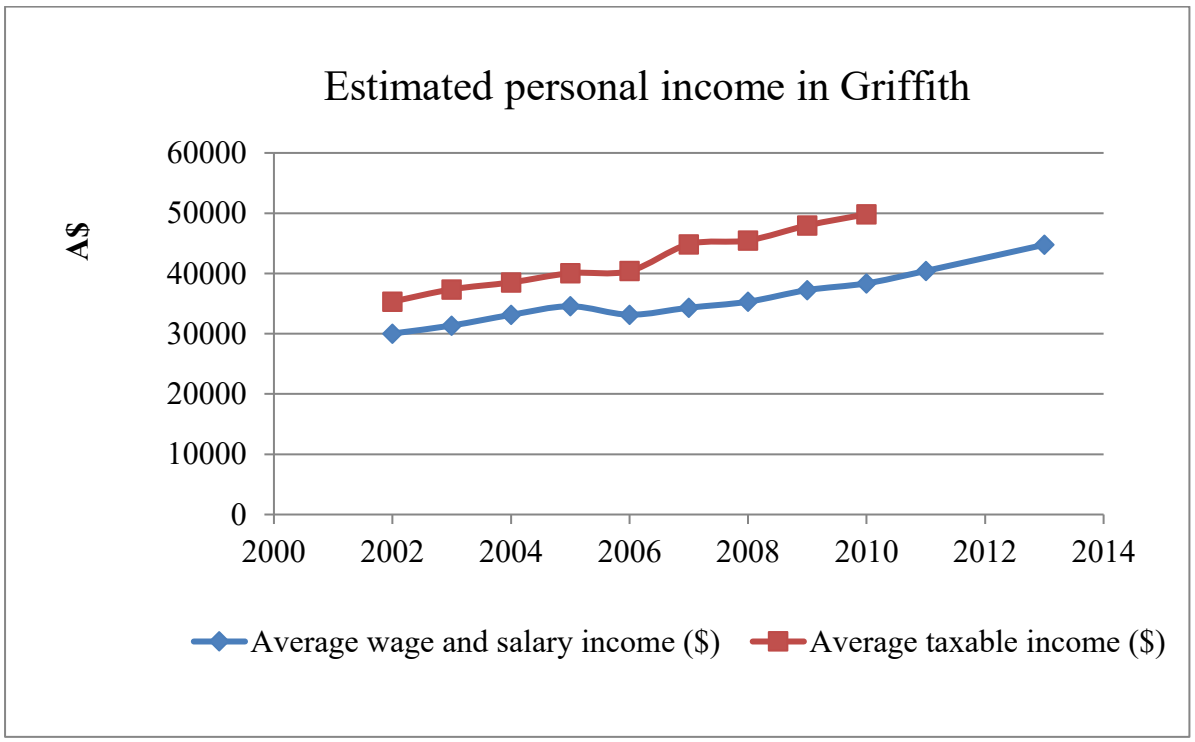
Table 26 and Figure 24 represent the estimates of nominal personal income in Griffith. There is a growing trend in average wage and salary income as well as average taxable income in Griffith over the period 2002-2013. In 2010, the average taxable income in Griffith was $49,831 and the total taxable income was $496.4 million. The average income from wage and salary in Griffith increased by 49% between 2002 and 2013, which was 6 percentage point less than the national average.

Table 27: Estimates of personal income in Griffith

Year	Average wage and salary income ($)	Average taxable income ($)	Total taxable income ($m)
2002	30028	35331	386.1
2003	31362	37365	414
2004	33125	38511	434.3
2005	34555	40045	451.8
2006	33158	40399	464
2007	34316	44850	499.7
2008	35310	45481	520.6
2009	37243	47966	510.8
2010	38359	49831	496.4
2011	40421		
2013	44764		

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Figure 24: Personal income in Griffith



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Agricultural production

Table 27 reports the gross value of agricultural production in Griffith region in 2001, 2006 and 2011. It shows that crops were the main agricultural product which accounted for 91% of total value of agriculture production in 2001, 77% in 2006 and 83% in 2011. Over the period 2001-2011, the value of crops remained stable while the value of livestock slaughtering and livestock products experienced strong volatility. Between 2001 and 2006, the value of agricultural production in Griffith increased from $291 million to $343 million. While the gross value of crops was stable at about $263 million during this period, the value of livestock slaughtering increased from about $4 million to $79 million while the value of livestock products decreased from $22.1 million to $1.2 million. Between 2006 and 2011, the total value of agricultural production decreased from $343 million to $281 million because of a decline in the value of both crops and livestock slaughtering.

Table 28: Gross value of agricultural production in Griffith

Gross value of agricultural production ($m)	2001	2006	2011
Gross value of crops	265.4	263.2	234
Gross value of livestock slaughtering	3.8	78.8	43.3
Gross value of livestock products	22.1	1.2	3.9
Total gross value of agricultural production	**291.3**	**343.3**	**281.2**

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001, Agriculture Census 2011

2.5.3 Moree Plains

Population

Moree is a town in Moree Plains Shire in northern New South Wales. The region covers 17,928 km^2 and is a major agricultural centre, noted for its productive agricultural soils. Local crops include cotton, wheat, barley, canola and sunflowers. Permanent crops such as citrus fruit, olives and pecan nuts as well as livestock operations are also part of the mix.

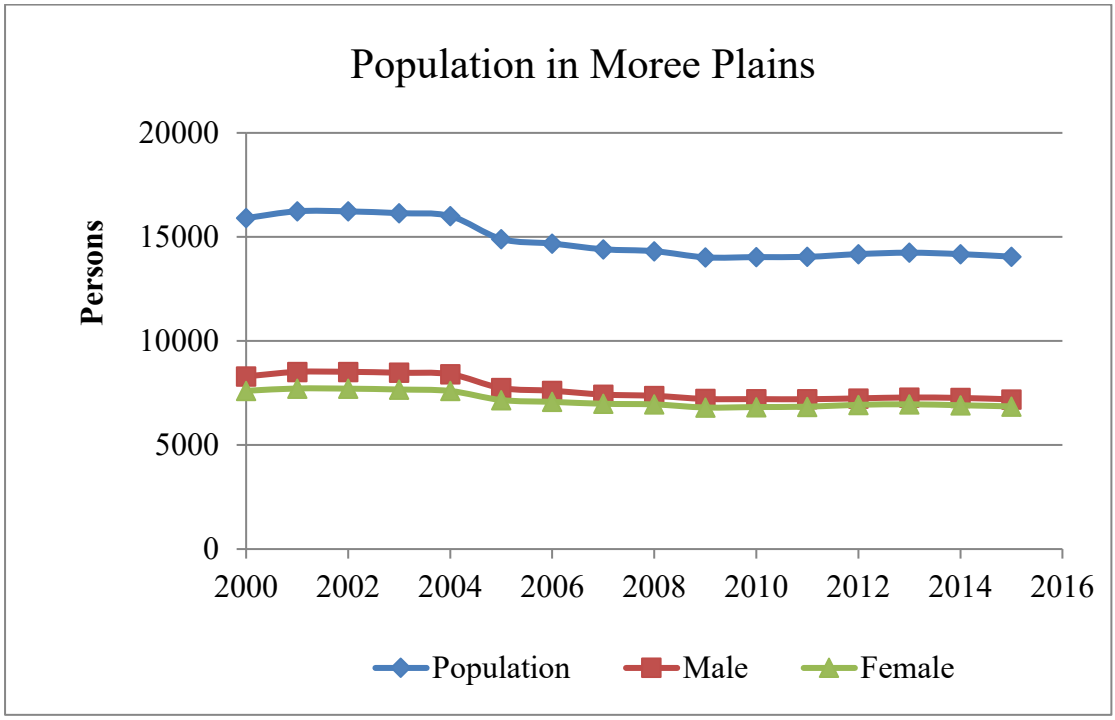
As shown in Table 28 and Figure 25, there is a downward trend in Moree population between 2000 and 2015 and the male population in the region is higher than the number of female population. The region is sparely populated with population density was about 0.8-0.9 persons/km^2 over the period 2000-2015. The indigenous community accounted for a large share of the region population (21% of the region population in 2011).

Table 29: Population in Moree Plains

Year	Population	Male	Female	Working age population (% of total)	Population density (persons/km2)	Indigenous community (%)
2000	15905	8300	7605	66.7	0.9	
2001	16233	8515	7718	66.9	0.9	19.7
2002	16227	8518	7709	66.9	0.9	
2003	16141	8473	7668	66.7	0.9	
2004	16002	8405	7597	66.7	0.9	
2005	14903	7740	7163	65.8	0.8	
2006	14682	7608	7074	65.4	0.8	21.1
2007	14408	7426	6982	65.1	0.8	
2008	14315	7364	6951	65.0	0.8	
2009	14019	7215	6804	64.8	0.8	
2010	14032	7206	6826	64.4	0.8	
2011	14043	7201	6842	64.3	0.8	20.8
2012	14175	7242	6933	64.0	0.8	
2013	14250	7290	6960	64.1	0.8	
2014	14175	7263	6912	63.8	0.8	
2015	14053	7196	6857	63.7	0.8	

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001; Data By Region

Figure 25: Trend in the population in Moree Plains



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Employment

Table 29 and Figure 26 report the labour force status in Moree. Between 2002 and 2008, there was a growing trend in the labour force and the number of persons employed in Moree although both statistics declined between 2009 and 2016. The number of unemployed persons in Moree remained stable over the period 2002-2016, although its unemployment rate was higher than the average unemployment rate of the MDB.

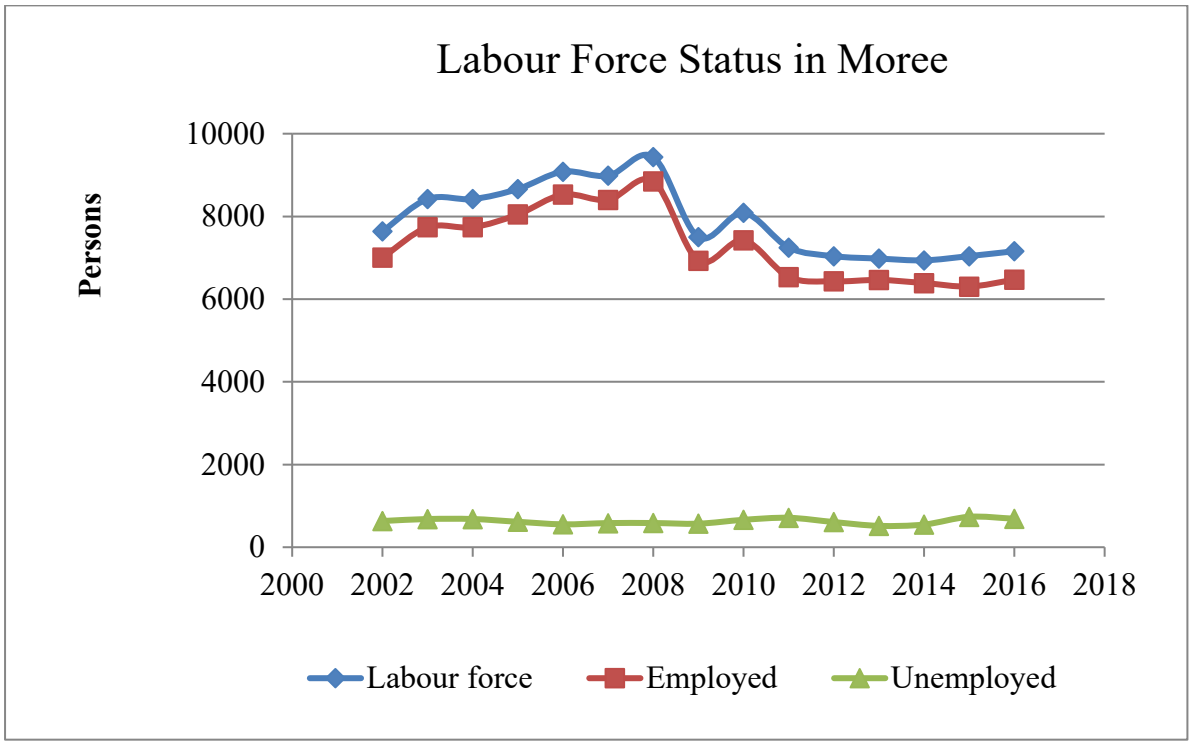
Table 30: Labour Force Status in Moree

Year	Labour force	Employed	Unemployed	Unemployment rate
2002	7639	7005	634	8.3
2003	8420	7738	682	8.1
2004	8420	7738	682	8.1
2005	8662	8047	615	7.1
2006	9082	8528	554	6.1
2007	8985	8401	584	6.5
2008	9435	8850	585	6.2
2009	7500	6930	570	7.6
2010	8085	7422	663	8.2
2011	7248	6536	712	9.8
2012	7038	6429	609	8.6
2013	6980	6463	517	7.4
2014	6938	6389	549	7.9
2015	7040	6305	736	10.5
2016	7158	6468	690	9.6

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001 for period 2002-2010 Department of Employment: Small Area Labour Markets for period 2011-2016

Table 30 shows number of persons employed in main industries in Moree Plains between 1996 and 2011. The Agriculture, Forestry and Fishing, and Wholesale and Retail trade are the main industries in the region. Between 1996 and 2011, employment in these industries decreased. Employment in Education and Training industry experienced a slightly growing trend over the period 1996-2011 (Figure 27). Employment in Heath Care and Social Assistance industry fluctuated and increased slightly between 1996 and 2011.

Figure 26: Trend in the labour force in Moree Plains



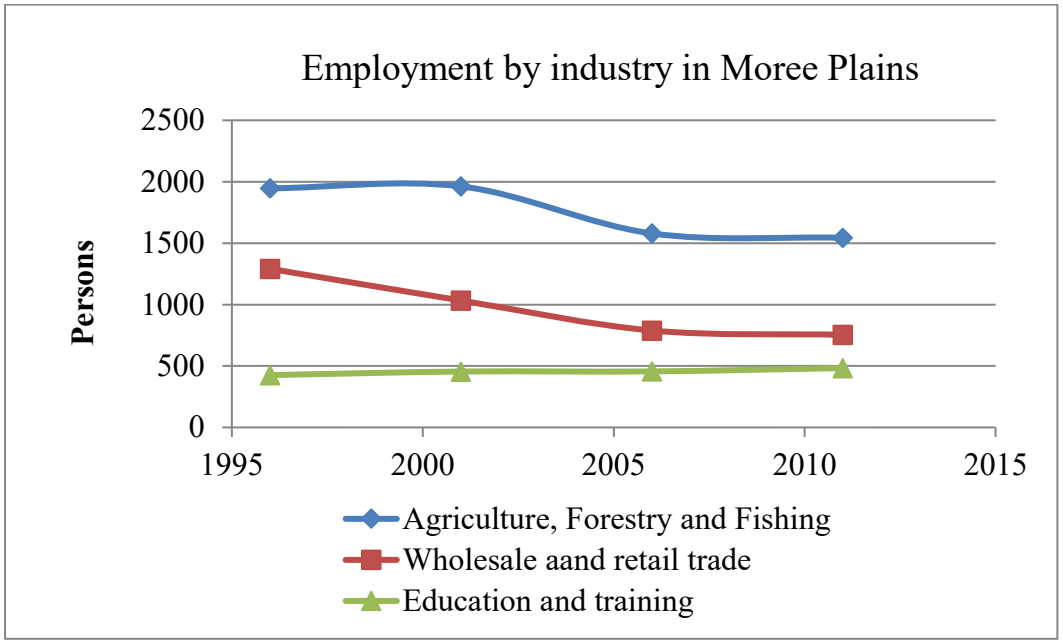
Source: ABS, National Regional Profile, cat. No. 1379.0.55.001 for period 2002-2010
Department of Employment: Small Area Labour Markets for period 2011-2016

Table 31: Number of persons employed by main industry in Moree Plains

Industry	1996	2001	2006	2011
Agriculture, Forestry and Fishing	1946	1962	1579	1544
Manufacturing	268	350	289	282
Construction	286	383	401	347
Wholesale and retail trade	1291	1033	789	754
Accommodation and food services	299	394	319	323
Public administration and safety	374	397	368	377
Education and training	426	455	456	483
Health care and social assistance	473	445	491	486

Source: ABS, Census Community Profiles

Figure 27: Employment by industry in Moree Plains

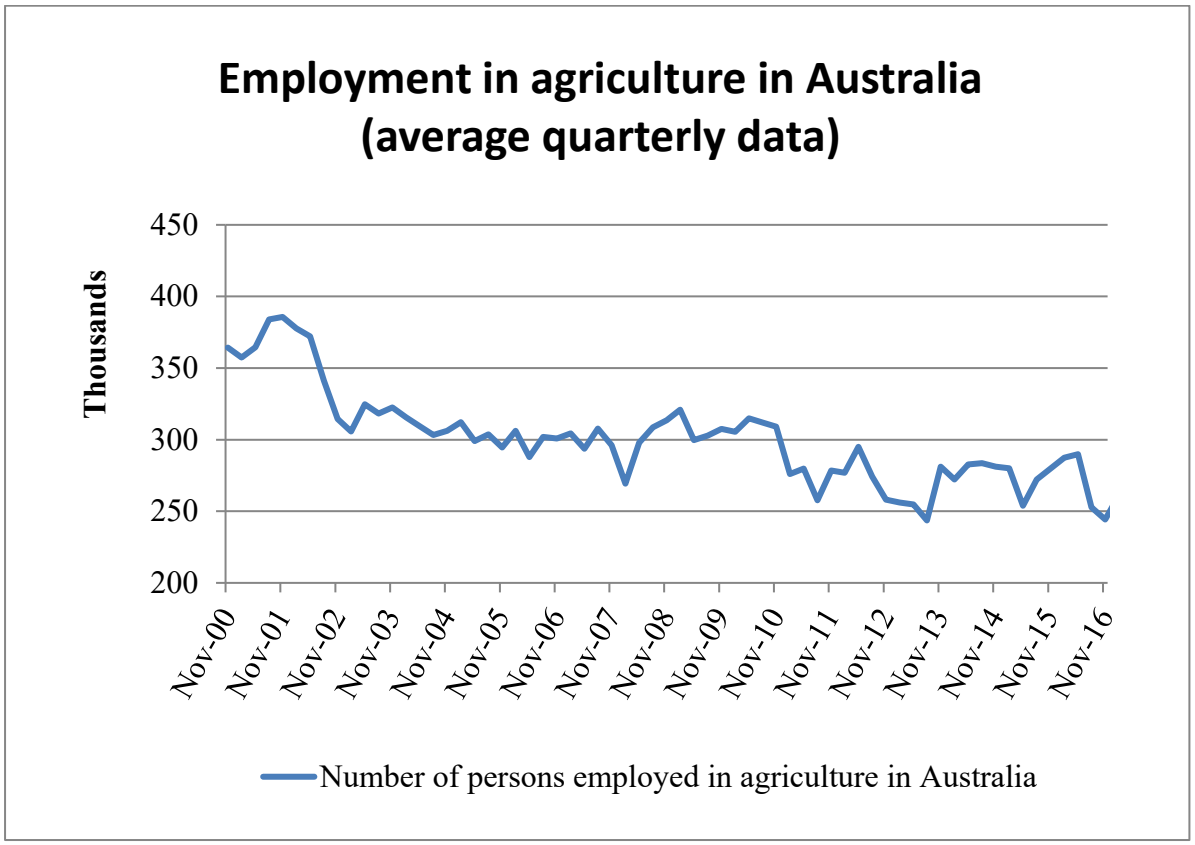


Source: ABS, Census Community Profiles

Drivers of population and employment changes in Moree Plains

Agricultural production is the primary industry of the Moree Plains region. In the last two decades, there was a switch in agricultural production from crops towards sheep and beef farming that requires less labour inputs. This has contributed to a decreasing trend in population and employment in agriculture sector in Moree Plains along with a series of droughts which started in 2003 that has severely affected agriculture industry in the region, and also as the result of mechanization process and a general national downward trend in employment in agriculture (Figure 28). Between 2001 and 2006, Moree Plains was recorded to have the largest population decline of any local government area in inland New South Wales.

Figure 28: National trend in employment in agriculture in Australia



Source: Labour Force, Australia, Detailed, Quarterly, Cat. No. 6291.0.55.003

Income

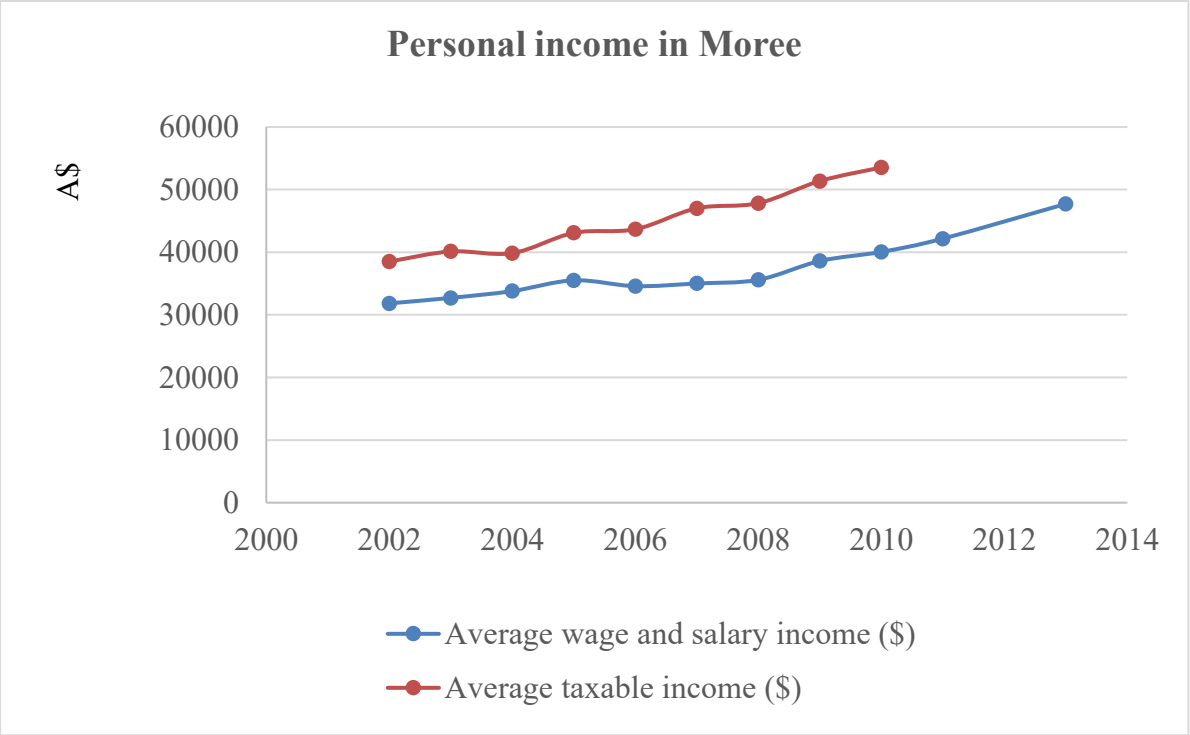
Table 31 and Figure 29 represent the estimates of personal income in Moree. There has been an increasing trend in both average wage and salary income and average taxable income as well as total taxable income in Moree over the period 2002-2013. In 2010, the average taxable income in Moree was $53,536 and the total taxable income was $271.1 million. Between 2002 and 2013, the average income from wage and salary in Moree Plains increased by 50%; while nationally the increase was 65%.

Table 32: Estimates of personal income in Moree Plains

Year	Average wage and salary income ($)	Average taxable income ($)	Total taxable income ($m)
2002	31830	38522	246
2003	32707	40124	`.3235.8
2004	33790	39858	227.5
2005	35509	43090	256
2006	34582	43675	258.6
2007	35011	47017	261.2
2008	35595	47837	261.4
2009	38597	51373	268
2010	40056	53536	271.1
2011	42168		
2013	47720		

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Figure 29: Trend in personal income in Moree



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Agricultural production

As Table 32 shows, crops accounted for about 90% of agricultural production in Moree, with the total value of agricultural production in Moree increasing from $513.5 million in 2001 to $912 million in 2011. The value of crops production increased steadily from $466 million in 2001 to $473 million in 2006 and reached $868 million in 2011; while the value of livestock slaughtering increased between 2001 and 2006, but decreased between 2006 and 2011. Although number of people employed in agriculture in Moree was less in 2006 and 2011 compared to 2001, the value of agricultural production increased over the period as the result of the increase in productivity in agricultural production and also the increase in price of agricultural commodities.

Table 33: Gross value of agricultural production in Moree

Gross value of agricultural production ($m)	2001	2006	2011
Gross value of crops	465.6	473.2	868.4
Gross value of livestock slaughtering	39.9	54.6	36.3
Gross value of livestock products	7.9	4.7	7.3
Total gross value of agricultural production	**513.5**	**532.5**	**912**

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001, Agriculture Census 2011

2.5.4 Greater Shepparton

Population

Greater Shepparton is a local government area in the Hume region of Victoria, located in the north-east part of the state. It covers an area of 2,422 square kilometres. In 2015, the population of Shepparton was 63,366. Shepparton's main industries are agriculture and associated manufacturing. Table 33 reports the population in Shepparton between 2000 and 2015. It shows that between 2000 and 2015, Shepparton population increased by about 11% from 57,211 to 63,366. Population density in Shepparton increased from 23.6 persons/km^2 in 2000 to 26,2 persons/km^2 in 2015. Working age group accounted for about 63% of the Shepparton population. The proportion of indigenous community increased from 2.8% in 2001 to 3.5% in 2011.

Table 34: Population in Greater Shepparton between 2000 and 2015

Year	Population	Male	Female	Working age population (% of total)	Population density (persons/km2)	Indigenous community (%)
2000	57211	28502	28709	64.4	23.6	
2001	58150	28952	29198	64.5	24.0	2.8
2002	58830	29305	29525	64.8	24.3	
2003	59517	29649	29868	64.9	24.6	
2004	58687	29255	29432	64.4	24.2	
2005	58829	29323	29506	64.5	24.3	
2006	59427	29640	29787	64.6	24.5	3.3
2007	60162	29962	30200	64.8	24.8	
2008	60383	30166	30217	64.6	24.9	
2009	60758	30406	30352	64.4	25.1	
2010	61443	30768	30675	64.2	25.4	
2011	61744	30986	30758	63.9	25.5	3.5
2012	62379	31281	31098	64.0	25.8	
2013	62784	31480	31304	63.7	25.9	
2014	63131	31565	31566	63.5	26.1	
2015	63366	31649	31717	63.3	26.2	

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001; Data By Region

Employment

Table 34 reports the employment status in Shepparton between 2002 and 2016. In 2006, the unemployment rate was 7.1% which was significantly higher than the average MDB level of 5%. In 2011, Shepparton unemployment rate remained at a high level of 7.7 which was well above the average MDB level of 4.7%. However, the town's unemployment rate reduced to 5.7% in 2016.

Table 35: Labour force in Greater Shepparton

Year	Labour force	Unemployed	Unemployment rate
2002	28864	1905	6.6
2003	29291	1611	5.5
2004	30250	1694	5.6
2005	30817	1849	6
2006	31338	2225	7.1
2007	31625	1518	4.8
2008	31765	1620	5.1
2009	27125	1519	5.6
2010	30228	2388	7.9
2011	30120	2308	7.7
2012	30531	2355	7.7
2013	30981	1834	5.9
2014	30220	2316	7.7
2015	32322	2398	7.4
2016	33973	1933	5.7

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001 for period 2002-2010 Department of Employment: Small Area Labour Markets for period 2011-2016

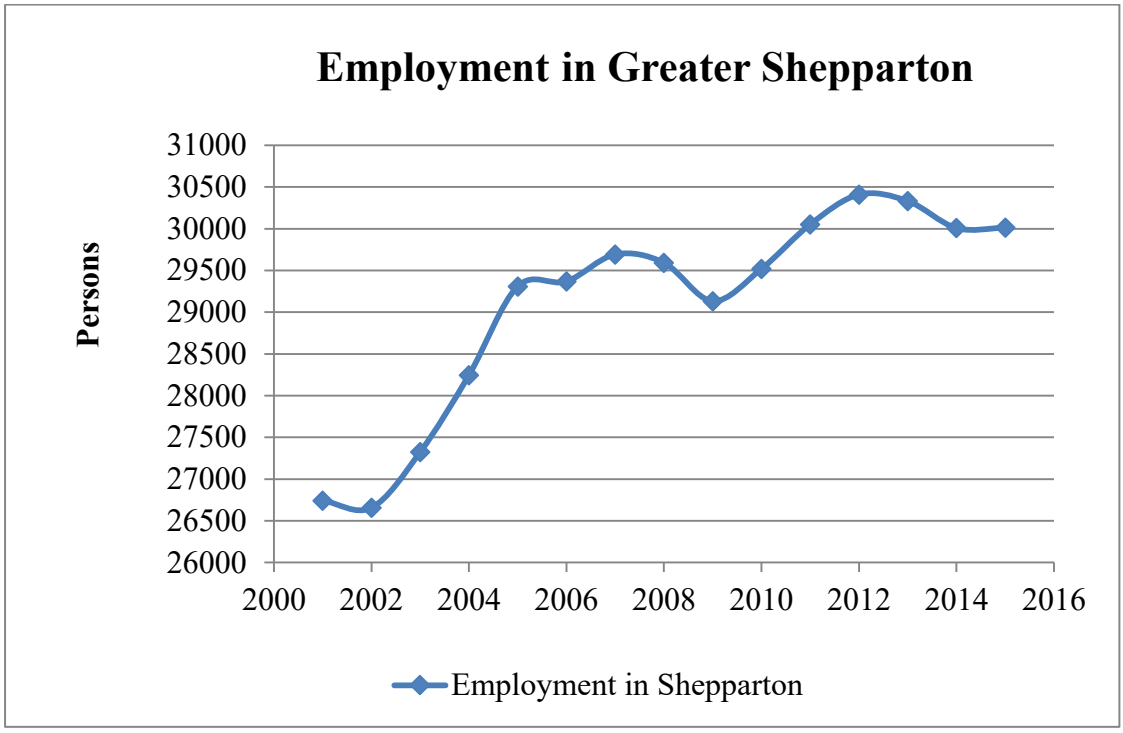
Table 35 reports the number of employed persons by industry in Greater Shepparton between 2001 and 2015. Although employment in Shepparton slightly decreased in 2008 and 2009, there was an increasing trend in the number of persons employed over the period 2001-2015 (Figure 30). The total employment in Greater Shepparton increased from 26,743 in 2000-01 to 30,012 in 2014-15.

Table 36: Employment by industry in Shepparton

Year	Employment by industry in Shepparton									
	Agriculture	Manufacturing	Construction	Transport, Postal and warehousing	Wholesale and retail trade	Public administration and Safety	Education and training	Health care and social assistance	Others	Total
2001	3177	3404	1794	1044	5455	747	1592	2963	6567	26743
2002	3243	3469	1936	1114	5387	839	1654	2882	6133	26657
2003	2507	3423	2043	1080	5802	949	1722	3044	6754	27324
2004	2194	3248	2016	1240	5808	1162	2052	3197	7328	28245
2005	2205	3570	2180	1356	5879	1315	2135	3169	7500	29309
2006	2232	4355	2430	1176	5824	1181	1969	3172	7030	29369
2007	2224	4506	2617	1044	5416	1261	2177	3587	6860	29692
2008	2459	4065	2487	1137	4873	1396	2428	4060	6687	29592
2009	2855	3782	2343	1123	4695	1306	2228	4111	6690	29133
2010	2846	3723	2610	1114	4865	1234	2161	4100	6866	29519
2011	2609	4049	2547	1293	5039	1192	2243	4061	7019	30052
2012	2472	4068	2461	1443	4949	1273	2455	4092	7196	30409
2013	2745	3593	2397	1324	4805	1401	2656	4089	7322	30332
2014	2810	3105	2201	1599	5078	1270	2435	4062	7448	30008
2015	2518	3220	2175	1993	5176	1158	2100	4094	7578	30012

Source: City of Greater Shepparton, Employment Report, 2016

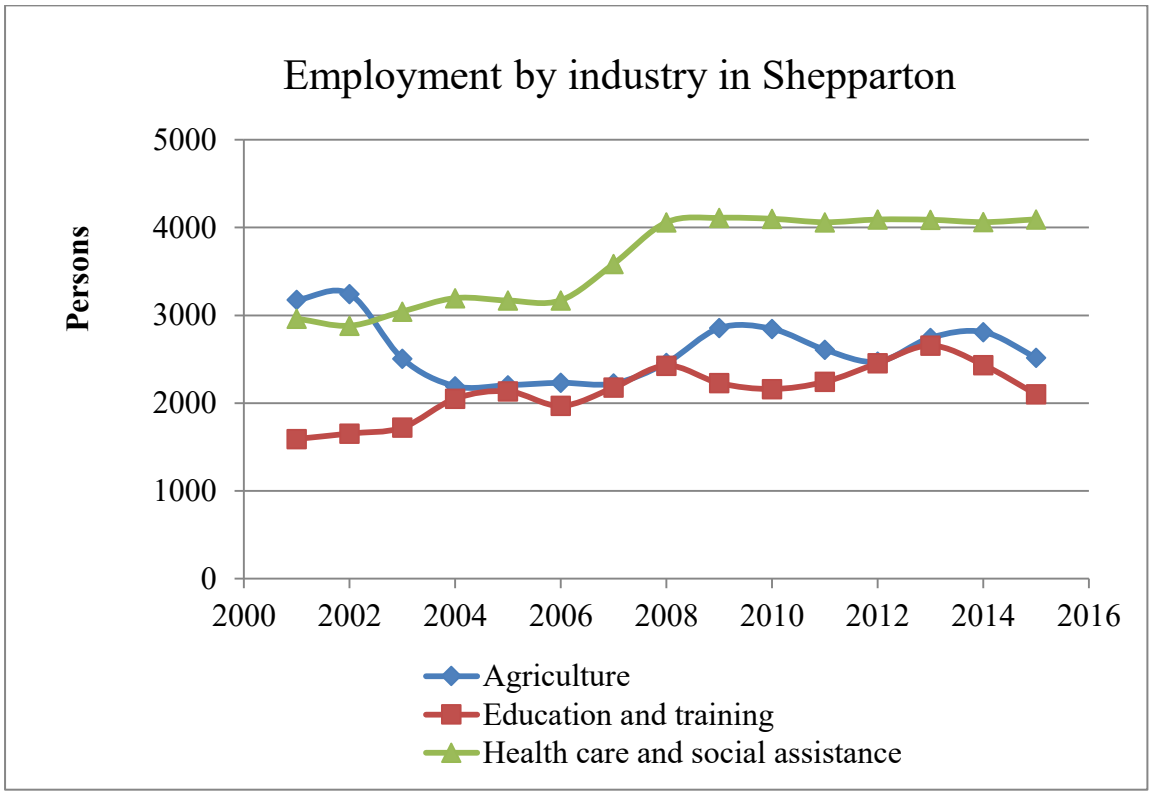
Figure 30: Employment in Greater Shepparton



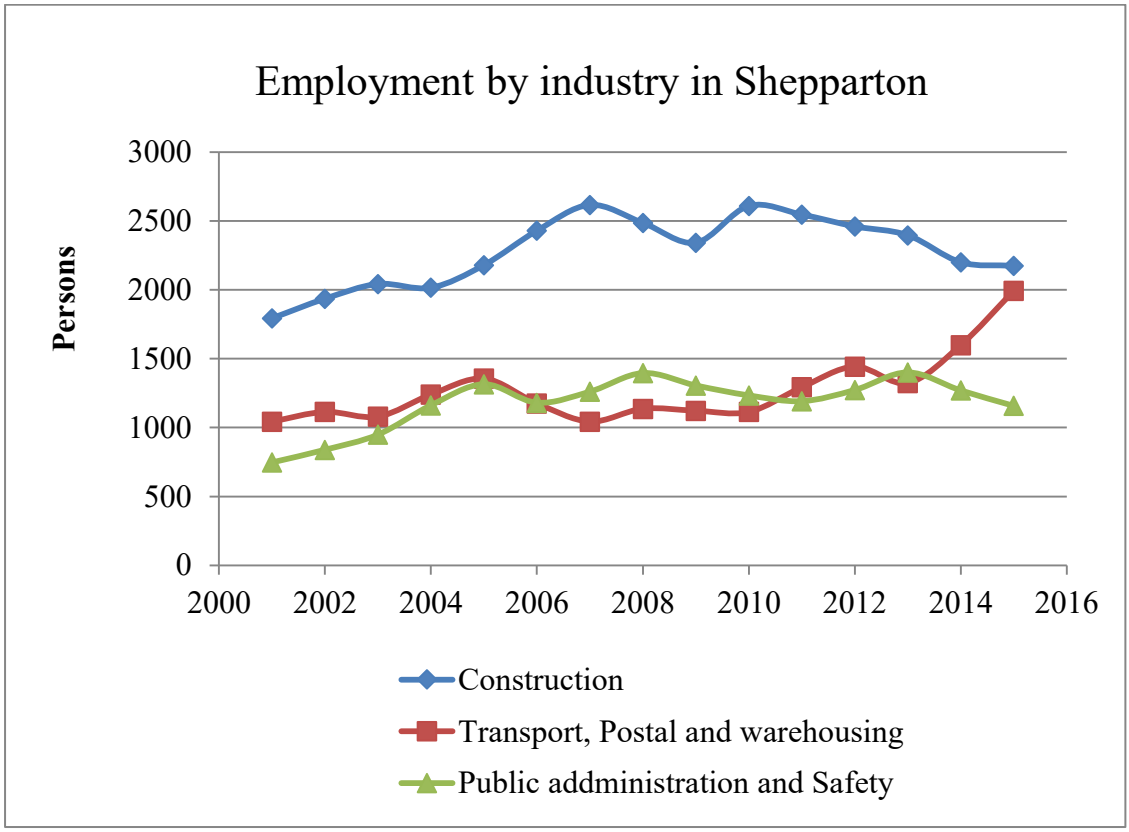
Source: City of Greater Shepparton, Employment Report, 2016

In Shepparton, Agriculture, Manufacturing, Wholesale and Retail trade and Health Care and Social Assistance are the four largest industries. In 2015, these industries accounted for more than 50% of the total employment in the region. Between 2001 and 2015, employment in agriculture and manufacturing industries fluctuated and decreased from about 6,500 in 2001 to 5,700 in 2015; while there was a significant increase in the number of persons employed in Health Care and Social Assistance industry. Other industries experienced a large increase in employment including Education and Training; Construction; Transport, Postal and Warehousing; and Public Administration and Safety (Figure 31).

Figure 31: Employment by industry in Greater Shepparton



(a) Source: City of Greater Shepparton, Employment Report, 2016



(b) Source: City of Greater Shepparton, Employment Report, 2016

Drivers of population and employment changes in Shepparton

The most important industry sectors in Greater Shepparton are: Agriculture; Health Care and Social Assistance; Wholesale and Retail Trade; Manufacturing; Education and Training; Construction; Transport, Postal and Warehousing; and Public Administration and Safety. More than 75% of the employment in the Greater Shepparton is employed in these industries. Increase in the population in the region was mainly associated with employment growth in these industries. Over the period 2001-2015, there was an increase in government investment in public administration and services that increased employment in the public services sector. Between 2006 and 2011 there has also been an increase in retirees moving to the City as a number of new 'lifestyle villages' were constructed in the region. Over the period 2003-2013, reduction in the employment in agriculture industry was caused by the consolidation of agriculture industry (City of Greater Shepparton, 2015).

New employment opportunities in the region that would spur population growth in the region include the Shepparton Bypass project, the road-rail interchange at Mooroopna and additional production jobs at Unilever in Tatura. Significant housing development opportunities have been identified in fringe areas in Shepparton that will contribute to Shepparton's population growth.

Income

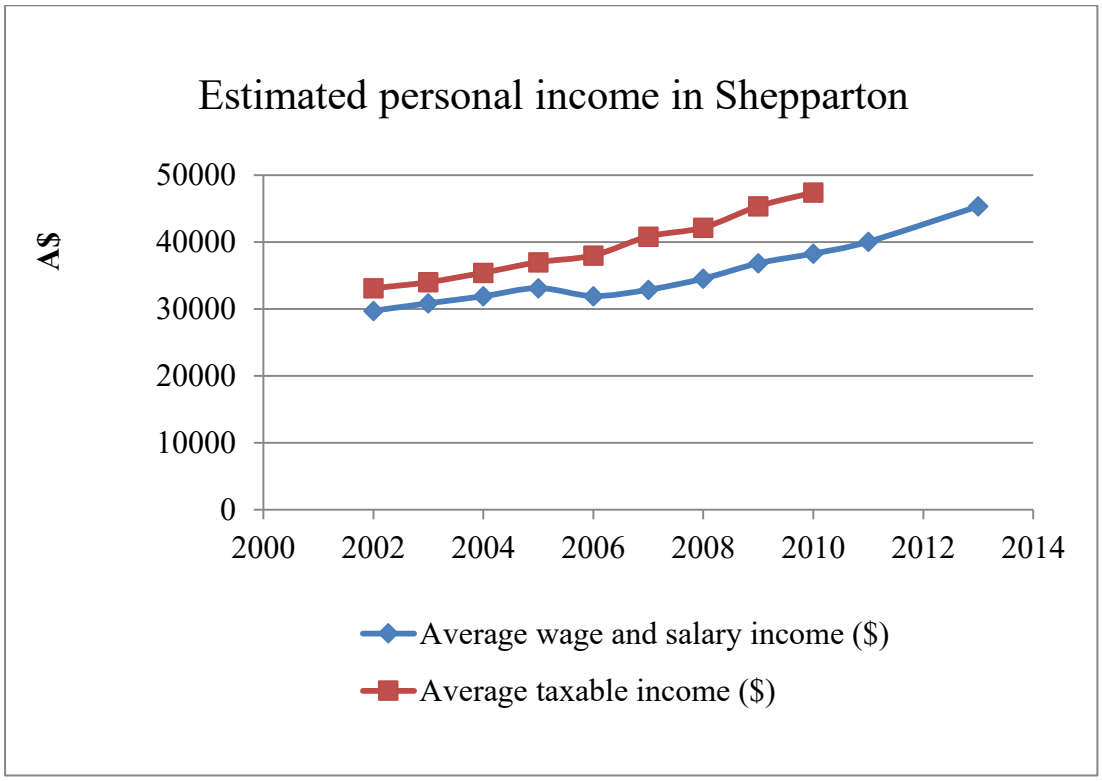
Table 36 and Figure 32 represent the estimates of personal income in Shepparton. Average wage and salary income as well as average taxable income increased steadily over the period 2002-2013. In 2010, the average taxable income in Shepparton was $47,396 and the total taxable income was $1125.6 million. The average income from wage and salary in Shepparton increased by 52% between 2002 and 2013; which was 13 percent less than the national income growth rate.

Table 37: Estimates of personal income in Shepparton

Year	Average wage and salary income ($)	Average taxable income ($)	Total taxable income ($m)
2002	29737	33100	822.1
2003	30858	34005	848.3
2004	31908	35428	896.1
2005	33120	36997	963.8
2006	31937	38010	1018.4
2007	32877	40833	1041.4
2008	34541	42170	1092
2009	36833	45346	1083.4
2010	38281	47396	1125.6
2011	40050		
2013	45334		

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Figure 32: Estimates of personal income in Shepparton



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Agricultural production

Table 37 reports the gross value of agricultural production in Shepparton in 2001, 2006 and 2011. It shows that the value of agricultural production in Shepparton increased from $412 million in 2001 to $620 million in 2011. Crops accounted for 70% of total agricultural production in the region in 2011. The gross value of crops increased from $207 million to $432 million between 2001 and 2011.

Table 38: Gross value of agricultural production in Shepparton

Gross value of agricultural production ($m)	2001	2006	2011
Gross value of crops	207	280.4	432.2
Gross value of livestock slaughtering	57.3	62	60.9
Gross value of livestock products	147.7	144.4	126.7
Total gross value of agricultural production	**411.9**	**486.8**	**619.8**

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001, Value of Agricultural Commodities Produce 2010-2011

2.5.5 Renmark Paringa

Population

Renmark Paringa is a local government area in the South Australia's rural Riverland area. It covers an area of land of 915 km^2. The agriculture industry is the largest employer in the area. The region grows about half of South Australia's grapes, and 90% of the citrus and stone fruit. Most major Australian wine companies source a significant amount of bulk wine from the Riverland. The Riverland is also a significant almond growing region.

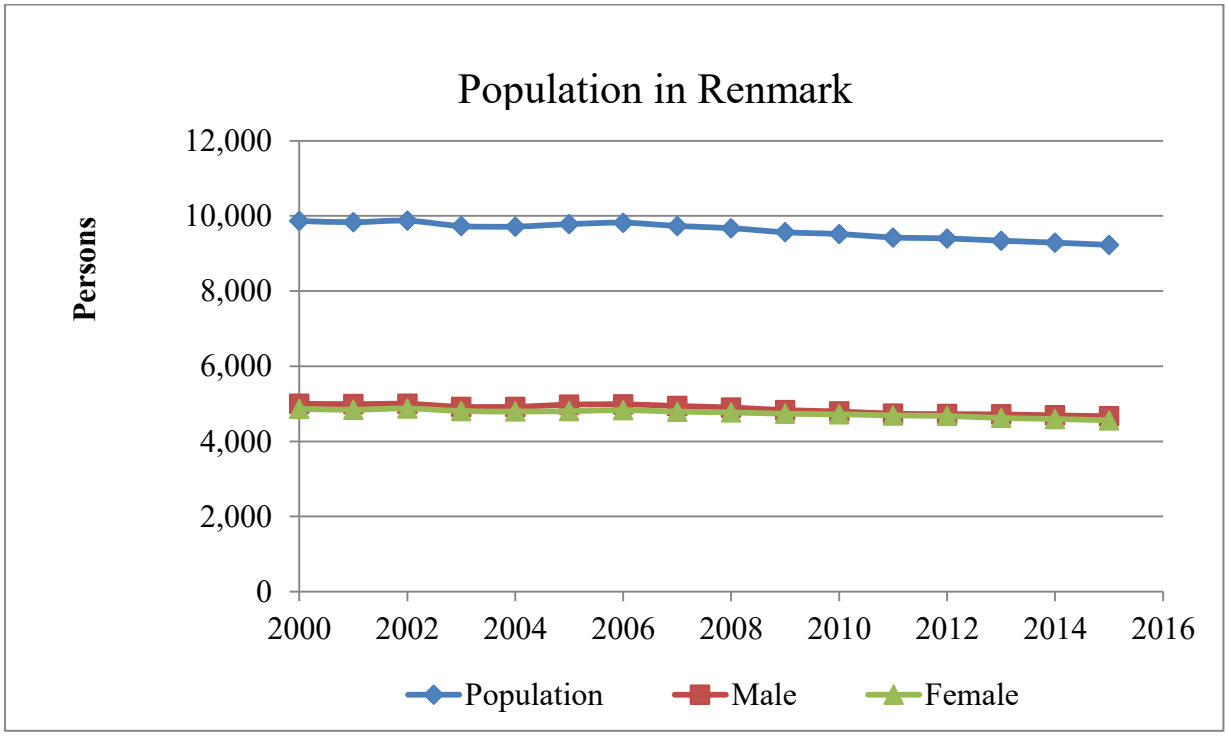
Table 38 and Figure 33 report the population in Renmark between 2000 and 2015. The Figure shows that there was a decreasing trend in Renmark population between 2000 and 2015. Renmark population decreased by 6.4% from 9,866 in 2000 to 9,230 in 2015. Renmark population density decreased from 10.8 persons/km^2 in 2000 to 10.1 persons/km^2 in 2015. During the period 2000-2015, working age population accounted for about 63-64% of the Renmark population. The population share of indigenous community decreased from 2.3% in 2001 to 1.8% in 2011.

Table 39: Population in Renmark

Year	Population	Male	Female	Working age population (% of total)	Population density (persons/km2)	Indigenous community (%)
2000	9866	5001	4865	64.3	10.8	
2001	9834	4992	4842	64.4	10.7	2.3
2002	9875	4999	4876	64.4	10.8	
2003	9731	4922	4809	64.1	10.6	
2004	9718	4922	4796	63.6	10.6	
2005	9783	4977	4806	64.1	10.7	
2006	9820	4988	4832	63.6	10.7	2.2
2007	9734	4942	4792	64.0	10.6	
2008	9674	4902	4772	64.5	10.6	
2009	9567	4832	4735	64.8	10.5	
2010	9519	4797	4722	64.6	10.4	
2011	9429	4738	4691	65.0	10.3	1.8
2012	9402	4727	4675	64.3	10.3	
2013	9346	4721	4625	63.9	10.2	
2014	9290	4693	4597	63.4	10.1	
2015	9230	4669	4561	62.9	10.1	

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001; Data By Region

Figure 33: Trend in Renmark population



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Employment

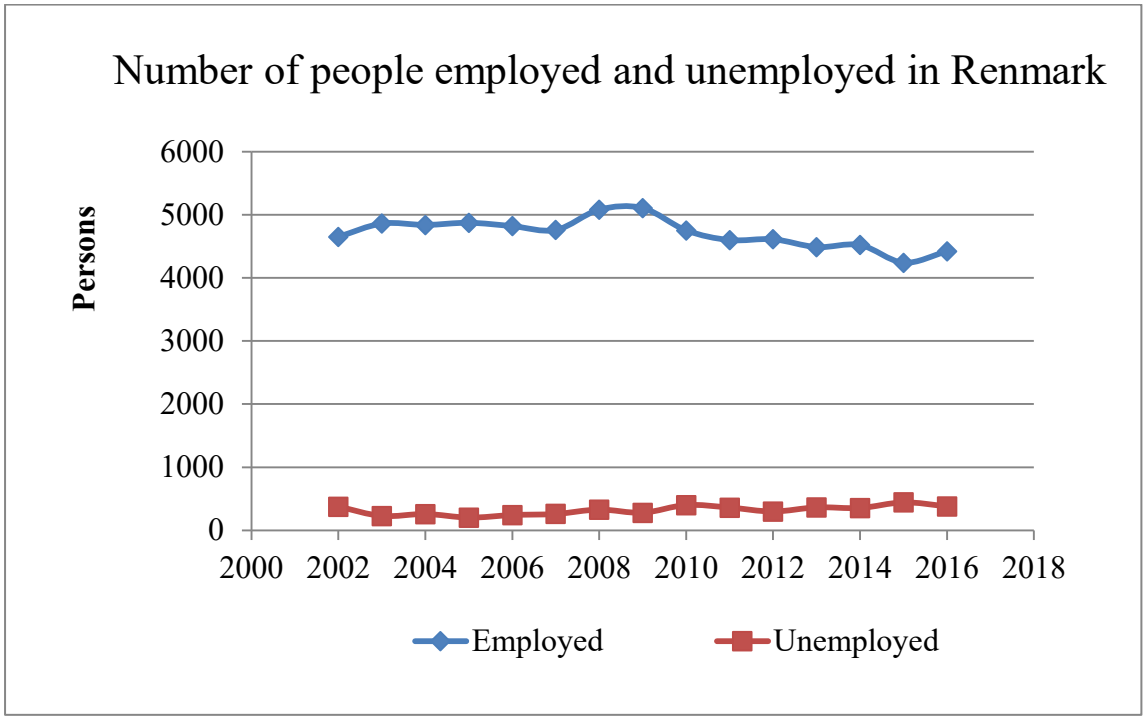
Table 39 and Figure 34 report the labour force status in Renmark. Between 2002 and 2007, the labour force as well as the number of employed and unemployed people remained stable. The number of persons employed decreased between 2010 and 2016 that matched the downward trend in Renmark population. The unemployment rate in Renmark in 2006 was slightly less than the average unemployment rate in the basin, but Renmark unemployment rate in 2011 was higher than the average of MDB unemployment rate.

Table 40: Labour force status in Renmark

Year	Labour force	Employed	Unemployed	Unemployment rate	Unemployment rate in MDB
2002	5027	4650	377	7.5	
2003	5089	4860	229	4.5	
2004	5098	4838	260	5.1	
2005	5075	4872	203	4.0	
2006	5063	4820	243	4.8	5.0
2007	5019	4758	261	5.2	
2008	5410	5080	330	6.1	
2009	5385	5105	280	5.2	
2010	5154	4752	402	7.8	
2011	4961	4599	362	7.3	4.7
2012	4911	4611	300	6.1	
2013	4853	4487	365	7.5	
2014	4875	4520	355	7.3	
2015	4685	4241	444	9.5	
2016	4802	4420	382	8.0	

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Figure 34: Number of people employed and unemployed in Renmark



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Table 40 reports the number of businesses in Renmark between 2003 and 2013. The total number of businesses in Renmark fluctuated with a growing trend between 2003 and 2007. However, the number of businesses in Renmark decreased between 2011 and 2015. Agriculture, Forestry and Fishing is the main industry in the region. There was a downward trend in the number of businesses in this industry over the period. In 2002, Agriculture, Forestry and Fishing accounted for about 58% of the number of businesses; in 2015 this industry accounted for 44% of the number of businesses in the region. Construction and Health Care and Social Assistance are growing industries in the region.

Table 41: Number of businesses in Renmark

Industry	2003	2004	2005	2006	2007	2011	2012	2013	2014	2015
Agriculture, Forestry and Fishing	570	552	558	552	525	455	438	432	423	406
Manufacturing	51	54	48	45	45	34	34	30	29	29
Construction	57	60	81	78	90	104	108	112	95	94
Retail trade	84	93	93	96	99	55	54	52	50	52
Transport, postal and warehousing	45	39	45	36	45	39	38	39	43	44
Education and training	0	0	0	3	3	3	3	3	0	3
Health care and social assistance	15	15	18	15	21	22	24	22	22	19
Others	153	150	180	192	204	295	291	275	268	272
Total (no.)	**975**	**963**	**1023**	**1017**	**1032**	**1007**	**990**	**965**	**930**	**919**

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001; Data By Region

Drivers of population and employment changes in Renmark Paringa

The agriculture industry accounted for 18% of the total employment in Renmark Paringa in 2011 (Census, 2011). Situated in the Riverland, which produces approximately 60% of the volume of the South Australia's Wine each year, the economy of Renmark Paringa is heavily reliant on irrigated orchards and vineyards. Due to the downturn of the grapes wine market started in 2007-08 with a sharp reduction in grapes price from $546 per tonne in 2007-08 to $369 per tonne in 2008-2009, with the price remaining at low levels thereafter, grapes production in Renmark Paringa experienced a downward trend between 2009 and 2013. The downturn of the grapes market, combined with a period of prolonged drought and the operation of the Small Block Irrigators Exit Grant started in 2008 contributed to the reduction of population and employment in Renmark Paringa. Other factors contributed to the outflow migration of population in Renmark include the contraction in manufacturing and retail trade sectors. There were 25 manufacturing companies and 41 retail trade companies were shut down between 2004 and 2015 in Renmark.

Income

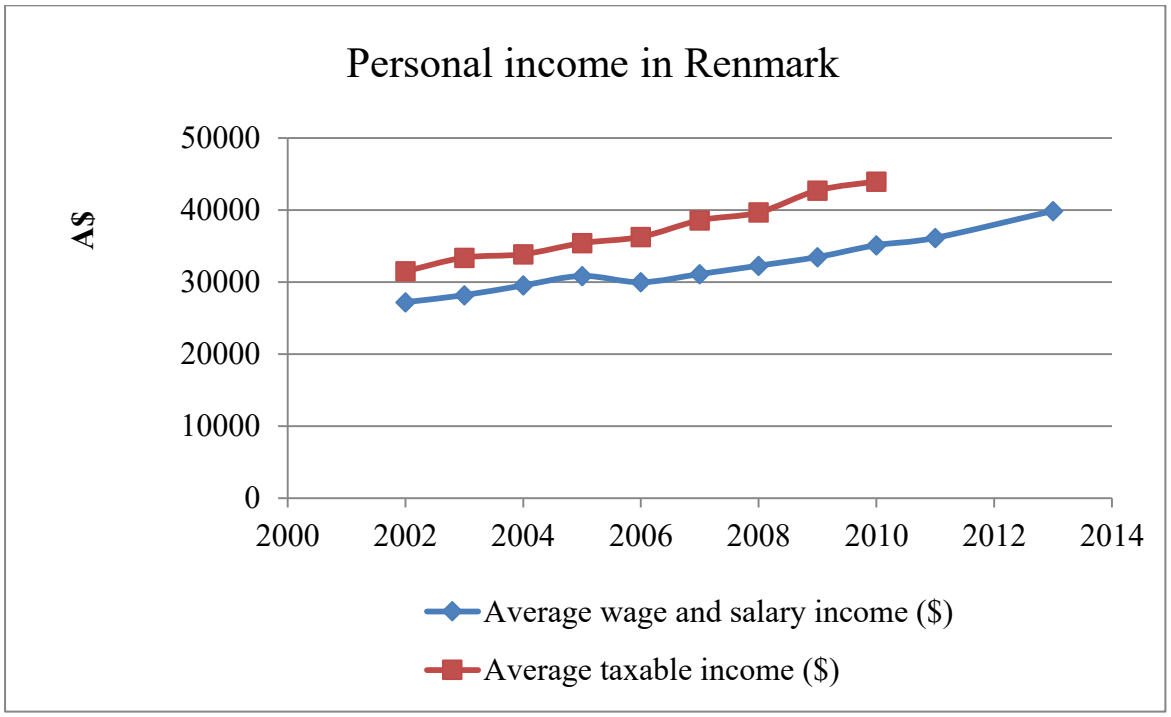
Table 41 and Figure 35 represent the estimates of personal income in Renmark. The average wage and salary income, as well as the average taxable income, increased steadily over the period 2002-2010. However, as the result of the reduction in the number of persons employed, total taxable income decreased in 2010. In 2010, the average taxable income in Renmark was $43,961 and the total taxable income was $158.9 million. The growth rate of wage and salary income in Renmark between 2002 and 2013 (47%) was less than the national growth rate (65%).

Table 42: Personal income in Renmark

Year	Average wage and salary income ($)	Average taxable income ($)	Total taxable income ($m)
2002	27214	31501	131.3
2003	28187	33401	143.4
2004	29538	33868	143.4
2005	30853	35420	152.4
2006	29982	36284	154.7
2007	31121	38585	155.4
2008	32281	39678	161.8
2009	33486	42736	165.3
2010	35133	43961	158.9
2011	36145		
2013	39889		

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Figure 35: Personal income in Renmark



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Agricultural production

Table 42 reports the gross value of agricultural production in Renmark in 2001, 2006 and 2011. Crops accounted for nearly 100% of agricultural production in Renmark. The Table shows that value of agricultural production in Renmark decreased from $206 million in 2001 to $183 million in 2006, and a further reduction to $141 million in 2011.

Table 43: Gross value of agricultural production in Renmark

Gross value of agricultural production ($m)	2001	2006	2011
Gross value of crops	205.3	182.3	138
Gross value of livestock slaughtering	0.2	0.3	1
Gross value of livestock products	0.6	0.6	1
Total gross value of agricultural production	**206.2**	**183.1**	**141**

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

2.5.6 Comparison of incomes and employment between local towns and national level

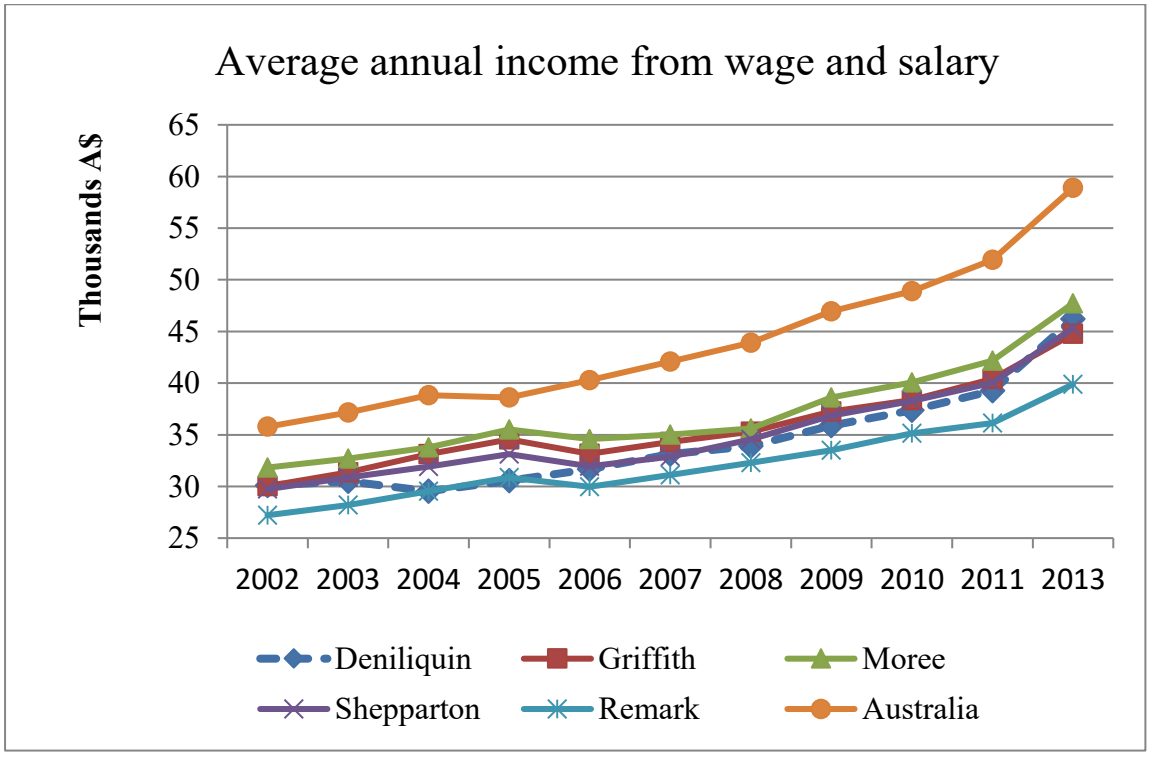
Table 43 and Figure 36 compare the average income from wage and salary for the five local towns examined above to the national level. The average incomes from wage and salary in the five towns are significantly less than the national average level. In 2013, the average income from wage and salary in Deniliquin, Griffith, Moree, and Shepparton was between $44,000 and $48,000; while the national average level was more than $58,000. Average income in Renmark was $40,000 in 2013.

Table 44: Comparison of average income between local towns and national level

Year	Average annual income from wage and salary (A$)					
	Deniliquin	Griffith	Moree	Shepparton	Remark	Australia
2002	30094	30028	31830	29737	27214	35782
2003	30486	31362	32707	30858	28187	37144
2004	29542	33125	33790	31908	29538	38820
2005	30545	34555	35509	33120	30853	38607
2006	31682	33158	34582	31937	29982	40276
2007	33119	34316	35011	32877	31121	42081
2008	33911	35310	35595	34541	32281	43921
2009	35873	37243	38597	36833	33486	46949
2010	37364	38359	40056	38281	35133	48907
2011	39252	40421	42168	40050	36145	51923
2013	46214	44764	47720	45334	39889	58893

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Figure 36: Comparison of average income between local towns and national level



Source: ABS, National Regional Profile, cat. No. 1379.0.55.001

Table 44 compares the unemployment rates of the five local towns to the national level over the period 2002-2016. The unemployment rates in Deniliquin and Griffith appear to be lower than the national level; while for most of the years unemployment rates in Moree, Shepparton and Renmark were higher than the national average.

Table 45: Comparison of unemployment rate between local towns and national level

Year	Unemployment rate					
	Deniliquin	Griffith	Moree	Shepparton	Remark	Australia
2002	4.6	4.6	8.3	6.6	7.5	6.4
2003	4.9	4.6	8.1	5.5	4.5	5.9
2004	4.4	3.7	8.1	5.6	5.1	5.4
2005	5.1	4.3	7.1	6.0	4	5.0
2006	6.1	5.5	6.1	7.1	4.8	4.8
2007	4.0	3.8	6.5	4.8	5.2	4.4
2008	4.0	3.7	6.2	5.1	6.1	4.2
2009	6.0	5	7.6	5.6	5.2	5.6
2010	5.7	5.5	8.2	7.9	7.8	5.2
2011	4.6	7.4	9.8	7.7	7.3	5.1
2012		5.4	8.6	7.7	6.1	5.2
2013		5.9	7.4	5.9	7.5	5.7
2014		5.4	7.9	7.7	7.3	6.1
2015		4.5	10.5	7.4	9.5	6.1
2016		3.6	9.6	5.7	8.0	5.7

Source: ABS, National Regional Profile, cat. No. 1379.0.55.001; World Bank

3 Effects of water reforms on key social-economic indicators in the basin

In this section we analyse the effects of water reforms in the MDB based on the data available as at June 2016 using a series of linear regression models. The dependent variables are:

- gross value of irrigated agricultural production (GVIAP) and gross value of agricultural production (GVAP) in the MDB in fixed price (price prevailed in 1997-98) ($ million);
- total area irrigated in the MDB (000 ha)

- water use efficiency of irrigated agricultural production in the MDB defined as the value of production in fixed price (price prevailed in 1997-98) per ML of water used ($/ML);
- number of irrigating agricultural businesses and total number of agricultural businesses;
- total water extraction for consumptive use in the MDB (GL) and;
- water allocation price (extracted from the Murray Irrigation) ($A/ML).

Explanatory variables grouped into three categories:

- variables related to water reform
  - water entitlements recovered through buybacks and infrastructure investment (GL)
  - Water allocation price (extracted from Murray Irrigation) (A$/ML)
- variables related to commodity prices
  - agricultural commodity producer price indexes (aggregated for all crops and aggregated for all agriculture products with reference year 1997-98 =100)
  - input prices (fertilizer price index, electricity price index, chemical price index, interest rate index, etc.) (reference year 1997-98 =100)
- variables related to water availability
  - dummy variables for the year 2006-07 and 2008-09 to capture the effects of the Millennium Drought in 2006-07 and 2008-09 which are the most severe years of drought
  - water allocation volume in the MDB (GL)
  - water storage at the end of the year in the MDB (GL)

We estimated linear regression models using the Ordinary Least Squares (OSL) method. For every model we undertook a diagnostic test for stationarity of the error terms of the model to check for spurious regressions; i.e. apparent correlations between dependent and explanatory variables that are not causally related to each other. We found that the error terms are stationary. The LM test and the Ljung–Box statistics also find no evidence of autocorrelation in error terms of the model where we test for AR(1) in Ljung–Box and LM tests. These diagnostic results imply that the results are non-spurious.

These results are subject to caveats in terms of the availability and the quality of the data used. We only have 10-15 years of data available so the accuracy of the estimated effects and relevant tests is restricted. While the tests for significance take account of the data limitations, it is still best to treat these results as indicative rather than definite. All results were reported at a basin scale and do not necessarily reflect local trends.

3.1 Factors affecting agricultural production in the MDB

As rainfall level is a crucial factor for agricultural production and rainfalls are unevenly distributed in time and spaces over the MDB, a detailed analysis at local areas and/or seasonal data is ideal. However, due to limitation regarding data availability and time frame of this research, we focused our analysis on aggregated level for annual data over the MDB.

We acknowledge that agricultural production might be affected by a range of factors such as government policies before the Water Act in 2007 and different years of drought over the period 2001-2015. However, with our data limitation where the data is only available between 10 and 15 years, the inclusion of a full set of explanatory variables is impossible. Therefore, we focused on analysing the effects recent policy-relevant factors and the most severe years of drought. We examined the relationship between GVIAP, GVAP and four factors: agricultural commodity producer price indexes (annual average, aggregated for all crops in model of GVIAP and aggregated for all agricultural products in model of GVAP); water allocation price (A$/ML); the amount of water recovery (GL) under the government water buy-back program and the infrastructure water efficiency improvement program as established in the Water Act in 2007. We included a dummy variable for the years 2006-07, 2007-08 and 2008-09 in the model of GVIAP to capture the effects of severe years of the Millennium Drought in 2006-07, 2007-08 and 2008-09. However, this dummy variable is not significant in the model of GVAP, therefore in the model of GVAP we included a dummy variable for only the year 2006-07 which is the most severe year of the Millennium Drought (Table 45). We also tested for the effect of other input prices including fertiliser, electricity, chemicals, wages, and interest rate index. As we did not find significant effects of these latter variables, we dropped these variables from the estimated models.

The results indicate that an increase in agricultural commodity price index of 1 percentage point will increase GVIAP and GVAP in the MDB by 0.8% and 0.6%, respectively. The effects of the Millennium Drought was negative and significant. The drought in period 2006-09 reduced the GVIAP by 23%; while the drought in 2006-07 reduced the GVAP by 18%. The effect of drought was larger for GVIAP than for GVAP. This could be explained by the number of irrigated agricultural businesses that closed after the severe drought in 2006-07 and the continuing dry conditions in the MDB between 2007 and 2009; while non-irrigated agriculture industry might have diversified production to adapt to the dry conditions and rely less on water availability.

The effects of water price on GVIAP and GVAP are negative and significant. An increase in water allocation price of $10 per ML (which is about 8.5% of the water allocation price in 2014-15) will reduce gross value of irrigated agricultural production by 0.6% and reduce gross value of agricultural production by 0.5%. The effect of water recovery was found to be negative and significant in the model of GVIAP; this effect was negative but insignificant in the model of GVAP. An increase of 10 GL in water recovery will reduce GVIAP by 0.4%.

Table 46: Factors affecting GVIAP and GVAP in the MDB

	Log of gross value of irrigated agricultural production (1997-98 $ million)	Log of gross value of agricultural production (1997-98 $ million)
Agricultural commodity Producer price index	0.008*	0.006**
Dummy variable for years 2006-07, 2007-08, 2008-09	-0.23**	
Dummy variable for years 2006-07		-0.18**
Water allocation price ($/ML)	-0.0006*	-0.0005**
Water recovery from buybacks & infrastructure (GL)	-0.0004*	-0.0003
Constant	7.66***	8.78***
N	10	11
Test for overall significant of the model	F=10.3 (p=0.012)	F=13.4 (p=0.004)
Ljung–Box statistics to test for AR(1)	Q=1.51 (p=0.219)	Q=1.37 (0.241)

Note: *,**,*** indicate statistical significance at the 10%, 5%, and 1% significance level respectively.

3.2 Factors affecting area irrigated in the MDB

We examined the effects of five factors on the total area irrigated in the MDB: agricultural commodity producer price indexes (aggregated for all crops); a dummy variable taking value 1 for the period 2007-2015 and taking value 0 for the period 2001-2007 to capture the effect of farmers' adjustment after the serve drought in 2006-07; water allocation price (A$/ML); water allocation announcement (GL); and the amount of water recovery (GL). The results show that all of these five factors have significant effects on the total area irrigated in the MDB. An increase in price of crop products significantly increases the area of land irrigated. As the result of farmers' adjustment to the severe drought in 2006-07 and the continuing dry condition thereafter, on average, total irrigated land was reduced by 365,000 ha per year in the period 2007-2015 compared to the period 2001-2006. Holding other factors in the model unchanged, a $10 increase in water allocation price will reduce the area irrigated by 13,000 ha; an increase of 1 GL in water recovery will reduce the total area irrigated by about 800 ha; while an increase

of 1 GL in water allocation announcement will increase the total land irrigated by 20 ha (Table 46). Care must be taken when interpreting these results because the relationship holds only for very small shifts in the explanatory variable (e.g. $1/ML increase in water allocation price, or 1GL increase in water recovery) while holding other variables in the model constant. The actual estimate of the area irrigated would need to include all model variables rather than a single coefficient in isolation.

Table 47: Factors affecting the area irrigated in the MDB

	Total area irrigated in MDB (000 ha)
Agricultural commodity Producer price index	16.2***
Dummy variable for period 2007-2015	-365**
Water allocation price ($/ML)	-1.27***
Water recovery from buybacks & infrastructure (GL)	-0.77*
Water allocation announcement (GL)	0.02*
Constant	201
N	15
Test for overall significant of the model	F=27.1 (p=0.000)
Ljung–Box statistics to test for AR(1)	Q=0.003(p=0.960)

Note: *,**,*** indicate statistical significance at the 10%, 5%, and 1% significance level respectively.

3.3 Effect of water reforms on water use efficiency

We examined how water use efficiency of irrigated agricultural production in the MDB, in terms of the value of irrigated agricultural production in 1997-98 price per ML of water used, changed with water allocation price and the amount of water recovery under the government water buy-backs and the infrastructure water efficiency improvement program as established in the Water Act in 2007. Water allocation price and water recovery have a positive and significant effect on the water use efficiency of irrigated agricultural production (Table 47). An increase in water allocation price by $1 per ML will increase the value of irrigated agriculture production per ML of water used by $0.86. A 1 GL increase in the amount of water recovery will increase the value of irrigated agriculture production per ML of water used by $0.96.

Table 48: Factors affecting water use efficiency in MDB

	Water use efficiency of irrigated agricultural production in the MDB in 1997-98 price ($/ML)
Water allocation price ($/ML)	0.86***
Water recovery from buybacks & infrastructure (GL)	0.96**
Constant	577***
N	10
Test for overall significant of the model	F= 6.19 (p=0.028)
Ljung–Box statistics to test for AR(1)	Q=0.31 (p=0.576)

Note: *,**,*** indicate statistical significance at the 10%, 5%, and 1% significance level respectively.

3.4 Factors affecting the number of agricultural businesses in MDB

We examined the effects of water allocation price and the amount of water recovery under the government water buy-backs and the infrastructure water efficiency improvement program on the number of irrigating agricultural businesses and on the total number of agricultural businesses in the MDB. The results show that there is a decreasing trend in the number of irrigating agricultural businesses and number of total agricultural businesses in the MDB over the period 2001-2015. Effects of water allocation price and water recovery are not significant in both models of irrigating as well as total agricultural businesses (Table 48).

Table 49: Effect of water price on the number of agricultural businesses in MDB

	Number of irrigating agricultural businesses	Number of agricultural businesses
Time trend	-399***	-872**
Water allocation price ($/ML)	-1.12	1.96
Water recovery from buybacks & infrastructure (GL)	-0.11	-0.25
Constant	19591***	62595***
N	11	11
Test for overall significant of the model	F=4.76 (p=0.041)	F=4.51 (p=0.046)
Ljung–Box statistics to test for AR(1)	Q=0.011 (p=0.918)	Q =0.740 (p=0.390)

Note: *,**,*** indicate statistical significance at the 10%, 5%, and 1% significance level respectively.

3.5 Factors that affect water allocation price

We examined the effects of water allocation announcement at the beginning of the season that includes net carryover water from the previous year, and water availability measured as the volume of water storage at the end of the year in the MDB, on water allocation price. The results show that effects of water allocation and water availability on water allocation price are significant. An increase in water allocation by 100 GL will reduce water allocation price by about 4$ per ML; while an increase in water availability by 100 GL will reduce water allocation price by $2 per ML (Table 49).

Table 50: Effect of water allocation and availability on water allocation price

	Water allocation price ($/ML)	
	Regression 1	Regression 2
Water allocation announced (GL)	-0.04***	
Water storage in MDB (GL)		-0.02**
Constant	475***	361***
N	15	15
Test for overall significance	F = 10.7 (p=0.006)	F =7.23 (p=0.019)
Ljung–Box statistics to test AR(1)	Q=0.172 (p=0.189)	Q=2.14 (p=0.143)

Note: *,**,*** indicate statistical significance at the 10%, 5%, and 1% significance level respectively.

3.6 Effect of water reform on volume of water extraction in MDB

We analysed the effects of water allocation price, water allocation announcement, and water recovery (GL) under the government water buy-back program and the infrastructure water efficiency improvement program as established in the Water Act in 2007, on volume of water extraction for consumptive uses in the MDB using data for the period 2001-2015. The results show that an increase of $1 per ML in water allocation price will reduce the total water extraction by about 7 GL. An increase of 1 GL in water allocation announcement will increase water extraction by about 0.4 GL; while an increase of 1 GL in water recovery will reduce the total water extraction by about 8 GL (Table 50).

Table 51: Effect of water price, allocation and recovery on water extraction in MDB

	Water extraction for consumptive uses (GL)
Water allocation price ($/ML)	-6.58**
Water allocation announced (GL)	0.36**
Water recovery from buybacks & infrastructure (GL)	-7.95***
Constant	6735***
N	15
Test for overall significance of the model	F = 12.8 (p=0.001)
Ljung–Box statistics to test for AR(1)	Q=2.92 (p=0.1)

Note: *,**,*** indicate statistical significance at the 10%, 5%, and 1% significance level respectively.

4 Discussion

Our study examined the changing nature of industries and communities in the Murray-Darling Basin in the past two decades and the possible drivers of these changes. We measured changes in a number of key variables related to agricultural production, water use, population and employment. It is clear from our analysis that there were significant changes in the economic and social structure of the Basin as a whole in recent years. These changes were not uniform across the Basin, with some communities growing and prospering, while others were in decline.

Multiple factors influenced the Basin's socio-economic structure, including rainfall and consequent water availability, local and international commodity prices, changes in agricultural technology, improved transport and internet communications, as well as the structural changes being brought about by reforms in water management. The latter comprise a suite of interventions that have now been operating for over 20 years including transfer of responsibility for irrigation areas from government to irrigator owned corporations, increases in water prices to better reflect operating and capital costs, introduction of water markets for water entitlements and water allocations, improvements in water use efficiencies both on-farm and off-farm, and the return of water from the consumptive pool to the environment. Some of these factors, such as changes in agricultural technology, were national in scope; some, such as the Millennium drought and many water reform programs, were regional or Basin-wide; while others were

local. Some factors operated over the short-term (e.g. changes in rainfall and water availability, changes in commodity prices) and their effects were detected almost immediately in production and economic data. However, most operated over the long term. Given this complexity, it is difficult to disentangle the effect of any particular influence on the Basin's production and society from the multitude of concurrent influences without careful systematic analysis. In this study, we used multiple regression models to find the likely causes of social and economic changes across the Basin.

Linear regressions are a useful approach to assess whether changes in these variables could be explained by variables related to water reform, commodity prices and water availability. However our study examined only a subset of drivers and socio-economic indicators, and they do not necessarily represent the full suite of indicators that are important to communities and industries in the Basin. Even when relationships were found they need to be treated with caution given that only 10-15 years of data were available and we did not model interaction effects. Despite these data limitations, these results provide important evidence of the effect of water reforms and other drivers on socio-economic indicators in the Basin.

Some changes and their probable causes were apparent from this analysis. The production of water-dependent annual crops such as rice, cotton, cereals fell sharply between 2006 and 2009 and then recovered in 2011 although not to pre-2006 levels in the case of rice. While a number of factors may have been in play, the Millennium drought was very likely to have been the main driver. Between 2013 and 2015, the production of these crops again declined and this was most probably associated with reduced water availability over those years. In contrast, grape production remained comparatively stable over the period 2001-2015. Grapes are a perennial crop, and their production was sustained through this period with water sourced from rainfall, allocations from high security entitlements, and temporary trade from rice growers, mixed farmers and dairy farmers who had more flexible production systems (NWC 2011).

The gross value of agricultural production (both GVIAP and GVAP) declined gradually through the drought period, reaching a low in 2008-09, but then grew steadily to record levels in 2013-14 and 2014-15, respectively. Trends in irrigated agricultural production in the MDB reflected national trends. Not surprisingly, our analysis showed that drought was a significant factor in explaining the decline in agricultural production across the Basin, probably because of reduced water allocations, and closure of irrigating agricultural businesses (1,985 fewer

businesses between 2006-07 and 2008-09). Model results showed that drought impacts on the irrigated agriculture industry probably persisted until at least 2008-09 with the arrival of the drought-breaking rains, while drought impacts on the agriculture industry as a whole were short-lived through 2006-07, suggesting the industry may have adjusted to the continuing dry conditions.

Water allocation prices were also found to have significantly affected agricultural production in the Basin. The rising water allocation price explained some of the decline in agricultural production during the drought, reflecting the reduced demand for water as allocation price increased. This was consistent with research by Burdack et al. (2011) who found that an increase in water allocation price would reduce the production of irrigated crops; the more the industry is dependent on irrigation, the more it is affected by an increase in water price.

The influence of water recovery appeared to be significant for irrigated agricultural production but not for total agricultural production. Effects were relatively small (a 10GL increase in recovery reduced GVIAP by 0.4% over the range of water recovery examined here), compared to effects of drought and water prices. Water recovery commenced in the mid-2000s as part of a number of initiatives including The Living Murray and the Basin Plan. Water recovery during this period was linked to reduced irrigated agricultural productivity in the Basin, as water entitlements were moved from agricultural production to environmental benefits. Similar effects were shown in an ABARES (2011) which found that reducing irrigation diversions by 26% could reduce the GVIAP in the basin by 10-15%.

Declines in value of agricultural production were significantly less than the declines in volumes of production, implying that there were mechanisms operating to cushion the effects of the drought and water recovery. While this analysis is unable to fully unravel these compensating mechanisms, the ability to trade water (part of the water reforms) was likely to have been a significant factor (NWC 2014).

Area of irrigated land in the MDB was reduced to about 365,000 ha in 2006-07 primarily because of the severe drought. The area under irrigation fluctuated considerably for rice, cotton, pastures, cereals but remained relatively stable for grapes and vegetables. The regression models imply that the total area irrigated was affected significantly by changes in water prices and water recovery, with increases in crop prices leading to an increase in the area under

irrigation, and an increase of 1GL in the water allocation announcement leading to an increase of 20ha in irrigated land. Conversely, 1GL of water recovery led to a reduction in irrigated area of about 800ha.

Water allocation price appeared to be driven by the volume of water allocation announced and water availability in the MDB. A decrease in water allocation by 100 GL was found to increase water allocation price by about $4 per ML. This was consistent with a recent report that found that total volume of water allocation was an important driver of water allocation price because it placed a constraint on the total supply of water available for consumption (Aither 2016).

Water use efficiency, averaged across all irrigated crops, improved significantly over the 2000-2008 period from A$486/ML to A$1171/ML although it then declined to A$700/ML in 2013-14. Water use efficiency reached a near-record high of A$1117/ML in the dry year 2015-16. The high WUE during the time of the Millennium drought could be caused by a number of factors: more efficient use of water in response to water scarcity, a shift from higher to lower irrigation requirement crops, and water trade that allowed the highest value horticulture to stay in production while crops with lower marginal value and higher demand for water were fallowed. The WUEs of the major water using crops – rice, cotton, grapes, vegetables - all fluctuated but generally increased during the period.

While the number of both agricultural businesses and irrigation businesses declined in the MDB between 2005 and 2016, this largely reflected a national decline in these businesses implying that there were no specific MDB factors at play here. Nor was there evidence that this trend was associated with water prices or the water recovery program. Despite this decline in the number of agricultural businesses, the number of employed persons in MDB continued to increase over the period 1996-2011, and the unemployment rate in the MDB was lower than the national unemployment rate. However this increase in overall employment masked some significant shifts in the structure of the Basin's workforce. There was a distinct shift away from agricultural and manufacturing employment towards services such as health care, public administration and utilities. The decline in the agricultural workforce (12%) was not specific to the Basin – it was virtually the same as the 11% decline in the agricultural workforce, nationwide.

The MDB has also changed socially. Over the period 1996-2016, the population increased in the MDB but at a lower rate than the national population growth rate. However, the Basin's population growth was not evenly distributed, with the outer regional and remote parts of the Basin declining in absolute population, while the inner regional areas and major cities of the MDB increased between 2001 and 2011.[3] There was a small decline in the proportion of young people in the Basin (0-14 years) between the 2006 and 2016 censuses and a corresponding small increase in the proportion of older people (65+).

While these results show how the Basin as a whole fared, different Basin towns fared quite differently. Five towns – Deniliquin, Shepparton, Renmark, Griffith, and Moree – were examined. Three of these towns, Deniliquin, Moree and Renmark, experienced declines in population and economic activity, while the other two grew strongly. Deniliquin experienced the greatest decline, with the number of businesses almost halving between 2003 and 2015 with agriculture/forestry/fishing businesses being particularly hard hit with a decline from 498 to 128 over that period. Moree's population declined by 12% between 2000 and 2015 while its agricultural/forestry/fishing labour force dropped by 20% between 1996 and 2011. The Renmark district experienced only a small (6%) decrease in population between 2000 and 2015, although the labour force remained relatively stable. However, the number of agricultural/forestry/fishing businesses declined by 29% between 2003 and 2015, while other sectors (notably construction) increased, so that, overall, there was no significant change in the number of businesses.

While some towns experienced a decline in key indicators, Griffith and Shepparton showed growth in population and employment during the reporting period. Population increased by 8% in Griffith and 11% in Shepparton between 2000 and 2015, and the proportion of indigenous community also increased in both regions. There was an increasing trend in total employment in Griffith (17%) and Shepparton (12%) during the reporting period (2000-01 to 2014-15). In Griffith, there was a strong boost in employment in agriculture between 2012 and 2015 following a 7-year decline. By 2015, Griffith's agriculture sector had fully recovered and agriculture employed the highest number of people of all reported sectors. Strong growth in

[3] Outer regional and remote parts of the Basin were areas where geographic distance imposed a moderate to high restriction upon accessibility to goods, services and opportunities for social interaction, while inner regional areas and major cities were areas where geographic distance imposed minimal to some restrictions (ABS 2001).

total employment in Shepparton from 2002 to 2007 reflected growth in services sectors including health care, construction and education, despite a decline in agricultural employment. Ongoing growth in employment from 2007 to 2015 was mainly due to growth in services sectors (transport, postal and warehousing) and to a lesser extent in health and agriculture.

The decline in agricultural employment in Shepparton (20%, 2001-2015), Moree (20%, 1996-2011) and Renmark (25%, 2003-2013) was similar to that occurring nationally (20% decline) over that period, showing that this decline was not specific to the Basin. However, Deniliquin's drop in agricultural employment (75%) between 2003 and 2013 was far greater than the national reduction. Only Griffith showed an increase (42%, 2001-2015) in agricultural employment over the full period of record.

In spite of the decline in agricultural businesses and employment, all towns in our assessment, except Griffith and Renmark, showed increases in the values of agricultural production. In spite of the decline in the agricultural workforce in the Moree district, the gross value of agricultural production rose substantially between 2001 and 2011 from $513m to $912m, while the Deniliquin district, in spite of the population and business decline, saw the gross value of agriculture increase significantly between 2001 and 2011 from $11.2 million to $38.8 million following a drop to $6.1 million in 2006 during the Millennium drought. In the Shepparton district, the gross value of agricultural production increased by 50% during the 2001-2011 period, with most of the growth occurring in cropping. The value of agricultural production was relatively stable in the Griffith district during the 2001-2011 period, at about $290m. Renmark, whose economy is heavily dependent on irrigated orchards and vineyards, was the exception. Due to the sharp reduction in grape price from $546 per tonne in 2007-08 to a new floor of about $369 per tonne from 2008-2009, grapes production in Renmark experienced a downward trend between 2009 and 2013. Overall, the value of agricultural production dropped from $206m in 2001 to $141m in 2011.

There are a number of reasons for the different trajectories of these MDB towns and their associated districts. The 2007-08 drought seriously affected Deniliquin's rice industry, and this downturn exacerbated other pressures on the district including increased mechanisation of agriculture, and the closing of government agency offices in 2005. On the other hand, Griffith's population and employment increased over the same period, partly driven by the increase in local investment in the town. A younger population is attracted to Griffith due to large

employment bases, particularly the Bajada Group which is the Riverina's largest employer, the Riverina Institute of TAFE campuses, and the Regional University Study Centre which was established in 2004 in Griffith. Griffith has also experienced strong commercial growth with new shopping centre developments in recent years (Riverina Cities, 2015).

Shepparton, like Griffith, showed an increase in population and employment during the last 15 years. While the size of the agricultural workforce has fluctuated over the period it has remain relatively steady at about 2600 for the last 8 years. However, employment in health care and social assistance has increased significantly (over 30%) during the same period so that it is now notably larger than agricultural employment. There has also been a growth in government investment in public administration and services, while there are new employment opportunities in the district outside of the agricultural sector, such as the Shepparton Bypass project, the road-rail interchange at Mooroopna and additional production jobs at Unilever in Tatura.

The Renmark district has been severely affected by drop in grape prices and this impact has been exacerbated by prolonged drought and the operation of the Small Block Irrigators Exit Grant. Unlike Griffith and Shepparton, Renmark has not experienced a compensating increase in activity in non-agricultural sectors. Instead there has been a contraction in manufacturing and retail trade sectors.

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Appendix: List of variables

Agricultural commodity Producer price indexes: are the agricultural commodity prices indexes (aggregated for all crops and aggregated for all agriculture products with reference year 1997-98 =100)

Dummy variable for year 2006-07: is a dummy variable that takes value 1 for year 2006-07 and takes value 0 otherwise

Dummy variable for years 2006-07, 2007-08, 2008-09: is a dummy variable that takes value 1 for years 2006-07, 2007-08, 2008-09 and takes value 0 otherwise

Dummy variable for period 2007-2015: is a dummy variable that takes value 2 for the period 2007-2015 and takes value 0 for the period 2001-2006.

Water allocation price: is price per ML of water allocation ($/ML)

Water recovery from buybacks & infrastructure (GL): is the amount of water recovery under the government water buy-back program and the infrastructure water efficiency improvement program as established in the Water Act in 2007

Log of gross value of irrigated agricultural production: is the natural logarithm of the gross value of irrigated agricultural production in the MDB in 1997-98 price ($ million)

Log of gross value of agricultural production: is the natural logarithm of the gross value of total agricultural production in the MDB in 1997-98 price ($ million)

*Water use efficiency of irrigated agricultural production in the MDB***:** defined as the gross value of irrigated agricultural production in the MDB in 1997-98 price divided by the amount of water used for irrigation in the MDB **(**A$/ML)

*Water use efficiency of rice production***:** defined as the value of rice production in the MDB divided by the amount of water used for rice production in the MDB **(**A$/ML)

*Water use efficiency of cotton production***:** defined as the value of cotton production in the MDB divided by the amount of water used for cotton production in the MDB **(**A$/ML)

*Water use efficiency of vegetables production***:** defined as the value of vegetables production in the MDB divided by the amount of water used for vegetables production in the MDB **(**A$/ML)

Number of irrigating agricultural businesses: is the number of irrigating agricultural businesses in the MDB

Number of agricultural businesses: is the total number of agricultural businesses in the MDB

Water Extraction: is the amount of water extraction for consumptive use in the MDB (GL)

Water allocation announced: is the amount of water allocation in the MDB (GL)

Water storage in MDB (GL): is the amount of water storage at the end of the year in the MDB.