Irrigation technology and water use on farms in the Murray–Darling Basin

2006–07 to 2011–12

Dale Ashton and Mark Oliver

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Summary

As part of water policy reforms in recent years, the Australian Government has provided funds to help irrigators invest in more efficient and productive on-farm irrigation technologies. To monitor changes in irrigation technologies and water use, ABARES has collected and analysed data from irrigation farms in the Murray–Darling Basin since 2006–07.

The results of the analysis presented in this report show a move toward more efficient irrigation technologies in some industries (particularly citrus, wine grapes and vegetables). The survey results also show overall reductions in water application rates for many farms in the Murray–Darling Basin and within all commodity types, but these rates vary significantly from year to year. The time series are relatively short; this makes it difficult to separate changes in water use associated with adoption of new irrigation technologies from water use changes caused by year-to-year variations in factors such as seasonal conditions, water availability and market prices for water.

Farm investment

Investment in new on-farm irrigation infrastructure and other farm capital plays an important role in farm productivity and water use efficiency. Over the survey period, the proportion of irrigation farms making additions to total capital increased from 31 per cent in 2006–07 to 45 per cent in 2010–11 as farm incomes improved following better seasonal conditions. The proportion of farms making additions to irrigation capital ranged between 7 per cent and 12 per cent over the survey period; this partly reflects initial uptake of funds from government programmes directed at upgrading on-farm irrigation infrastructure. However, the extent of investment in new irrigation infrastructure differed by industry.

Survey results show that some horticulture farms have replaced older irrigation infrastructure with newer technologies. In 2010–11 an estimated 21 per cent of horticulture farms had on-farm irrigation infrastructure that was less than five years old, compared with only 9 per cent in 2006–07. In 2010–11, 15 per cent of horticulture farms had on-farm irrigation infrastructure that was older than 20 years, compared with 28 per cent in 2006–07.

While some broadacre farms replaced older infrastructure with newer technologies, replacement has occurred at a much slower rate than for horticulture farms. For dairy farms, widespread replacement of irrigation infrastructure has not occurred to the same extent as for horticulture or broadacre farms. Feedback from workshops conducted by ABARES and Dairy Australia in 2013 (Ashton et. al forthcoming) indicated that many dairy farmers were seeking to improve water use efficiency by making better use of existing infrastructure rather than investing in new infrastructure. The survey results show that in 2010–11 an estimated 6 per cent of dairy farms had on-farm irrigation infrastructure that was less than five years old, compared with 9 per cent in 2006–07; however, little change was noted in the proportion of farms with infrastructure older than 20 years.

Irrigation systems and water use

The most commonly used irrigation systems in each year were flood/furrow and drip/trickle irrigation systems, accounting for 57 per cent and 19 per cent of farms respectively in 2011–12. In the same period, smaller proportions of irrigators used other types of systems, including travelling irrigators (11 per cent), low throw sprinklers (9 per cent), overhead sprinklers (3 per cent), micro-spray systems (4 per cent) and moveable spraylines (2 per cent). Some farms used more than one type of irrigation system.
Flood/furrow systems were most commonly used by broadacre and dairy farms. Drip/trickle and low-throw systems were the most common systems on many horticulture farms, while micro-systems, overhead sprinklers and flood/furrow were also important on many farms.

Between 2006–07 and 2011–12 the proportion of horticulture farms using drip/trickle systems increased, while fewer horticulture farms used flood/furrow or overhead sprinkler systems. For other industries (such as rice and cotton), changes to technologies include better water metering and soil moisture monitoring tools rather than changes in water application methods.

Year-to-year changes in the proportion of irrigators using various systems were also partly the result of changes in the area of crops irrigated and the availability of water. For example, the proportion of irrigators using flood/furrow systems fell in 2007–08 and 2008–09 because of reduced cotton and rice production on broadacre farms, but rose sharply in subsequent years as more water was available and the area planted to rice and cotton increased.

At the basin scale, from 2006–07 to 2011–12, the highest average water application rates were for low throw sprinklers and micro-systems, while travelling irrigators and moveable spray lines had the lowest average rates. For each irrigation system, variations in average water application rates over time were affected by several factors (including seasonal conditions, water availability, traded water prices and changes in the cropping mix). While the results vary slightly by industry, average water application rates tended to decline over the survey period for the major irrigation systems used in each industry.
1 Introduction

The Australian irrigation sector has undergone a gradual process of change since the 1980s that has influenced patterns of investment in on-farm irrigation infrastructure. For many irrigators, initial investments were made when water for irrigation was relatively plentiful and available at low cost. However, prolonged drought and stressed river and groundwater systems in the Murray–Darling Basin over the past decade heightened awareness of the need for irrigators to use water more efficiently.

Through programmes such as the On-Farm Irrigation Efficiency Program (OFIEP), the Northern Victoria Irrigation Renewal Project (on-farm) and the Private Irrigation Infrastructure Program for South Australia, the Australian Government provided funds to help irrigators invest in more efficient on-farm irrigation technologies. An aim of these programmes was to help modernise on-farm irrigation technology, making irrigation more efficient and productive (DSEWPaC 2012). For example, the OFIEP helped irrigators install new water meters, convert flood irrigation to sprinklers and drip systems and install soil moisture monitoring equipment (DSEWPaC 2012).

In 2010 the Department of Environment (DOE) commissioned ABARES to monitor irrigation technologies, water use and farm productivity as part of the annual survey of irrigation farms in the Murray–Darling Basin.

Information was collected from surveyed farms on their irrigation water use by crop, water application technology and investment in on-farm irrigation infrastructure. These data allow regional and industry percentages and averages to be determined; they also capture and allow interpretation of farm level variations.

Preliminary results for 2006–07 to 2009–10 were included in the ABARES report Responding to change: irrigation in the Murray–Darling Basin (Ashton & Oliver 2012). Building on analysis in that report, further detailed analysis has been undertaken using an additional two years of survey data to 2011–12.

This report addresses two key issues:

- monitoring changes in irrigation technologies
- examining changes in the water use efficiency of farms.

The results of the analysis show a move in some industries (particularly citrus, wine grapes and vegetables) toward irrigation technologies that have resulted in reduced average water application rates. While results vary by industry, average water application rates tended to decline for the major irrigation systems used in each industry. The survey results also show that from 2006–07 to 2010–11 total factor productivity of irrigated farms in the Murray–Darling Basin rose on average.
2 Farm investment

Investment in farm capital (in the form of land, fixed structures, livestock, plant and equipment) is a key component of agricultural production. It is important to all aspects of farm business management, including financial performance, production efficiency and farm productivity. Farmers combine capital items with other farm inputs, such as labour, fertiliser and irrigation water to produce a range of agricultural outputs. Many factors influence the returns on these capital investments, including initial and ongoing costs, quantity of output produced, prices received for outputs and prices paid for inputs.

New investments typically allow farmers to replace capital items that have deteriorated and/or outlived their useful life with newer items. Most investments—particularly those in land and fixed on-farm infrastructure—are usually made with longer-term outcomes in mind and based on expected returns over the life of the investment.

A farmer’s motivation to make new investments is influenced by factors affecting relative net returns from the alternative options available, expectations about future profitability, existing debt and debt servicing requirements, farm business liquidity and access to non-farm income. Government assistance can also affect investment behaviour by making additional funds available and, in some cases, bringing forward the timing of new investments.

In making investment choices, a farmer would most likely invest in activities that offer the greatest capacity to contribute to productivity improvements and, hence, farm profitability. However, a farmer’s investment behaviour is also influenced by the indivisible nature of many farm investments, particularly where costs are irreversible and returns are uncertain. Some irrigation investments, such as installing drip irrigation systems, involve large and irreversible capital investments where the returns are generated over many years and returns or benefits are uncertain. Uncertainty, irreversibility and the indivisibility of many investments may lead to farmers delaying the timing of new investments (McClintock 2010).

In addition, a farmer’s decision to invest in new irrigation technology depends on the trade-off between the present value of water, water conservation benefits of the new technology, and costs associated with implementing the technology change. In determining water conservation benefits, the price of water becomes a critical factor. In general, other input costs being held constant, the higher the price of water the greater the value of water savings and, hence, the greater the incentives to invest in water saving measures.

Investments that involve adoption of new technologies often occur when the business is approaching or has reached a critical limit in capacity. For such investments, technologies that are perceived as being risky are less likely to be adopted because risk reduces the expected benefits from adoption (Morrison, Oczkowski & Greig 2011). In some cases, delaying an investment in order to wait for additional information about a project’s returns can avoid losses; for example, where uncertainty exists about future traded water prices. It can be worthwhile for an individual to delay adoption where an avoided loss is greater than the profit forgone by waiting (McClintock 2010).

Changes in irrigation management practices, such as monitoring water needs and scheduled watering, can also lead to gains in water use efficiency. Implementing such changes often costs less than making investments in irrigation infrastructure. As a consequence, some irrigators will implement changes to management practices before making large infrastructure investments.
New investment

The proportion of irrigation farms making additions to total capital fluctuated from year to year, ranging from 31 per cent in 2006–07 to 45 per cent in 2010–11 (Figure 1). On average, investment per farm increased over the period, particularly in 2010–11, as farm incomes improved in response to better seasonal conditions. Most of the increase in capital investment per farm in 2010–11 was for purchases of land.

The proportion of farms making additions to irrigation capital ranged from 7 per cent in 2009–10 to 12 per cent in 2010–11 (Figure 1). On average, farms making investments added over $80 000 in new irrigation capital per farm in most years (Figure 2).

![Figure 1 Percent of irrigation farms making capital additions, Murray–Darling Basin average per farm](image)

Source: ABARES survey of irrigation farms in the Murray–Darling Basin
New investment in fixed irrigation infrastructure accounted for around 5 per cent of the average opening value of irrigation capital over the period. Several farms in the survey made new investments in on-farm irrigation infrastructure that were significantly higher than the opening value of their irrigation capital. Many of these farms appear to have completely replaced existing irrigation systems with newer technologies.

By state, New South Wales had the highest proportion of farms making additions to irrigation capital in each year (Table 1). However, in most years, average investment per farm tended to be lower for New South Wales than Queensland and Victoria (Figure 3).

By region, the proportion of farms making additions to irrigation capital in each year varied little, although the average amount invested varied from year to year. In 2010–11 the largest average irrigation capital investments per farm were made by irrigators in the northern regions of the basin (Condamine–Balonne, Border Rivers, Namoi, Macquarie–Castlereagh and Lachlan).

Table 1 Irrigation farms adding irrigation capital, Murray–Darling Basin

<table>
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<tbody>
<tr>
<td>New South Wales</td>
<td>%</td>
<td>20</td>
<td>18</td>
<td>14</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>Victoria</td>
<td>%</td>
<td>3</td>
<td>11</td>
<td>8</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Queensland</td>
<td>%</td>
<td>2</td>
<td>13</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>South Australia</td>
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<td>4</td>
<td>16</td>
<td>10</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Murray–Darling Basin</td>
<td>%</td>
<td>20</td>
<td>18</td>
<td>14</td>
<td>9</td>
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</tr>
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</table>

Source: ABARES survey of irrigation farms in the Murray–Darling Basin
Farm performance and investment

Changes that have been observed in total farm investment over the survey period are related to changes in farm incomes, farm business debt, off-farm income and government assistance.

The survey data show a small positive relationship between farm investment and financial performance (based on rate of return excluding capital appreciation). This suggests that irrigators are more likely to make new investments during times of better farm financial performance because of greater capacity to service new debt and/or availability of surplus funds. Expectations of future profitability also influence investment decisions. In times of poorer farm financial performance, irrigators are more likely to take on additional short-term debt to cover farm working capital than make longer-term farm investments.

Farm cash income

Farm cash income—defined as total cash receipts minus total cash costs—is a measure of farm cash flow. Farm incomes (which tend to vary considerably from year to year as a result of various factors) influence the ability of farmers to service new and existing debt and, subsequently, the ability to make new farm investments. At a basin scale, farm incomes for irrigated broadacre farms improved markedly in 2010–11 and 2011–12. However, financial performance for horticulture and dairy farms was mixed, improving in 2010–11 before declining in 2011–12.

Farm business debt

Financial institutions that lend to farm businesses take into account the capacity of the business to service debt and the equity (or security) farmers have in their business. Farm business equity is the value of owned capital less farm business debt. In the context of farm investment
decisions, farm equity indicates the degree of debt overhang that might influence a farmer's ability to obtain additional debt for making new capital investments.

Despite increases in farm debt on average over the five years to 2011–12, farm business equity has remained strong for irrigation farms, consistently averaging around 82 per cent as higher values for agricultural land and permanent water access entitlements offset increases in debt. However, results have been mixed for individual farms across the Murray–Darling Basin. By industry, equity ratios for dairy farms increased between 2006–07 and 2010–11 but fell slightly for irrigated broadacre and horticulture farms.

**Off-farm income**

Off-farm income plays an important role in farm investment decisions by boosting farm cash incomes. The survey results show that most irrigation farms in the Murray–Darling Basin had some form of off-farm income, including wages and salaries, off-farm sharefarming, government assistance and non-farm investments. Average off-farm income for irrigation farms increased each year from 2006–07 to 2011–12. Increases in average off-farm income were particularly important in the context of declines in average farm cash incomes across the basin in 2008–09 and 2009–10. When off-farm income is taken into account, total farm family income (farm cash income plus off-farm income) rose in 2009–10 on average, whereas farm cash income declined.

However, off-farm income was found to have a negative relationship with farm investment as those irrigators with higher off-farm income made fewer new investments in on-farm irrigation infrastructure over the survey period.

**Asset fixity**

The presence of fixed irrigation capital may be an impediment to the rate of adoption of new irrigation technologies. Irrigators typically have significant investments in on-farm irrigation infrastructure that have little or no salvage value. If these fixed investments have not reached the end of their economic life, an irrigator may have limited economic incentive to adopt new irrigation technologies. Consequently, the age distribution of existing irrigation infrastructure is important in understanding the timing and extent to which irrigators might invest in new technologies.

A fixed asset has three important characteristics: a purchase price, an economic value and a salvage value. When considering an investment, growers compare the value of an additional asset with the purchase price; the value of an additional asset is determined by the private benefit the asset provides over its lifetime—the economic value—plus its salvage value. For disinvestment (selling or removing assets), the grower compares the present value of the remaining cash flow of the asset in use with its salvage value. In some cases, the salvage value could actually be negative if, for example, unused on-farm infrastructure needs to be removed. An irrigator's decision to invest depends on the difference between the total value (economic value plus salvage value) and the purchase price.

In 2010–11, across the Murray–Darling Basin, an estimated 10 per cent of irrigators had on-farm irrigation infrastructure less than five years old, compared with 44 per cent of farms that had infrastructure older than 20 years (Figure 4).

This is important for public policy because on-farm irrigation infrastructure and assets typically have long life cycles (often more than 20 years) and have little or no salvage value. If the asset has not reached the end of its productive period, an irrigator will have an incentive to delay making a new investment.
Several horticulture farms in the survey had replaced older infrastructure with newer technologies. In 2010–11 an estimated 21 per cent of horticulture farms had on-farm irrigation infrastructure that was less than five years old, compared with only 9 per cent in 2006–07 (Figure 5). The proportion of horticulture farms with on-farm irrigation infrastructure that was more than 20 years old had dropped to 15 per cent in 2010–11, compared with 28 per cent in 2006–07.

While some broadacre farms have replaced older infrastructure with newer technologies, replacement has occurred at a much slower rate than for horticulture farms and the differences between estimates for 2006–07 and 2010–11 are not statistically significant. In 2006–07 and 2010–11 around 10 per cent of horticultural farms had on-farm irrigation infrastructure that was less than five years old (Figure 6). In contrast, in 2010–11 an estimated 46 per cent of broadacre farms had on-farm irrigation infrastructure that was more than 20 years old.
For dairy, in 2010–11 an estimated 6 per cent of farms had on-farm irrigation infrastructure that was less than five years old (Figure 7). The proportion of dairy farms with on-farm irrigation infrastructure that was more than 20 years old was around 55 per cent in 2006–07 and 2010–11. Replacement of irrigation infrastructure on dairy farms has not been occurring at the same rate as horticulture or broadacre farms. Anecdotal evidence from workshops conducted by ABARES and Dairy Australia in 2013 (Ashton et al. 2013) suggests that, rather than replacing or upgrading infrastructure, many dairy farmers are seeking to improve water use by adjusting existing infrastructure (for example, by using soil moisture monitoring to manage water applications). This is partly a result of the variability of dairy farm incomes over the survey period and lower average rates of return relative to those of horticulture or broadacre farms. Combined with the flexibility to substitute fodder grown on farm with off-farm purchases, these
factors mean dairy farmers have not faced the same economic incentives to upgrade irrigation infrastructure as horticulture or broadacre producers.

Figure 7 Age of fixed on-farm irrigation infrastructure, dairy farms

By state, in 2010–11 Victoria had the highest proportion of farms with relatively new irrigation capital (less than five years) and the lowest proportion with relatively old capital (more than 20 years). Within Victoria, the Murray region had the highest proportion of farms with relatively new irrigation capital (29 per cent) (Figure 8). In contrast, only 10 per cent of farms in the Goulburn–Broken region and 6 per cent in the Loddon–Avoca region had relatively new irrigation capital in 2010–11.

For New South Wales, the results differed significantly across the regions. The Murrumbidgee region had the highest proportion of farms with new irrigation capital (28 per cent), while the other regions had relatively low proportions. The New South Wales Murray (68 per cent) and Namoi (51 per cent) regions had relatively high proportions of farms with old capital. The two Queensland regions (Border Rivers and Condamine–Balonne) had relatively low proportions of farms with old and new capital (around 10 per cent each) compared with cotton growing regions in New South Wales (3 per cent for Namoi and 4 per cent for Macquarie–Castlereagh).

South Australia also had relatively low proportions of farms with new irrigation capital (7 per cent and 6 per cent for South Australian Murray and Eastern Mount Lofty Ranges respectively).
Figure 8 Age of fixed on-farm irrigation infrastructure, by region, 2010–11

Source: ABARES survey of irrigation farms in the Murray–Darling Basin
3 Irrigation systems and water use

Irrigation technologies

As part of the ABARES survey of irrigation farms, data were collected on the types of irrigation systems used for each crop type (Box 1). The survey results presented in this chapter should be viewed in the context of varying seasonal conditions and subsequent changes in water availability prevailing over the survey period (Box 2). Overall, various irrigation systems were used throughout the Murray–Darling Basin and some farms used more than one system.

Box 1 Irrigation systems

The ABARES survey of irrigation farms in the Murray–Darling Basin included a set of questions on farmers’ use of various types of irrigation systems, comprising:

**Flood/furrow**—including bay, border check, bankless channel and siphon irrigated furrow systems.

**Fixed sprinklers**—an arrangement of fixed pipelines with sprinklers mounted on risers of varying height. The ABARES survey categorised fixed sprinkler systems into overhead sprinklers (sprinklers mounted on risers above a tree canopy or crop) and low throw sprinklers (sprinklers closer to ground level).

**Micro-jet sprinklers and drip/trickle**—apply water above or below the soil surface at low flow rates in the form of droplets and miniature streams or sprays. The emitting devices include tape, tricklers, pulsators, micro-sprinklers, micro-sprayers and micro-jets.

**Travelling irrigators**—comprise centre-pivot, linear or lateral move and travelling gun systems. Centre-pivot irrigators consist of a single pipeline (lateral) of varying length supported by a truss network (towers). The self-propelled towers/lateral rotates around a pivot in the centre of an irrigation circle. Linear or lateral move systems resemble centre-pivots except that they move in a continuous straight path across a paddock. Travelling gun systems consist of either a large gun sprinkler or a boom spray unit mounted on a wheel or trailer and connected to a flexible hose on a reel.

**Moveable spray lines**—include hand-move sprinkler systems and side-roll sprinkler systems. Hand-move systems involve moving lightweight pipelines manually from one position to another. Side-roll systems resemble hand move systems except that wheels are attached to the pipeline, allowing it to be rolled from one position to another.

An irrigator’s choice of irrigation system depends on many factors, including farm topography, crop type, water quantity and quality, on-farm water storage capacity, labour and financial resources, total area irrigated and existing infrastructure. These factors, combined with water availability, water cost and prevailing seasonal conditions, influence the volume of water used for irrigation each year. Consequently, annual changes in measures of water use efficiency, such as megalitres of water applied per hectare, are likely to be the result of changes in a range of variables.
The first three years of the survey (2006–07 to 2008–09) were among the driest on record for the southern Murray–Darling Basin, characterised by severe drought and historically low water allocations (Map 1). As a consequence of low inflows to many river systems, the volume of water held in major storages was among the lowest ever recorded. As a result, irrigation water allocations were significantly reduced and diversions of water for irrigation fell from almost 8800 gigalitres in 2005–06 to little more than 4600 in 2006–07 (Figure 9).

Finally, toward the end of 2009, a La Niña weather event brought above average rainfall to much of the Basin. Seasonal conditions and water availability were much improved with above average rainfall being recorded across most of the Basin in 2009–10 and 2010–11. By 2011 most major water storages in the Basin approached 100 per cent capacity and water allocations to most irrigators were at or near 100 per cent. In 2011–12 seasonal conditions remained favourable, with above average rainfall across the Murray–Darling Basin.

Figure 9 Irrigation diversions and selected water allocations

Note: Murrumbidgee allocations are for general security water and include any additional allocations made by Murrumbidgee Irrigation Ltd. Goulburn allocations are for high reliability water shares.

Sources: Goulburn–Murray Water (GMW 2012); Murray–Darling Basin Authority (MDBA 2012); Murray–Darling Basin Commission (MDBC 2008); Murrumbidgee Irrigation Ltd (2012)
Map 1 Rainfall deciles 2006–07 to 2011–12, Murray-Darling Basin

Source: Australian Bureau of Meteorology
Use of irrigation systems

The survey results for farms that irrigated show that the most commonly used irrigation systems in each year were flood/furrow and drip/trickle irrigation systems. In 2011–12 flood/furrow systems accounted for 57 per cent and drip/trickle irrigation systems for 19 per cent of farms. In the same period, smaller proportions of irrigators used other types of systems, including travelling irrigators (11 per cent), low throw sprinklers (9 per cent), overhead sprinklers (3 per cent), micro-spray systems (4 per cent) and moveable spraylines (2 per cent).

Flood/furrow systems were most commonly used by broadacre and dairy farms (Figure 10). Between 2006–07 to 2011–12 at least 70 per cent of these farms used flood/furrow irrigation. A much smaller proportion of broadacre and dairy farms also used moveable spraylines and travelling irrigators.

Figure 10 Main irrigation systems, by industry, Murray–Darling Basin

![Graph showing the percentage of farms using different irrigation systems over the years]

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

While drip/trickle and low-throw systems were the most common irrigation systems on horticulture farms, micro-systems, overhead sprinklers and flood/furrow were still important on many farms (Figure 10). Survey results suggest that between 2006–07 and 2011–12 the proportion of horticulture farms using drip/trickle systems increased, while fewer horticulture farms used flood/furrow or overhead sprinkler systems.

Year-to-year changes in the proportion of irrigators using various systems were partly the result of changes in the area of crops irrigated and the availability of water. For example, in 2007–08 and 2008–09 the proportion of irrigators using flood/furrow systems fell because of reduced cotton and rice production on broadacre farms. Many of these farms did not irrigate at all during this period because of low water availability and relatively high prices for traded water allocations. As seasonal conditions and water availability improved, the number and proportion
of broadacre farms using flood/furrow systems to irrigate cotton and rice increased from 2009–10 to 2011–12.

The share of total area irrigated and total water used for some irrigation systems differed substantially from the share of farms using each system. For example, flood/furrow systems were used by 57 per cent of farms but accounted for 78 per cent of the total area of crops and pasture irrigated and 80 per cent of the total water used in 2011–12. In contrast, the 12 per cent of farms using drip/trickel systems in 2011–12 each accounted for 5 per cent of water used and total area irrigated.

**Water application rates**

For each irrigation system in Box 1, average water application rates (Box 3) vary over time in response to factors such as seasonal conditions, water availability, water price and changes in cropping mix. While results vary slightly by industry, average water application rates tended to decline for the major irrigation systems used in each industry over the survey period.

**Box 3 Water application rates and water use efficiency defined**

Several definitions of water use efficiency are useful to decision-makers, depending on the purpose and data available. At an individual crop level, water use efficiency usually refers to the proportion of irrigation water applied that is used by plants. Such a measure is useful for irrigators to monitor the relative efficiency of individual crops and for making management decisions such as timing and extent of irrigation water applications. However, reliable data on water use efficiency are not usually readily available.

An alternative is to measure the quantity of irrigation water applied to crops or pasture. Water application rate (expressed in megalitres per hectare) is a broader measure than water use efficiency, but it has one advantage: changes in water application rates will reflect changes in water use efficiency for individual crops and data are more readily available at a whole farm level.

Water use efficiency can be improved through various measures such as on and off-farm infrastructure and management practices. Off-farm, repair of irrigation channels or replacement with piping can significantly reduce delivery losses. On-farm, land forming can improve efficiency of flood irrigation. Less efficient irrigation methods such as flood and overhead sprinklers may be replaced with more efficient technologies such as drip irrigation. Efficiency gains may also be made through improvements to management practices, such as better scheduling or timing of irrigation water applications.

Irrigators undertaking investment in water use efficiency improvement will benefit from the water savings that result from using less water to achieve the same level of production. These savings can then be used in three ways: the irrigator can retain them and increase revenue by expanding the area irrigated, an irrigator may be able to sell the savings on the market or the savings can be left in the river.

At the basin scale, from 2006–07 to 2011–12 the highest average water application rates by irrigation system were for low throw sprinklers and micro-systems. Flood/furrow systems were used for a variety of crops and pasture, ranging from relatively high water application rates for rice to low application rates for some tree crops. Consequently, flood/furrow systems had lower average application rates than low throw sprinklers or micro-systems. The lowest averages for the period were for travelling irrigators and moveable spray lines, each at around 2.3 megalitres per hectare (Table 2). Within each irrigation system, average water application rates varied widely by type of crop (Figure 11). Further analysis of water use and irrigation systems, by commodity and farm type, is provided in the section on horticulture farms.
Table 2 Water application rate, by irrigation system, Murray–Darling Basin

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</thead>
<tbody>
<tr>
<td>Flood/furrow</td>
<td>ML/ha</td>
<td>3.4</td>
<td>2.7</td>
<td>2.7</td>
<td>2.8</td>
<td>4.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Overhead sprinklers</td>
<td>ML/ha</td>
<td>6.2</td>
<td>4.0</td>
<td>5.0</td>
<td>3.1</td>
<td>3.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Low throw sprinklers</td>
<td>ML/ha</td>
<td>6.0</td>
<td>6.1</td>
<td>7.2</td>
<td>7.5</td>
<td>6.4</td>
<td>7.6</td>
</tr>
<tr>
<td>Micro-systems</td>
<td>ML/ha</td>
<td>6.3</td>
<td>4.1</td>
<td>5.3</td>
<td>4.3</td>
<td>4.8</td>
<td>5.4</td>
</tr>
<tr>
<td>Drip/trickle</td>
<td>ML/ha</td>
<td>4.0</td>
<td>4.3</td>
<td>4.8</td>
<td>4.6</td>
<td>4.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Travelling irrigators</td>
<td>ML/ha</td>
<td>2.4</td>
<td>2.0</td>
<td>3.0</td>
<td>2.6</td>
<td>2.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Moveable spray lines</td>
<td>ML/ha</td>
<td>2.4</td>
<td>1.4</td>
<td>1.1</td>
<td>2.5</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Murray–Darling Basin</td>
<td>ML/ha</td>
<td>3.5</td>
<td>3.0</td>
<td>3.2</td>
<td>3.0</td>
<td>4.1</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Note: Water application rate is total volume of water applied per hectare irrigated.
Source: ABARES survey of irrigation farms in the Murray–Darling Basin

Figure 11 Water application rate, by system and commodity, Murray–Darling Basin

From 2006–07 to 2011–12, systems most commonly used by horticulture farms—low throw sprinklers, travelling irrigators, moveable spraylines and micro-systems—had the lowest variation in water application rates across all farms. This result partly reflects the more regular watering needs of permanent horticultural plantings and the higher reliability water entitlements held by horticulture farms. Because tree and vine crops require regular watering and particular crops have the same water requirements regardless of location, the volume of water applied per hectare tends to be similar across all farms for each crop.
In contrast, flood/furrow and overhead sprinkler systems had higher variation in water application rates across the period. Greater differences in water requirements for individual crops—such as rice, cotton, wheat and pasture—and changes in water availability over the period were the main reasons for the greater variation observed for these systems. Broadacre crops and pasture provide much greater scope for variation in water application rates. This is because water availability and soil types tend to vary more across broadacre farms than horticulture farms. Also, broadacre and dairy farmers have greater scope to vary their water applications according to circumstances; their crops and pasture do not require regular water, unlike horticulture crops such as trees and vines. As a consequence, broadacre and dairy farms recorded greater variability in water application rates.

Horticulture farms

Horticulture industry farms range from specialist growers of just one or two horticulture crop types to those that grow a variety of horticulture and other crops. Reflecting this diversity of crop types, the horticultural industry used a greater range of irrigation systems than the broadacre or dairy industries.

With relatively small areas irrigated, horticulture farms tend to use a variety of irrigation systems that suit the intensive nature of most horticulture crops. Drip/trickle systems and low throw sprinklers were the most commonly used water application systems by horticulture farms in the Murray–Darling Basin.

Vegetables

Vegetable growers used a variety of irrigation systems, with the more common being drip/trickle, travelling irrigators, overhead sprinklers and moveable spraylines (Figure 12).

Figure 12 Main irrigation systems, vegetable farms, Murray–Darling Basin

The proportion of vegetable growers using travelling irrigators and moveable spraylines combined increased from around 14 per cent in 2006–07 to 41 per cent of farms in 2011–12.
Survey results suggest the change toward travelling irrigators and moveable spraylines was largely at the expense of fixed overhead sprinklers. The proportion of vegetable growers using fixed overhead sprinklers declined from 27 per cent in 2006–07 to 5 per cent in 2011–12.

The average area of vegetable crops irrigated per farm in 2011–12 was 131 per cent higher than in 2006–07, while the average volume of water used per farm was 65 per cent higher (Table 3). Consequently, the average volume of water used per hectare for vegetable growers in 2011–12 was 28 per cent lower than in 2006–07. Water application rates were lower for vegetable growers using travelling irrigators (down by 40 per cent), drip/trickle (down by 25 per cent), and flood/furrow systems (down by 59 per cent) (Figure 13). While average application rates for moveable spraylines appear to have risen over the survey period, low application rates in 2006–07 and 2008–09 most likely reflect the effect of drought on water availability for these farms. In the remaining years, average water application rates for moveable spraylines were similar to rates applied to vegetables using other irrigation systems.

Table 3 Area irrigated and water used, vegetable farms, Murray–Darling Basin

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<tbody>
<tr>
<td>Area of vegetables</td>
<td>ha</td>
<td>18</td>
<td>25</td>
<td>27</td>
<td>41</td>
<td>37</td>
<td>41</td>
</tr>
<tr>
<td>Volume of water</td>
<td>ML</td>
<td>88</td>
<td>113</td>
<td>122</td>
<td>163</td>
<td>128</td>
<td>146</td>
</tr>
<tr>
<td>Water application</td>
<td>ML/ha</td>
<td>4.9</td>
<td>4.6</td>
<td>4.5</td>
<td>4.0</td>
<td>3.4</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

Reflecting these changes, between 2006–07 and 2011–12, the proportion of vegetable farms using less than 4 megalitres per hectare increased (Figure 14). The small increase in the proportion of farms using more than 8 megalitres per hectare appears to be the result of some farms making greater use of micro-sprays in intensive year-round production systems.
Citrus

In 2011–12 most citrus farms were using drip/trickle and low–throw sprinklers. Together, these systems accounted for around 86 per cent of citrus farms, 86 per cent of water used on citrus and 84 per cent of total area of citrus irrigated. Drip/trickle systems accounted for 53 per cent of the total area of citrus trees irrigated and 52 per cent of the total water used on citrus trees. Low throw sprinklers accounted for 31 per cent of the area of citrus trees irrigated and 34 per cent of water used on citrus. Between 2006–07 and 2011–12 the proportion of citrus farms using drip/trickle systems increased, while the proportion using flood/furrow systems declined from 20 per cent in 2006–07 to 8 per cent in 2011–12 (Figure 15).
The average area of citrus crops irrigated per farm in 2011–12 was 59 per cent higher than in 2006–07 (Table 4), although the total area of citrus across the whole Basin declined slightly as some smaller citrus farms removed trees or exited the industry. The average volume of water used per farm in 2011–12 was 41 per cent higher than in 2006–07, while average water application rates per hectare were 11 per cent lower than in 2006–07. Water application rates trended down for citrus growers using overhead sprinklers and low throw sprinklers, although rates fluctuated from year to year (Figure 16).

Changes in distribution of farms by water application rate over the survey period show a slight increase in the proportion of farms using less than 6 megalitres of water per hectare and slightly fewer farms with relatively higher water application rates of more than 6 megalitres per hectare (Figure 17).

### Table 4 Area irrigated and water used, citrus farms, Murray–Darling Basin

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</thead>
<tbody>
<tr>
<td>Area of citrus irrigated</td>
<td>ha</td>
<td>12</td>
<td>16</td>
<td>18</td>
<td>19</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>Volume of water used</td>
<td>ML</td>
<td>84</td>
<td>92</td>
<td>129</td>
<td>142</td>
<td>104</td>
<td>117</td>
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<tr>
<td>Water application rate</td>
<td>ML/ha</td>
<td>7.2</td>
<td>5.7</td>
<td>7.1</td>
<td>7.4</td>
<td>5.5</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

### Figure 16 Water application rates, citrus, Murray–Darling Basin

Source: ABARES survey of irrigation farms in the Murray–Darling Basin
Figure 17 Distribution of citrus farms, by water application rate

percent of farms

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

Stone fruit

Stone fruit farms also shifted toward more water efficient technologies such as drip/trickle systems. Between 2006–07 and 2011–12 the proportion of stone fruit growers using drip/trickle increased. The proportion of stone fruit farms using other systems declined over the period (Figure 18).

Figure 18 Main irrigation systems, stone fruit farms, Murray–Darling Basin

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

The pattern of use of systems was reflected in trends in the proportion of water used and area irrigated. In 2011–12 drip/trickle systems accounted for 64 per cent of the total area of stone fruit trees irrigated and 57 per cent of the total water used on stone fruit. Micro-sprays
accounted for 25 per cent of the area of stone fruit trees irrigated and 25 per cent of water used on stone fruit.

The average area of stone fruit crops irrigated per farm in 2011–12 was 132 per cent higher than in 2006–07 (Table 5). The average volume of water used per farm in 2011–12 was 48 per cent higher than in 2006–07, while average water application rates were 36 per cent lower. Average water application rates declined for all types of irrigation system used by stone fruit farms, with drip/trickle declining by 15 per cent, micro-spray by 35 per cent and low throw sprinklers by 50 per cent (Figure 19).

Table 5 Area irrigated and water used, stone fruit farms, Murray–Darling Basin

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<tbody>
<tr>
<td>Area of stone fruit</td>
<td>ha</td>
<td>6</td>
<td>10</td>
<td>7</td>
<td>12</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>irrigated</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume of water used</td>
<td>ML</td>
<td>31</td>
<td>38</td>
<td>33</td>
<td>46</td>
<td>44</td>
<td>45</td>
</tr>
<tr>
<td>Water application rate</td>
<td>ML/ha</td>
<td>5.4</td>
<td>3.9</td>
<td>4.7</td>
<td>3.8</td>
<td>3.2</td>
<td>3.5</td>
</tr>
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</table>

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

Figure 19 Water application rates, stone fruit farms, Murray–Darling Basin average per farm

Source: ABARES survey of irrigation farms in the Murray–Darling Basin
The proportion of stone fruit farms applying lower volumes of water per hectare increased markedly (Figure 20), reflecting the reductions in average water application rates per hectare for each irrigation system.

Figure 20 Distribution of stone fruit farms, by water application rate proportion of farms

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

**Pome fruit**

Pome fruit farms most commonly used drip/trickle, low throw sprinklers and micro-spray systems. Between 2006–07 and 2011–12 the proportion of pome fruit farms using low throw sprinklers or micro-spray systems increased, while the proportion using other systems (mainly drip/trickle) declined (Figure 21).

The proportion of pome fruit growers using various systems was reflected in the contribution of each system to total water use and area of pome fruit irrigated. In 2011–12 micro-spray systems accounted for 52 per cent of the total area of pome fruit trees irrigated and 58 per cent of the total water used on pome fruit. In the same period, drip/trickle systems accounted for 25 per cent of the area of pome fruit trees irrigated and 18 per cent of water used on pome fruit. Low throw fixed sprinklers accounted for 9 per cent of the area of pome fruit trees irrigated and 14 per cent of water used (Figure 22).

The average area of pome fruit crops irrigated per farm in 2011–12 was 31 per cent higher than in 2006–07, while the average volume of water used per farm was 40 per cent higher in 2011–12 than in 2006–07 (Table 6). Average water application rates for micro-spray and low throw sprinklers varied over the survey period. The average water application rate for micro-spray systems trended downward. Application rates for low throw sprinklers fell sharply in 2008–09, largely in response to reduced water availability relative to the previous year, but rose in subsequent years. Average water application rates for drip/trickle systems remained relatively steady over the survey period apart from a low rate recorded in 2006–07 (Figure 23).
Table 6 Area irrigated and water used, pome fruit farms, Murray–Darling Basin

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<tbody>
<tr>
<td>Area of pome fruit irrigated</td>
<td>ha</td>
<td>12</td>
<td>15</td>
<td>11</td>
<td>13</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Volume of water used</td>
<td>ML</td>
<td>39</td>
<td>54</td>
<td>36</td>
<td>44</td>
<td>52</td>
<td>55</td>
</tr>
<tr>
<td>Water application rate</td>
<td>ML/ha</td>
<td>3.3</td>
<td>3.6</td>
<td>3.2</td>
<td>3.3</td>
<td>3.0</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

Figure 21 Irrigation systems, pome fruit, Murray–Darling Basin

Distribution of pome fruit farms by water application rate shows fewer farms with relatively higher water application rates (more than 8 megalitres per hectare) in 2011–12 than in 2006–07 (Figure 23).
Wine grapes

Most wine grape farms in all years used a drip/trickle system for irrigating their wine grape crops—77 per cent of farms in 2011–12 compared with 57 per cent in 2006–07. This reflects corresponding increases in the proportions of water used and area of wine grapes irrigated with drip/trickle systems. These systems accounted for 93 per cent of the total area of wine grapes irrigated and 91 per cent of the total water used on wine grapes in 2011–12 (Figure 24). The proportion of wine grape growers using other sprinkler systems declined between 2006–07 and 2011–12.
The average area of wine grape crops irrigated per farm in 2011–12 was 57 per cent higher than in 2006–07. The average volume of water used per farm was 60 per cent higher, with average water application rates 2 per cent higher than in 2011–12 (Table 7). Average water application rates trended down for flood/furrow and overhead sprinklers, despite wide variation in the average from year to year. Average water application rates for drip/trickle systems remained largely unchanged over the survey period (Figure 25).

Table 7 Area irrigated and water used, wine grape farms, Murray–Darling Basin

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<tbody>
<tr>
<td>Area of wine grapes</td>
<td>ha</td>
<td>105</td>
<td>88</td>
<td>107</td>
<td>141</td>
<td>133</td>
</tr>
<tr>
<td>irrigated</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Volume of water used</td>
<td>ML</td>
<td>280</td>
<td>294</td>
<td>351</td>
<td>433</td>
<td>570</td>
</tr>
<tr>
<td>Water application rate</td>
<td>ML/ha</td>
<td>4.3</td>
<td>4.1</td>
<td>4.8</td>
<td>4.3</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Distribution of wine grape farms by water application rate was slightly narrower in 2011–12 than in 2006–07. Fewer wine grape farms applied water at water application rates above 6 megalitres per hectare (Figure 26).
Broadacre farms

Rice

Results for rice farms were strongly influenced by changes in water availability and traded water allocation prices over the period. While all rice crops covered by the survey were irrigated by flood/furrow systems, the area irrigated, volume of water used and water application rates changed markedly over the survey period (Figure 27).
Over the survey period, these farms also used flood/furrow systems or travelling irrigators on other broadacre crops (such as wheat). An increasing number of rice farms irrigated a small area of horticulture crops (mainly vegetables, citrus or wine grapes) using technologies such as travelling irrigators, drip/trickle, overhead sprinklers, or moveable spraylines. However, too few of these farms were included in the survey to produce reliable estimates of technologies or water application rates for crops other than rice.

Figure 27 Main irrigation systems, rice farms, Murray–Darling Basin

Overall, the average area of rice per farm in 2011–12 was estimated to have been 82 per cent higher than in 2006–07, while the total area irrigated rose by only 1 per cent (Table 8). The average volume of water used per farm was estimated to have been 32 per cent higher in 2011–12 than in 2006–07. Average water application rates for rice crops declined by around 9 per cent over the survey period to 2011–12 as rice farms used their water more effectively (Figure 28).

Table 8 Area irrigated and water used, rice farms, Murray–Darling Basin

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</thead>
<tbody>
<tr>
<td>Area of rice irrigated</td>
<td>ha</td>
<td>58</td>
<td>63</td>
<td>73</td>
<td>38</td>
<td>82</td>
<td>106</td>
</tr>
<tr>
<td>Volume of water used</td>
<td>ML</td>
<td>761</td>
<td>329</td>
<td>1031</td>
<td>508</td>
<td>943</td>
<td>1239</td>
</tr>
<tr>
<td>Water application rate</td>
<td>ML/ha</td>
<td>13.1</td>
<td>13.6</td>
<td>14.2</td>
<td>13.5</td>
<td>11.6</td>
<td>11.7</td>
</tr>
</tbody>
</table>

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

In 2006–07 around two-thirds of rice farms applied more than 12 megalitres per hectare to rice crops, compared with 43 per cent in 2011–12 (Figure 29). Between 2006–07 and 2011–12 several farms applied less than 8 megalitres per hectare to rice. For 2006–07 the data suggests that some farms responded to a situation of low water allocations by applying available water to a rice crop that had already been planted. In many cases these crops were then baled for hay
rather than harvested for grain, with the water that had been applied leaving a moist soil profile that was used by a crop of wheat planted in the following season. With no failed crops recorded in the data for 2011–12, the increased proportion of farms applying lower volumes of water to rice in that year appears to have been a result of farms using water more efficiently.

**Figure 28 Water application rates, rice, Murray–Darling Basin**

Average per farm

![Graph showing water application rates, rice, Murray–Darling Basin](image)

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

**Figure 29 Distribution of rice farms, by water application rate**

Percent of farms

![Bar chart showing distribution of rice farms, by water application rate](image)

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

**Cotton**

As with rice farms, most cotton growing farms irrigated using a flood/furrow system. A relatively small number of farms irrigated with other systems, such as travelling irrigators and overhead sprinklers for cotton and drip/trickle systems for vegetable crops. The proportion of
farms using a system other than flood/furrow to irrigate cotton rose from 3 per cent in 2006–07 to 12 per cent in 2011–12 (Figure 30).

Figure 30 Irrigation systems, cotton, Murray–Darling Basin

![Graph showing proportion of farms, proportion of water used, and proportion of area irrigated by irrigation system from 2006–07 to 2011–12.](image)

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

In 2011–12 flood/furrow systems accounted for 89 per cent of the area irrigated and 85 per cent of water applied on cotton farms (Figure 30). In contrast, flood/furrow systems accounted for 96 per cent of the area irrigated and 98 per cent of water used on cotton farms in 2006–07.

The average of cotton irrigated fell in 2007–08, before rising in each subsequent year as seasonal conditions and water availability improved. In 2011–12 the average water application rate per hectare for cotton crops irrigated using a flood/furrow system was around 11 per cent lower than in 2006–07, although the average fluctuated from year to year (Table 9, Figure 31). Distribution of farms by water application rate shows a reduction in the proportion of cotton farms applying water at higher rates (more than 6 megalitres per hectare) in 2011–12 than in 2006–07 (Figure 32).

Table 9 Area irrigated and water used, cotton farms, Murray–Darling Basin

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<tbody>
<tr>
<td>Area of cotton irrigated</td>
<td>ha</td>
<td>212</td>
<td>160</td>
<td>199</td>
<td>244</td>
<td>280</td>
</tr>
<tr>
<td>Volume of water used</td>
<td>ML</td>
<td>1154</td>
<td>788</td>
<td>963</td>
<td>1345</td>
<td>1277</td>
</tr>
<tr>
<td>Water application rate</td>
<td>ML/ha</td>
<td>5.4</td>
<td>4.9</td>
<td>4.8</td>
<td>5.5</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Source: ABARES survey of irrigation farms in the Murray–Darling Basin
As with rice and cotton farms, most dairy farms irrigated pasture or field crops using a flood/furrow system. A relatively small number of farms used other irrigation systems such as travelling irrigators and moveable spraylines. The proportion of farms using a system other than flood/furrow to irrigate crops or pasture rose from 2 per cent in 2006–07 to 8 per cent in 2011–12 (Figure 33).
In 2011–12 the area irrigated by flood/furrow systems on dairy farms was 56 per cent higher than in 2006–07, while the volume of water used by these systems was only 18 per cent higher (Table 10). In 2011–12 flood/furrow systems accounted for 93 per cent of the area irrigated and 90 per cent of the water applied on dairy farms. In contrast, flood/furrow systems accounted for 96 per cent of the area irrigated and 95 per cent of water used on dairy farms in 2006–07.

For each irrigation system, water application rates were lower in 2011–12 than in 2006–07 (Figure 34), with an increase in the proportion of dairy farms applying water at lower rates per hectare (Figure 35).

### Table 10 Area irrigated and water used, dairy farms, Murray–Darling Basin

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area of pasture irrigated</strong></td>
<td>ha</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume of water used</td>
<td>ML</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water application rate</td>
<td>ML/ha</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Source: ABARES survey of irrigation farms in the Murray–Darling Basin
Figure 34 Water application rates, dairy farms, Murray–Darling Basin

average per farm

Source: ABARES survey of irrigation farms in the Murray–Darling Basin

Figure 35 Distribution of dairy farms, by water application rate, Murray–Darling Basin

percent of farms

Source: ABARES survey of irrigation farms in the Murray–Darling Basin
Appendix A: Survey methods and definitions

The ABARES survey of irrigation farms collected information from broadacre (including rice and cotton), dairy and horticulture irrigation farms in 10 regions in the Murray–Darling Basin. These survey regions cover the major irrigation regions in the basin and are based on those defined by the CSIRO in its Sustainable Yields Project (CSIRO 2007).

The regions are Condamine–Balonne, Border Rivers, Namoi, Macquarie–Castlereagh, Lachlan, Murrumbidgee, Murray, Goulburn–Broken, Loddon–Avoca and Eastern Mount Lofty Ranges (Map 2). The Murray region includes parts of New South Wales, Victoria and South Australia. Not all CSIRO regions were covered by the survey because of relatively small numbers of irrigation farms in those regions.

Map 2 Reporting regions

Source: ABARES
ABARES field officers conducted the irrigation survey between February and June 2012, using face-to-face interviews. The farm financial and physical information collected included land area and value, crop and livestock production and sales, irrigation water use by crop type and pasture, irrigation water delivery methods, farm receipts and costs, labour use, debts and assets and market values of farm capital.

The survey also included questions on types of water licences held, participation in water trading, types of irrigation infrastructure, basis for irrigation scheduling decisions, and future intentions.

While every effort was made to interview the same farms in most years, this was not possible in all regions and industries. In some cases, changes in the composition of the sample have resulted in relatively large differences in estimates between years. Relative standard errors can be used to provide an indication of whether changes in the estimates are statistically significant or not (refer to following sections for further information on relative standard errors).

Target populations

ABARES surveys are designed, and samples selected, from a framework drawn from the Australian Business Register (ABR) and maintained by the Australian Bureau of Statistics (ABS). The framework includes agricultural establishments (farms) classified by size and industry in each statistical local area. To be eligible for the ABARES survey, farms had to have engaged in irrigated agricultural activities during 2010–11, had an estimated value of agricultural operations of $40 000 or more and be defined as broadacre, dairy or horticulture industry farms.

Industry definitions used in this report are based on the Australian and New Zealand Standard Industrial Classification (ANZSIC). This classification is consistent with an international standard and permits comparisons between industries within Australia and internationally. Farms assigned to a particular ANZSIC class have a high proportion of their total output characterised by that class (ABS & SNZ 2006).

Table A1 lists ANZSIC industry classes and codes for the broadacre, dairy and horticulture categories that were used for this study.

<table>
<thead>
<tr>
<th>Broadacre</th>
<th>ANZSIC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep farming</td>
<td>0141</td>
</tr>
<tr>
<td>Beef cattle farming</td>
<td>0142</td>
</tr>
<tr>
<td>Sheep–beef cattle farming</td>
<td>0144</td>
</tr>
<tr>
<td>Grain–sheep and grain–beef cattle farming</td>
<td>0145</td>
</tr>
<tr>
<td>Rice growing</td>
<td>0146</td>
</tr>
<tr>
<td>Other grain growing</td>
<td>0149</td>
</tr>
<tr>
<td>Cotton growing</td>
<td>0152</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dairy</th>
<th>ANZSIC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cattle farming</td>
<td>0160</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Horticulture</th>
<th>ANZSIC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable growing (under cover)</td>
<td>0122</td>
</tr>
<tr>
<td>Vegetable growing (outdoors)</td>
<td>0123</td>
</tr>
<tr>
<td>Grape growing</td>
<td>0131</td>
</tr>
<tr>
<td>Apple and pear growing</td>
<td>0134</td>
</tr>
<tr>
<td>Stone fruit growing</td>
<td>0135</td>
</tr>
<tr>
<td>Citrus fruit growing</td>
<td>0136</td>
</tr>
<tr>
<td>Other fruit and tree nut growing</td>
<td>0139</td>
</tr>
</tbody>
</table>

Survey design

The farm population to be surveyed was stratified by operation size using the estimated value of agricultural operation (EVAO). The size of each stratum was determined using the Dalenius–
Hodges method (Lehtonen & Pakinen 2004). The sample allocation to each stratum was performed using a mixture of the Neyman allocation, which takes into account variability within strata of the auxiliary variable (in this case EVAO), and proportional allocation, which only considers the population number in each stratum. The Neyman allocation allocates large proportions of sample to strata with large variability—in the case of this survey, strata of larger farms (Lehtonen & Pakinen 2004).

**Sample weighting**

Farm level estimates published by ABARES are calculated by appropriately weighting data collected from each sample farm and then using the weighted data to calculate population estimates. Sample weights are calculated so that population estimates from the sample for numbers of farms, areas of crops and numbers of livestock correspond as closely as possible to the most recently available ABS estimates from Agricultural Census and Surveys data. The weighting methodology uses a model-based approach, with a linear regression model linking the survey variables and the estimation benchmark variables. Details of this method are described in Bardsley and Chambers (1984).

Generally, larger farms have smaller weights and smaller farms have larger weights, the relatively lower number of large farms and the strategy of sampling a higher fraction of large farms than small farms (the former having a wider range of variability of key characteristics and accounting for a much larger proportion of total output).

**Preliminary and provisional estimates**

Preliminary and provisional estimates of farm financial performance are produced within a few weeks of the completion of survey collections. However, these may be updated several times at later dates. These subsequent versions will be more accurate as a result of updated information and slightly more accurate input datasets.

The 2010–11 estimates are preliminary, based on full production and accounting information from farmers. However, these estimates are likely to change as further editing of sample farms is undertaken.

The 2011–12 estimates are provisional, based on data collected by ABARES officers in interviews conducted from February to June 2012. Provisional estimates include crop and livestock production, receipts and expenditure up to the date of interview, expected production and receipts and expenditure for the remainder of the provisional year. Provisional estimates are subject to greater uncertainty than preliminary and final estimates.

**Reliability of estimates**

Reliability of estimates of population characteristics presented in this report depends on the design of the sample and the accuracy of the measurement of characteristics for individual sample farms.

**Sampling errors**

Only a subset of farms out of the total number in a particular industry/region is surveyed. Data collected from each sample farm are weighted to calculate population estimates. Estimates derived from these farms are likely to be different from those that would have been obtained if information had been collected from a census of all farms. Any such differences are called sampling errors.

The size of the sampling error is most influenced by the survey design and the estimation procedures, as well as the sample size and variability of farms in the population. The larger the
sample size, the lower the sampling error is likely to be. Therefore, national estimates are likely to have smaller sampling errors than industry and region estimates.

Sampling errors are a guide to the reliability of survey estimates and have been calculated for all estimates in this report. These sampling errors, expressed as percentages of the survey estimates and termed relative standard errors, are provided next to each estimate in parentheses.

**Calculating confidence intervals using relative standard errors**

Relative standard errors can be used to calculate confidence intervals; these indicate how close the actual population value is likely to be to the survey estimate.

The standard error is obtained by multiplying the relative standard error by the survey estimate and dividing by 100. For example, if average total cash receipts are estimated to be $100 000 with a relative standard error of 6 per cent, the standard error for this estimate is $6000. One standard error is equal to $6000 and two standard errors are equal to $12 000.

For a 66 per cent confidence interval, there is roughly a two-in-three chance that the census value (the value that would have been obtained if all farms in the target population had been surveyed) is within one standard error of the survey estimate. This range of one standard error is described as the 66 per cent confidence interval. In this example there is an approximately two-in-three chance that the census value is between $94 000 and $106 000 ($100 000 plus or minus $6000).

For a 95 per cent confidence interval, there is roughly a 19-in-20 chance that the census value is within two standard errors of the survey estimate (the 95 per cent confidence interval). In this example, there is an approximately 19-in-20 chance that the census value lies between $88 000 and $112 000 ($100 000 + or – $12 000).

**Comparing estimates**

When comparing estimates between two groups, it is important to recognise that the differences are subject to sampling error. A conservative estimate (an overestimate) of the standard error of the difference can be found by adding the squares of the estimated standard errors of the component estimates and taking the square root of the result.

For example, estimates of farm cash income are $139 210 for farms in New South Wales and $162 020 for farms in Queensland, with the relative standard errors being 33 per cent and 26 per cent, respectively. The difference between these two estimates is $22 810. The standard error of the difference is estimated as:

$$\sqrt{(33 \times $139 210 / 100)^2 + (26 \times $162 020 / 100)^2} = $62 330$$

A 95 per cent confidence interval for the difference is:

$$\text{Difference} \pm 1.96 \times \text{Standard Error of the Difference} = ($99 357, $144 977)$$

Hence, if 100 different samples are taken, in 95 of them the difference between these two estimates would be between –$99 357 and $144 977.
# Glossary

## General

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner–manager</td>
<td>The primary decision-maker for the farm business. This person is usually responsible for the day-to-day operation of the farm and may own or have a share in the farm business.</td>
</tr>
</tbody>
</table>

## Physical items

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef cattle</td>
<td>Cattle kept primarily for producing meat, irrespective of breed.</td>
</tr>
<tr>
<td>Dairy cattle</td>
<td>Cattle kept or intended mainly for production of milk or cream.</td>
</tr>
<tr>
<td>Hired labour</td>
<td>Excludes the farm business manager, partners and family labour, and work by contractors. Expenditure on contract services appears as a cash cost.</td>
</tr>
<tr>
<td>Labour</td>
<td>Measured in work weeks, as estimated by the owner–manager or manager. It includes all work on the farm by the owner–manager, partners, family, hired permanent and casual workers and sharefarmers but excludes work done by contractors.</td>
</tr>
<tr>
<td>Total area operated</td>
<td>Includes all land operated by the farm business, whether owned or rented by the business, but excludes land sharefarmed on another farm.</td>
</tr>
</tbody>
</table>

## Financial items

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>The value of farm capital is the value of all the assets used on a farm, including the value of leased items but excluding machinery and equipment either hired or used by contractors. The value of owned capital is the value of farm capital excluding the value of leased machinery and equipment. ABARES uses the owner–manager's valuation of the farm property. The valuation includes the value of land and fixed improvements used by each farm business in the survey, excluding land sharefarmed off the sample farm. Residences on the farm are included in the valuations. Livestock are valued at estimated market prices for the land use zones within each state. These values are based on recorded sales and purchases by sample farms. The total value of items purchased or sold during the survey year was added to or subtracted from farm capital at 31 December of the relevant financial year, irrespective of the actual date of purchase or sale.</td>
</tr>
<tr>
<td>Build-up in trading stocks</td>
<td>The closing value of all changes in the inventories of trading stocks during the financial year. It includes the value of any change in herd or flock size or in stocks of wool, fruit and grains held on the farm. It is negative if inventories are run down.</td>
</tr>
<tr>
<td>Change in debt</td>
<td>Estimated as the difference between debt at 1 July and the following 30 June within the survey year, rather than between debt at 30 June in consecutive years. It is an estimate of the change in indebtedness of a given population of farms during the financial year and is thus unaffected by changes in sample or population between years.</td>
</tr>
<tr>
<td>Depreciation</td>
<td>Estimated by the diminishing value method, based on replacement cost and age of each item. The rates applied are standard rates allowed by the</td>
</tr>
</tbody>
</table>
For items purchased or sold during the financial year, depreciation is assessed as if the transaction had taken place at the midpoint of the year. Calculation of farm business profit does not account for depreciation on items subject to a finance lease because cash costs already include finance lease payments.

Farm business debt
Estimated as all debts attributable to the farm business, but excluding personal debt, lease financed debt and underwritten loans (including harvest loans).

Farm business equity
The value of owned capital, less farm business debt at 30 June. The estimate is based on those sample farms for which complete data on farm debt are available.

Farm business profit
Farm cash income plus build-up in trading stocks, less depreciation and less the imputed value of the owner–manager, partner(s) and family labour.

Farm cash income
The difference between total cash receipts and total cash costs.

Farm equity ratio
Calculated as farm business equity as a percentage of owned capital at 30 June.

Farm liquid assets
Assets owned by the farm business that can be readily converted to cash. They include savings bank deposits, interest bearing deposits, debentures and shares. Exclude are items such as real estate, life assurance policies and other farms or businesses.

Imputed labour cost
Payments for owner–manager and family labour may bear little relationship to the actual work input. An estimate of the labour input of the owner–manager, partners and their families is calculated in work weeks and a value is imputed at the relevant Federal Pastoral Industry Award rates.

Off-farm income
Collected for the owner–manager and spouse only. Includes income from wages, other businesses, investment, government assistance to the farm household and social welfare payments.

Profit at full equity
Farm business profit, plus rent, interest and finance lease payments, less depreciation on leased items. It is the return produced by all the resources used in the farm business.

Rates of return
Calculated by expressing profit at full equity as a percentage of total opening capital. Rate of return represents the ability of the business to generate a return to all capital used by the business, including that which is borrowed or leased. The rates of return estimated are:

- rate of return excluding capital appreciation
- rate of return including capital appreciation

Receipts and costs
Receipts for livestock and livestock products sold are determined at the point of sale. Selling charges and charges for transport to the point of sale are included in the costs of sample farms.

Receipts for crops sold during the survey year are gross of deductions made by marketing authorities for freight and selling charges. These deductions are included in farm costs. Receipts for other farm products are determined on a farm-gate basis. All cash receipt items are the revenue received in the
Financial Year.  

Farm receipts and costs relate to the whole area operated, including areas operated by on-farm sharefarmers. Thus, cash receipts include receipts from the sale of products produced by sharefarmers. If possible, on-farm sharefarmers’ costs are amalgamated with those of the sample farm. Otherwise, the total sum paid to sharefarmers is treated as a cash cost.

Some sample farm businesses engage in off-farm contracting or sharefarming, employing labour and capital equipment also used in normal on-farm activities. Since it is not possible to accurately allocate costs between off-farm and on-farm operations, the income and expenditure attributable to such off-farm operations are included in the receipts and costs of the sample farm business.

Total Cash Costs  Payments made by the farm business for materials and services and for permanent and casual hired labour (excluding owner–manager, partner and other family labour). It includes the value of livestock transfers onto the property as well as any lease payments on capital, produce purchased for resale, rent, interest, livestock purchases and payments to sharefarmers. Capital and household expenditures are excluded from total cash costs.

Handling and marketing expenses include commission, yard dues and levies for farm produce sold.

Administration costs include accountancy fees, banking and legal expenses, postage, stationery, subscriptions and telephone.

Contracts paid, refer to expenditure on contracts such as harvesting. Capital and land development contracts are not included.

Other cash costs include stores and rations, seed purchased, electricity, artificial insemination and herd testing fees, advisory services, motor vehicle expenses, travelling expenses and insurance. While other cash costs may comprise a relatively large proportion of total cash costs, individually the components are relatively small and, as such, have not been listed.

Total Cash Receipts  Total of revenues received by the farm business during the financial year, including revenues from sale of livestock, livestock products and crops, plus the value of livestock transfers off a property. It includes revenue received from agistment, royalties, rebates, refunds, plant hire, contracts, sharefarming, insurance claims and compensation, and government assistance payments to the farm business.
References


