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## Dairy water use in Australian dairy farms: Past trends and future prospects

Shahbaz Khan, Akhtar Abbas, Tariq Rana and Jason Carroll

February 2010

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## ABBREVIATIONS

COAG	Council of Australian Governments
DIDCO	Dairy Industry Development Company
DM	dry matter
ET	evapotranspiration
FAO	Food and Agriculture Organization
GDP	gross domestic product
GL	gigalitre
GMW	Goulburn Murray Water
L	litre
MDB	Murray–Darling Basin
ML	megalitre
SDP	Sub Tropical Dairy Program
SKM	Sinclair Knight Merz
SPI	standard precipitation index
WfHC	Water for a Healthy Country
WSPs	water sharing plans

## EXECUTIVE SUMMARY

*Dairy Water Situation and Outlook* reports the water usage, and the associated environmental impacts and land capacity of Australian dairy regions. The objectives of the study are to:

- analyse the water use of the dairy industry
- analyse the key water issues faced by the dairy industry and
- find the effects of current water use practices of the dairy industry on the sustainability of water resources.

This report is intended for use by the dairy industry to develop policy and industry actions in water use and management.

The dairy industry is Australia's third largest rural industry (after beef and wheat). It employs approximately 100 000 people (directly and indirectly) and produces dairy products valued at \$9 billion a year. The industry exports more than 50% of its total milk production and holds 11% of the world trade – only New Zealand and the European Union hold more. It has been, and will continue to be, a significant contributor to the national economy. Australia has approximately 9256 dairy farms. The dominant cow breeds are Holstein Friesian (70%), Jersey, Jersey-Holstien and Illawarra. Total milk production is 10.125 billion litres from more than 2.01 million dairy cows, with average annual milk production of 5000 litres per cow. Total farm gate value of dairy industry was \$4.6 billion with an export value of \$2.9 billion in 2007/08.

Dairy farming is the largest water consuming industry, accounting for some one-third of land under irrigation. The industry generates more income for the economy from irrigated agriculture than any other industry (CSIRO, 2005). It uses approximately 25% of the surface irrigation water in Australia. It is also a major user of groundwater in all areas especially in South Australia. Since 2000, the industry has experienced considerable change to its operating environment. The combination of post-deregulation restructuring and the impacts of a '1-in-100 year' drought has had a significant impact on both milk production and the confidence of farmers. For the 66-month period ending in May 2007, 23.1% of Australia was in the lowest rainfall decile. Much of the Murray–Darling Basin continued to suffer from severe drought on this longer timescale (Braganza, 2008). The level of rainfall had a significant impact on the dairy industry in terms of water availability for pasture irrigation, dairy herd consumption and other related uses.

Dairy farming in Victoria is relatively extensive, using 53% of state's irrigated land. Tasmania's dairy industry uses 26% of its irrigated land while South Australia and Western Australia use 14% and 13% of state's irrigated land respectively.

Victoria comprises 71% of the Australian dairy industry; New South Wales is the second largest with 14%. Queensland, South Australia and Tasmania contribute almost equally at 5% each.

Major sources of water for dairying are:

- self-extracted water
- water provided by irrigation providers and
- effluent re-use.

Total water use by agriculture was 16 660 GL in 2000/01. Dairy farming is the second largest single irrigation water user after cotton within irrigated agriculture:

- livestock, pasture, grains used 5568 GL or 33% of total consumption
- cotton used 2908 GL or 17%

- dairy farming used 2834 GL or 17% and
- rice used 1951 GL or 12%.

Of the total agricultural water used, 9132 GL or 55% was from self-extracted sources, 7105 GL or 43% came from mains (e.g. supplied by irrigation authorities) and 423 GL was re-use water.

There are significant variations in water use based on water source as well as water use among the states and territories:

- Victoria had the highest percentage water use from main channels, 38% of all water used from this source
- Tasmania had the lowest, with only 21% of all water from main channels (excluding all hydro-electric in-stream use).

Generally, the number of dairy farms is declining – decreased by 35% from 1994/95 to 2004/05. Obvious reasons for this decline could be:

- water shortage due to the persistent drought and restricted supplies
- land use change
- changing business priorities and
- change of land ownership.

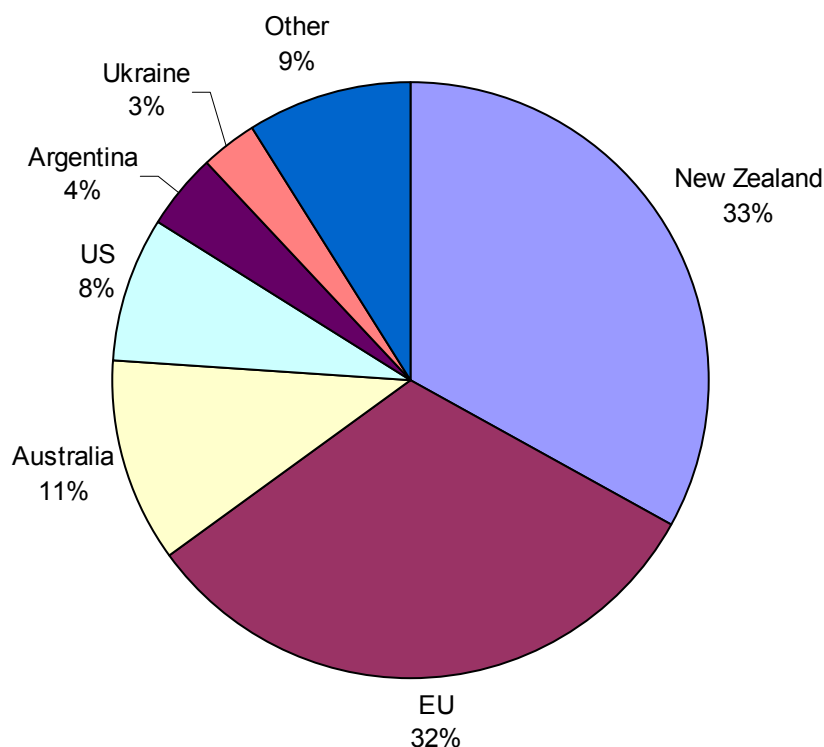
However the number of milking cows has been steadily increasing – up 16% in 2000/01 from 1994/95. A slight decrease (9%) occurred during 2004/05. Surveyed data show that the highest number of milking cows in irrigated farms (375) is in Western Victorian dairy while the highest number of milking cows in dryland dairy (234) is in Western Australia dairy. The lowest number in both irrigated and dryland dairying (172 and 135 respectively) is in the Sub Tropical Dairy Program (SDP).

Victorian dairies are the highest producers of milk with 7405 million litres during 2000/01. Milk production had been increasing (up to 2000/01) but then decreased by 11% in 2004/05. The milk production per cow is highest in South Australia – an average of 5955 litres per cow since 1995/96. It is slightly less in Victoria with 4944 litres per cow. Queensland has the lowest milk production per cow with 4089 litres on average since 1995/96.



# 1. INTRODUCTION

Australia's dairy industry is its third largest rural industry, employing approximately 100 000 people and producing products valued at \$9 billion a year. It is a major contributor to the wealth and prosperity of the regional communities that depend on irrigated agriculture. The industry exports more than 50% of its total milk production and holds 11% of the world trade after New Zealand and the European Union (Figure 1). It has been, and will continue to be, a significant contributor to the national economy (see Table 1 for a snapshot of the dairy industry).



**Figure 1. Australian dairy's share in world trade in 2007/08 (Source: Dairy Australia, 2008).**

**Table 1: Australian dairy industry facts and figures 2007/08.**

Facts	Figures
Dairy farms	9 223
Dairy cows (million)	1.7
Average herd size (cows)	214
Average annual milk per cow (L)	5 231
Total milk production (million litres)	9 223
Farm gate value – 2004/05 (\$ billion)	4.6
Ex-factory value (\$ billion)	11.5
Export value – 2004/05 (\$ billion)	2.9 (11% of world dairy trade)
Average consumption per person per year	104 L milk, 12 kg cheese

Source: <[www.dairyaustralia.com.au/Our-Dairy-Industry/Industry-Statistics.aspx](http://www.dairyaustralia.com.au/Our-Dairy-Industry/Industry-Statistics.aspx)>

Australia's dairy industry has undergone considerable change in recent years, with increasing farm and herd sizes, changing markets, deregulation, and changing technologies in areas such as new milking sheds to soil testing to herd health management (Kompas and Che, 2004; Ginnivan, 2009). Nevertheless, the industry continues to face many challenges (Ginnivan, 2009). Against a long-term expectation of increased world demand, costs and prices are volatile. Market access and production systems are becoming more complex and more demanding of management and decision making. Although issues such as the ethics of

treatment of animals and the environment require attention, natural resource management is more demanding with decreasing supplies and increasing competition for water, and concerns over climate change impacts on future water supplies. The current drought has had a large impact on the industry, with a decrease in production from about 11.2 million litres in 2002 to 9.2 in 2007 (Ginnivan, 2009). At the farm level, the drought has seen great reductions in cash income, and increased pressures for productivity and efficiency gains (Kompas and Che, 2006). Differences in farm efficiency are principally determined by dairy shed technology, the proportion of land irrigated, feed concentration, and the number of dairy cows milked at peak season. More efficient farms are those that use better dairy sheds, more irrigation and feeds, and milk more cows at peak season (Kompas and Che, 2006).

Water is a major factor in production and efficiency in the dairy industry, for the individual farm and in overall industry performance. Kompas and Che (2004) concluded that changes in productivity may often simply be a reflection of good or bad seasonal conditions. They concluded that *... for both production and efficiency, water and its availability is clearly a large part of the story in the Australian dairy industry, and a major challenge for domestic policy* (Kompas and Che, 2006).

Dairy farms use water for pasture irrigation, stock drinking water, and cleaning and cooling dairies. By far the largest use is pasture irrigation.

The dairy industry is Australia's largest user of irrigation water using approximately 25% of Australia's surface irrigation water. It is also a major user of groundwater, especially in South Australia. Most of Australia's dairy regions are experiencing a long and severe drought with rainfall far below average. The much reduced rainfall has had a significant impact on the industry.

Despite its importance, the Australian dairy industry does not have access to comprehensive data on how the industry uses water and the issues it faces. Understanding what will drive the irrigated dairy industry's competitive and sustainable position is vital if the industry is to effectively position itself nationally and guide industry and government investment. This report presents a comprehensive analysis of water use in the irrigated dairying regions across Australia that will help understand overall water requirements, issues and fill knowledge gaps.

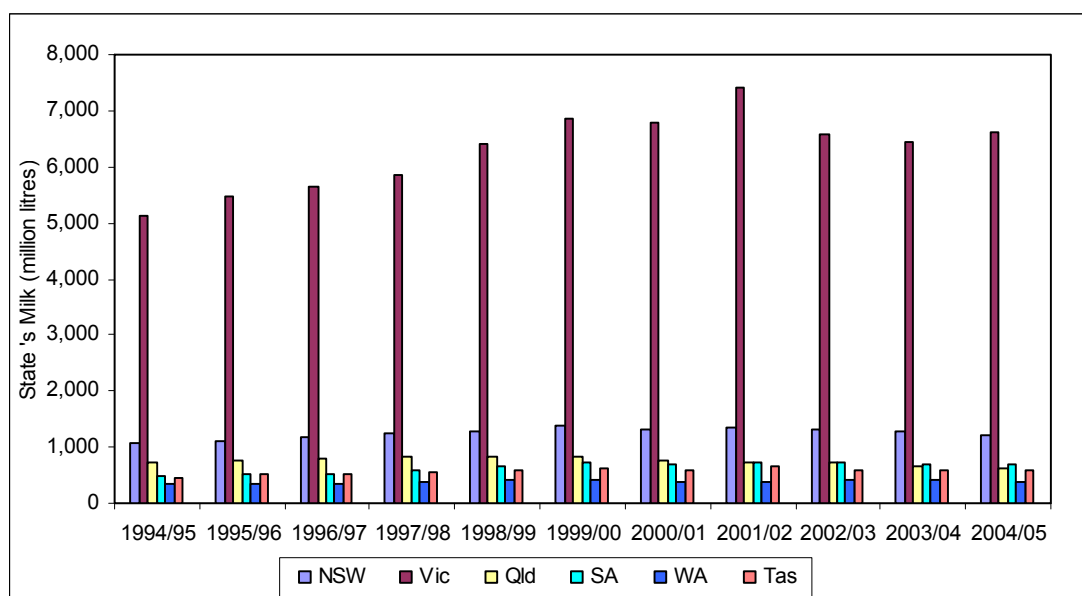
## **1.1. Objectives**

The objectives of the study are to:

- analyse the water use of the dairy industry
- analyse the key water issues faced by the dairy industry and.
- find the effects of current water use practices of the dairy industry on the sustainability of water resources.

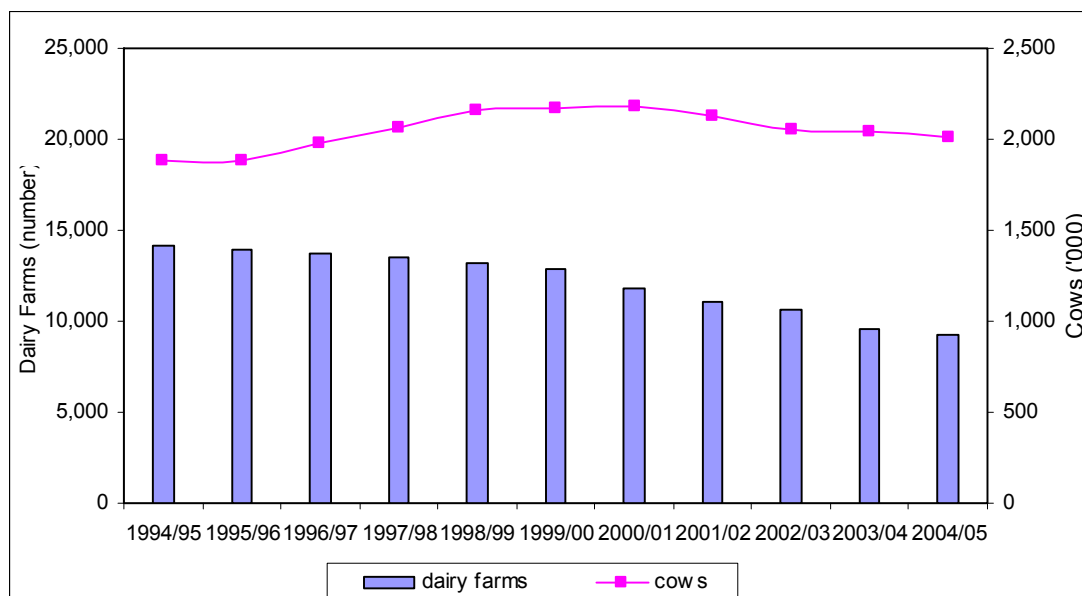
## **1.2. A snapshot of the dairy industry**

The dairy industry is spread throughout Australia, with both irrigated and dryland dairy farms. The greatest concentration is irrigated dairy farming in the southern Murray–Darling Basin. Victoria dominates overall milk production (Figure 2).



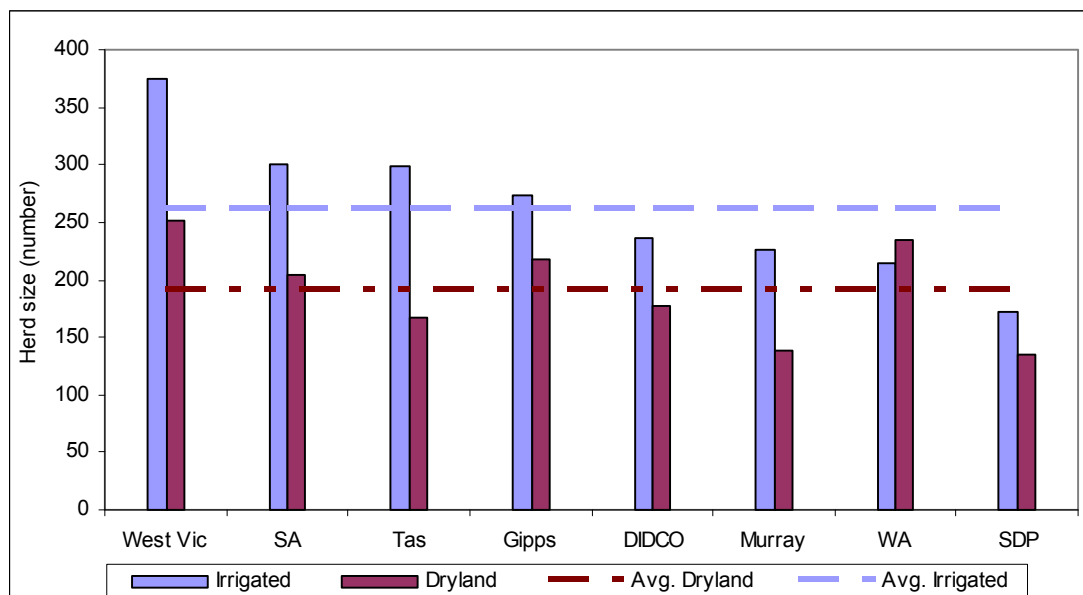
**Figure 2. State wide milk production in Australia.**

The dairy industry has about 9000 farms, down from more than 14 000 in 1994/05 (Figure 3). However, the number of cows has remained fairly constant over the same period (Figure 3). Dairy deregulation, reducing terms of trade combined with the impact of climate change have been major drivers for reducing dairy farm numbers. These factors have also increased the size of farms – bigger farms are more competitive. The area under dairy farms in Australia was approximately 2.26 million ha in 2003/4, down from 2.66 million ha the previous year.



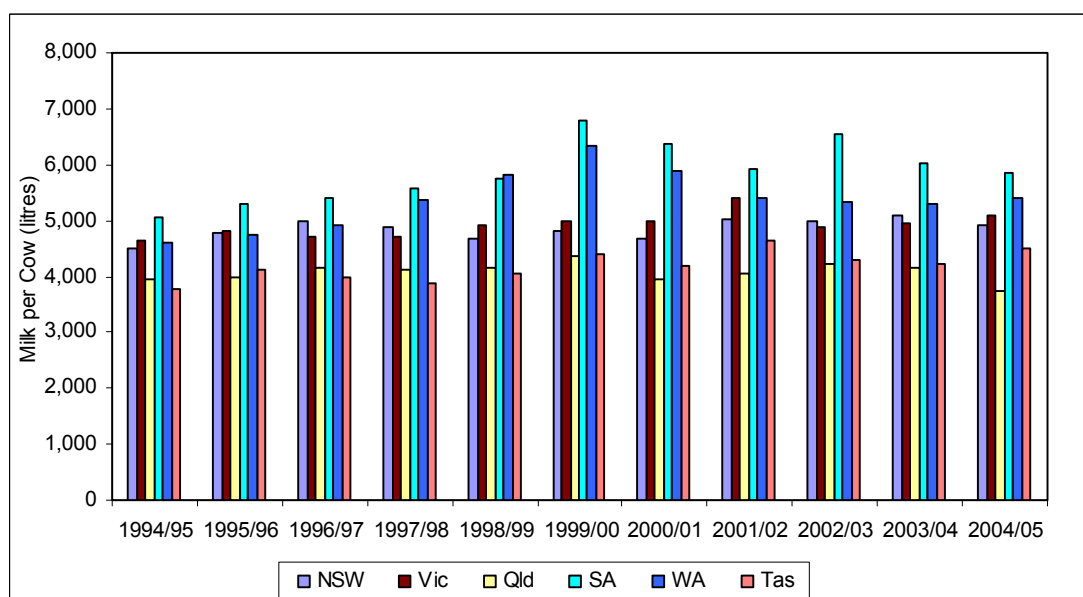
**Figure 3. Number of irrigated dairy farms and number of milking cows.**

The average herd size is 214 cows per farm, slightly more on irrigated farms and slightly less on dryland farms (Figure 4). The herd size varies from region to region (Figure 4).



**Figure 4. Number of cows per farm in dairy regions of Australia (from Watson, 2006). DIDCO is the Dairy Industry Development Company and covers most of NSW production. SDP is the Sub Tropical Dairy Program and covers northern NSW and Queensland.**

The average milk production per cow of 5321 litres per year steadily increased to 2001/02, but then fell 11% to 2004/05, and varies from region to region (Figure 5).

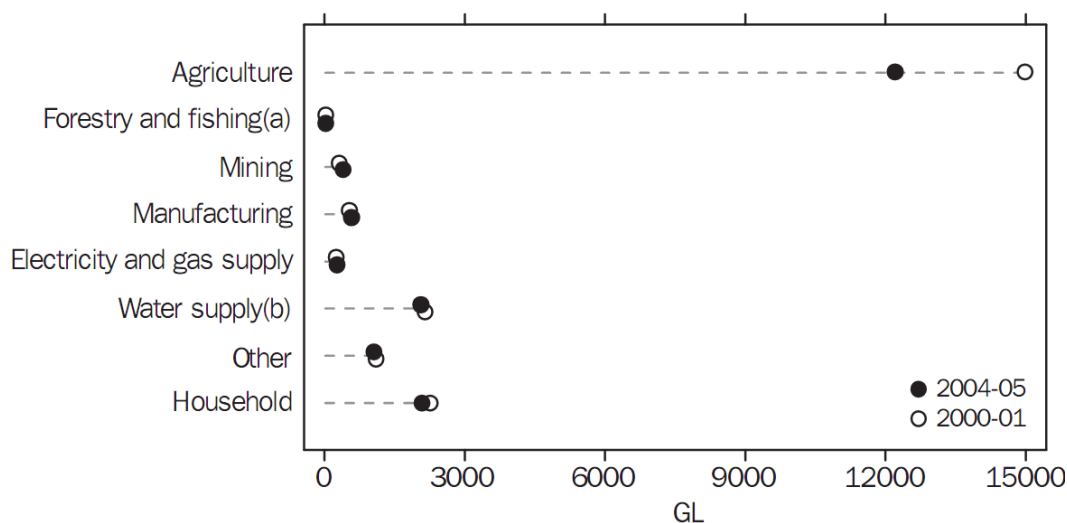


**Figure 5. State-wide average annual milk production per cow.**

## 2. WATER IN AUSTRALIA

### 2.1. Water use in Australia

Water use in Australia in 2004/05 was nearly 80 000 GL – just over 60 000 GL of this was for in-stream use, largely hydropower generation (ABS, 2006). Consumption was slightly more than 18 000 GL, down from the 2000/01 use of nearly 22 000 GL because of the continuing drought in the south east. Of this, the agricultural industry consumed some 65% or approximately 12 200 GL, down from nearly 15 000 GL in 2000/01 (see Figure 6). Of the total drop in consumption from 2000/01 to 2004/05 of 2936 GL, 2798 came from agriculture which has borne the greatest impact of the drought. Of the total water use, approximately 11 300 GL was supplied by water supply companies, with the remainder being self extracted. The 12 200 GL of consumption within the agricultural industry comprised approximately 53% self extracted and 44% supplied, with the remainder from recycling (Table 2).



(a) Includes Services to agriculture; hunting and trapping.

(b) Includes Sewerage and drainage services.

**Figure 6. Water consumption in Australia during 2000/01 and 2004/05 (Source: ABS, 2006).**

Within the agricultural industry, the Australian Bureau of Statistics (ABS) category of 'livestock, pasture, grains and other' consumed approximately 36% of the total, followed by dairy farming with 19% and cotton with 15% (ABS, 2006). The dairy industry water consumption of 2276 GL in 2004/05 was down from the 2000/01 figure of 2593 GL, reflecting the impact of the drought. Other agricultural industries also consumed less water, with the greatest amount being for rice which fell from 2223 GL (16% of the total consumption) in 2000/01 to 631 GL in 2004/05 (5%). The fall of 12% in water consumption in dairy was slightly less than the overall fall in agriculture of 19%. Sugar, fruit and grapes all consumed marginally more water than they did in 2004/05 than in 2000/01.

**Table 2: Water use (GL) by agriculture industry during 2004/05 (Source: ABS, 2006).**

	Self extracted	Distributed	Re-use	Consumption
Dairy farming	857	1 339	79	2 276
Vegetables	307	133	16	455
Sugar	404	859	6	1 269
Fruit	307	339	1	648
Grapes	191	522	4	717
Cotton	1 697	122	2	1 822
Rice	225	394	12	631
Livestock, pasture <sup>1</sup> , grains & other	2 594	1 621	160	4 374
<b>Total</b>	<b>6 582</b>	<b>5 329</b>	<b>280</b>	<b>12 191</b>

<sup>1</sup> Excludes pasture for dairy farming

Most irrigation water use in the dairy industry occurs along the Murray River in northern Victoria and southern New South Wales. Dairy farming is the main water user in Victoria, consuming 54% of the state's agricultural water (Table 3). Dairy in Tasmania is proportionally the second largest with 33% of this state's water used in dairy farming although total irrigation water used in Tasmanian dairy farming is still lower than that used in NSW, Victoria or South Australia. In the other states, dairy consumes 10% or less of the total of the state's irrigation water.

**Table 3: Water use (GL) by agriculture industry during 2004/05 at state and territory level (ABS, 2006)**

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Dairy farming	263	1 710	69	95	54	85	—	—
Vegetables	69	84	103	95	52	52	1	0
Sugar	1	—	1 116	—	152	—	—	—
Fruit	134	198	116	144	39	10	7	0
Grapes	171	320	8	204	9	2	3	0
Cotton	964	—	857	—	—	—	—	—
Rice	624	6	—	—	—	—	—	—
Livestock, pasture <sup>1</sup> , grains & other	1 907	962	647	483	229	110	36	1
<b>Total</b>	<b>4 133</b>	<b>3 281</b>	<b>2 916</b>	<b>1 020</b>	<b>535</b>	<b>258</b>	<b>47</b>	<b>1</b>

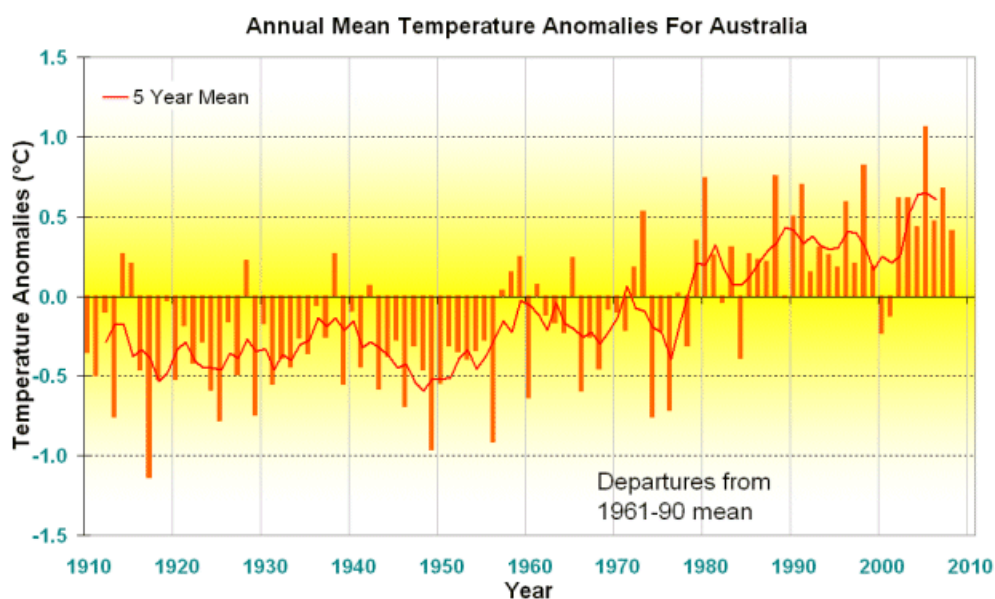
<sup>1</sup> Excludes pasture for dairy farming

## 2.2. Climate trends and impacts

### 2.2.1. Historic trends and impacts

Climate change and the severe water crisis are crippling south-east Australia's agriculture and environment. The need to provide water for its growing uses (agricultural, industrial, domestic and environmental) and maintaining the river's health has pushed the Murray–Darling Basin to its limits. Dairy farmers face challenges of sustainability and profitability while investing for the future in the context of water availability. The low rainfall during 1997, 2002 and 2006 can be understood in terms of the El Niño events that occurred during these years. Earlier El Niño events were commonly followed by good drought-breaking rains (NWC, 2006). However, in the following years the drought was gradually worsened: Murray inflows in the first quarter of 2009 were the lowest in 117 years (MDBA, 2009).

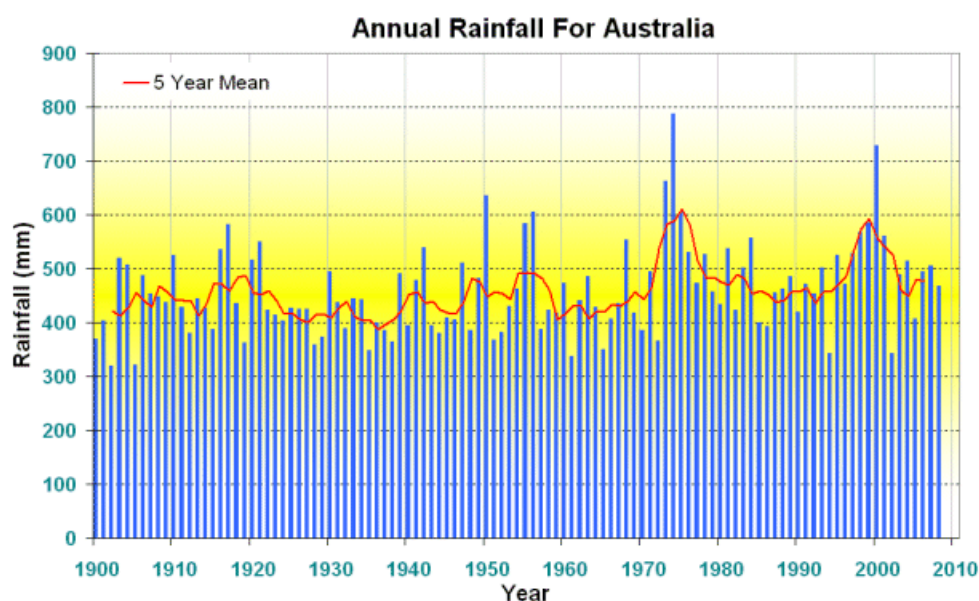
The mean temperature for 2003 was 0.62°C above the 1961–90 average, making it Australia's sixth warmest year on record since 1910 (Figure 7). Australia's annual mean maximum temperature was 0.65°C above normal (sixth highest), with the mean minimum temperature being 0.59°C above normal (fourth highest). Melbourne had its hottest day on record on 7 February 2009 when the temperature reached 46.4°C.



**Figure 7. Annual mean temperature anomalies – based on 1961–90 normal (Source: BOM, 2009a).**

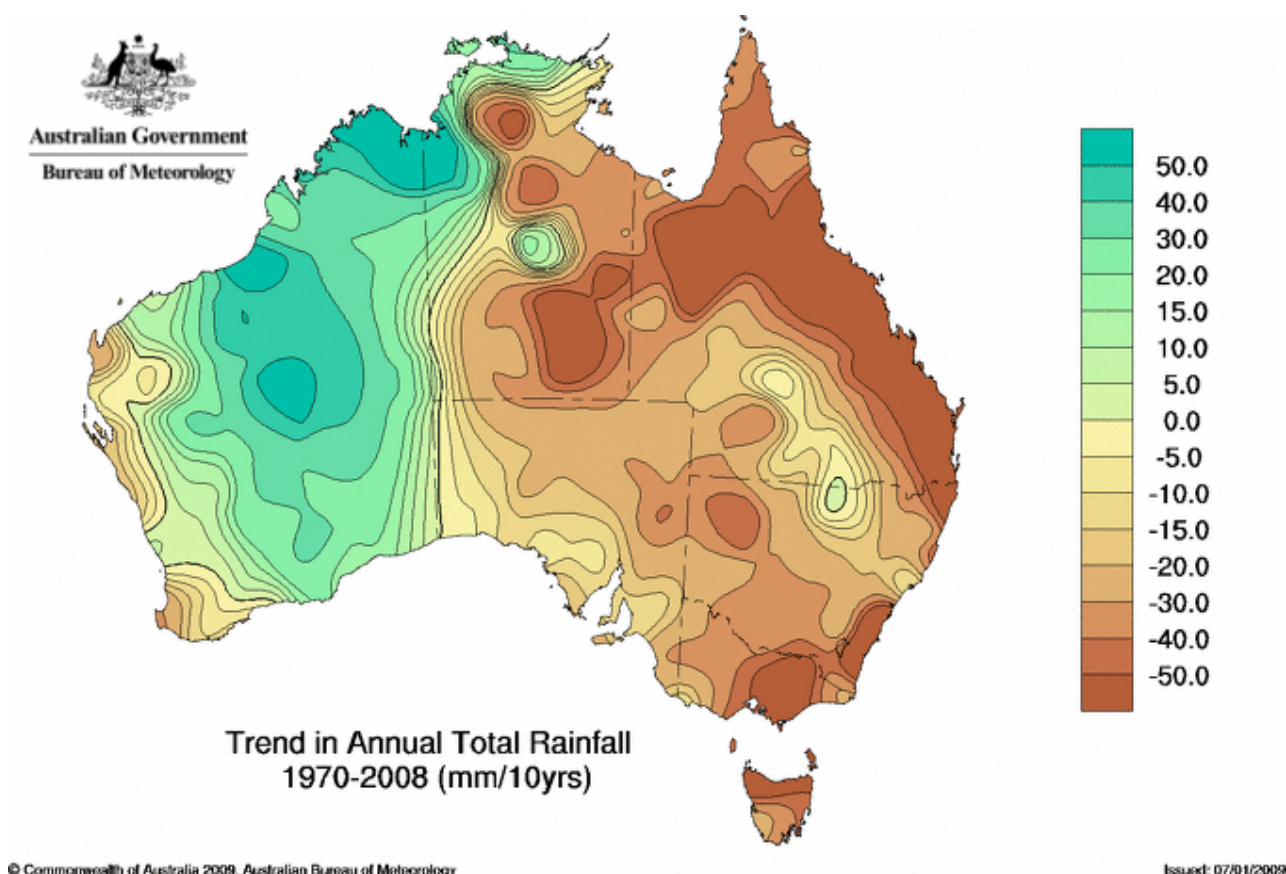
Variability of precipitation also results in variations in the use of water from year to year, particularly for irrigation. The dairy regions face water scarcity due to increased water demands and climate variability. The severe drought since 2002/03, particularly in terms of its spatial extent, was associated with an El Niño event that developed during the autumn of 2002. We calculated the concept of standardised precipitation index (SPI) for each dairy region to track droughts and assess climatic variability (see Appendix B for the conceptual details on SPI).

While much of south-eastern Australia has experienced drought in recent years, the same is not true of the whole country, and that most recent years were not far from the long-term, country-wide average of 472 mm (Figure 8). However, the country-wide average masks spatial variability, with the east and southeast generally being drier than average in recent years. The eastern half of the country has experienced a drying trend since 1970 (Figure 9). Most of Australia's dairy production is in areas of the drying trend.





**Figure 8. Australian annual mean rainfall (Source: BOM, 2009a).**



**Figure 9. Australian rainfall trends, 1970–2008 (Source: BOM, 2009b).**

### 2.2.2. Projected future climate impacts

Climate change is expected to affect Australia. Two recent climate and water availability projections are particularly relevant to the dairy industry. Hennessy (2007) reported climate change projections for 2030, based on projections by 23 models and a range of emissions scenarios accepted by the Intergovernmental Panel on Climate Change. Broad conclusions were that the dairy regions of Australia are projected to experience:

- warmer temperatures – generally by about 0.5 to 1.5°C, with some variation from region to region
- less rainfall – generally a reduction of between 0 to 5% in summer and autumn, and between 3 and 9% in winter and spring, with some variation from region to region and an overall uncertainty of up to  $\pm 10\%$  – and
- less run-off – generally a reduction of between 0 to 9%, with some variation from region to region and an overall uncertainty of -43 to +20%.

The CSIRO Murray-Darling Basin Sustainable Yield study (CSIRO, 2008) reported water availability in the Murray–Darling Basin (MDB) under the historical climate of the last 111 years, in the recent climate (i.e. drought conditions in the southern part of the MDB), and under climate conditions projected for 2030. Apart from dealing only with the Murray–Darling Basin, the significant difference between this study and that of Hennessy (2007) is that extensive river modelling was undertaken to assess the cumulative climate change impact along the river system. Groundwater use and the impact of climate change on it were also considered. The broad results of the climate change projections of this study are:

- The southern part of the MDB in particular would experience declines in water availability.
- Droughts similar to the current exceptional drought will become increasingly common.



- Water availability averaged through all years is, under a median scenario at 2030, projected to decline by 11% across the MDB, and by 13% in the southern part of the MDB (and with variability catchment by catchment).
- The projected average decline in water use under the median scenario, and with current water sharing rules, is 4% across the MDB, which would further reduce the flow through the mouth to 30% of the estimated flow before development.
- The impact of climate change on surface water use would be much greater in dry years. In the extreme dry climate scenario diversions in the driest years would fall by over 70% in the Murray and 80 to 90% in the Victorian part of the MDB.
- Groundwater use is likely to rise under current sharing arrangements so that it is more than one-quarter of total water use. Increased groundwater use will lead to induced streamflow leakage, and hence reduce streamflow. Major drawdowns of water levels will occur in some aquifers in the absence of management intervention.
- Expansion of commercial forestry plantations and increases in the total capacity of farm dams may affect run-off reaching rivers. 'Best estimate' projections indicate that the impact is likely to be minor across the MDB. However, some local impacts could be significant.

The projected declines in water availability and use are greater than those implied by the reductions in run-off considered by Hennessy (2007).

Northern Australia, Tasmania and the south-west of Western Australia are the subject of current sustainable yields studies by CSIRO (CSIRO, 2009). The latter two will be of considerable interest to the dairy industry when the results are made available following reporting to the Council of Australian Governments (COAG) at the end of 2009.

## 2.3. Evolution of water policy

In the early twentieth century, control of water resources was vested in the states with a system of water allocation using a licensing regime. Expansion of irrigation activity led to clearing of native vegetation and increase in water demand that was met by water supplies from infrastructure development. This led to severe degradation of land and water resources. A gradual phasing out strategy was imposed on the issue of irrigation licences between 1970 and 1990. In 1994, COAG set out to implement a strategic framework to achieve an efficient and sustainable water industry. This framework was designed to promote consistent and integrated water resource management throughout Australia. The framework provides for water entitlements and trading, environmental requirements, institutional reform, public consultation and education, water pricing, and research (DEH, 2004). In 2003, COAG agreed to the National Water Initiative the objectives of which were to:

- improve the security of water access entitlement
- ensure ecosystem health
- ensure water is put to the best use and
- encourage water conservation in Australia's cities.

It also included provisions to establish institutional and regulatory arrangements to facilitate intra and interstate trade where water pricing would be based on full cost recovery for water services.

The *Water Act 2007* (Cwlth) (amended by the *Water Amendment Act 2008* [Cwlth]) implements key reforms for water management in Australia. The Water Act will assist in implementing the following key elements:

- The Basin Plan, including a sustainable cap on diversions
- water charging, and water market and water trading rules
- environmental water and

- new investments in water information.

The Basin Plan will provide the foundation for managing the MDB's water resources in a way that can be sustained with time and in the national interests. However, as water resources become scarcer, tension between different users (including the environment) can be expected to increase. All water users, including dairy farming, will be affected.

## **2.4. Water trading and markets**

### **2.4.1. Background**

Water trading is the process of buying and selling water entitlements, where entitlements can include water supplied as part of a licence, allocation or other entitlement. Under the 2007 Water Act, the farmers were given flexibility to trade their water access rights and ensure more efficient and sustainable water use across the Murray–Darling Basin.

The main reason for establishing markets and water trading is to maximise the productive and efficient use of water (NWC, 2009). Water trading is assumed to benefit dairy (and other) farmers because it increases flexibility in farm decisions, including the decisions about priorities for water use, managing risk and cash flow, and whether and when to leave farming (Frontier Economics, 2007). Frontier Economics (2007), reported that that without temporary trade, the dairy industry would have fared worse in the last ten years of drought than it actually has. Nevertheless, many dairy enterprises collapsed, though with permanent trade (of entitlements) farmers leaving the farm did so with more money than they would otherwise. However, there is widespread community opposition to permanent trading out of a district, as this can lead to contraction of communities.

Temporary trade is driven largely by seasonal factors, whereas permanent trade leads to long-term structural changes (Wijedasa et al., 2002). Permanent trade has allowed the wine boom to be based on extensive new plantings, and allowed the almond boom to occur. As a result of these booms, less water will be available for temporary trade back into dairy areas as the planting mature (Frontier Economics, 2007).

Thus, water trade has benefits and costs that are both economic and social.

### **2.4.2. Current trade and the dairy industry**

The 2004/05 annual water account (ABS, 2006) showed that 248 GL of water was traded permanently and 1053 GL temporarily in this year. Victoria had the highest volume (444 GL) of temporarily water traded, whereas the highest volume of permanently water traded was in Western Australia with 63 GL. By 2007/08, the permanent trade Australia wide was 921 GL and the temporary trade was 1594 GL (NWC, 2008). In 2007/08, interstate permanent trade was negligible, whereas interstate temporary trade accounted for 235 GL. During 2004/05, the highest average price for permanent water trading reported was for Queensland at \$1750 /ML followed by Western Australia at \$680 /ML. The temporary water trading (average price) was \$96 /ML in NSW followed by \$80 /ML in WA (ABS, 2006). However, trading prices vary greatly throughout the year. In 2007/08, the water price in the Victorian Murray region at the start of the irrigation season was approximately \$1000–1200, falling to approximately \$200–300 in the later part of the year (NWC, 2008). In that year, 94% of permanent trade and 99% of temporary trade was in the Murray–Darling Basin.

Since dairy is the main agricultural user of water, it is no surprise that it is also a major participant in water trading. Wijedasa et al. (2002) estimated that horticulture and dairy farming account for more than 80% of purchases of permanent water entitlements in irrigation areas within the Goulburn–Murray Irrigation Scheme, based on a survey conducted from March to May 2001. Alexander (2005) estimated that the trade of temporary water was the highest (22% of the entitlements) in Murray Irrigation followed by Goulburn Murray Pyramid-Boort (about 20% of the entitlements). The lowest was in Boyana River with 1%. On average, 7.3% of the entitlements were temporarily traded in all irrigation districts. Permanently traded water was the highest (4% of the entitlements) in Goulburn Murray Pyramid-Boort. The second highest was in the areas of West Corungan, Goulburn Murray

Torrumbarry, and Cressy Longford with 3% of the total entitlements. On average, 1.8% of the total entitlements were permanently traded in all irrigation districts. In the whole Murray–Darling Basin in 2006/7, 31% of dairy farms engaged in temporary trading, the largest group amongst the main agricultural industries (Oliver et al., 2009). Dairy farmers were the most prominent water buyers, as they sought to offset low seasonal allocations.

#### **2.4.3. Trade and the future**

Volumes of water traded have increased in recent years. The National Water Initiative aims to increase water markets and trade (NWC, 2009). It is argued that existing barriers to trade, such as exit fees and limits to inter-regional trade, should be lowered (Productivity Commission, 2006). Overall, therefore, it seems likely that trade, including inter-regional trade, will increase.

Peterson et al. (2004), showed that lowered water availability in the future (cf Section 2.2.1, above) will reduce the gross regional product in the Murray–Darling Basin; the reduction will be greatest with no trade and least with free trade under a removal of barriers. Under a 10% reduction in water availability, the dairy industry output was projected to fall by some 8% with intra-regional trade, and by 4% with the removal of barriers to inter-regional trade.

### 3. WATER IN DAIRY INDUSTRY

#### 3.1. Conceptual water balance for an irrigated and a rainfed dairy farm

A farm water balance shows where water comes from, where it is used and where it ends up. It is used to determine where the main opportunities are to save water, how water may be managed better and how much must be managed as effluent. Water balance calculators, such as that available from SEQIF (2009), which focus on effluent management are available for dairy farms. This report focuses on the main components of a whole farm water balance. While the principles and general figures are well known, we are not aware of a published water balance for Australian dairy farms.

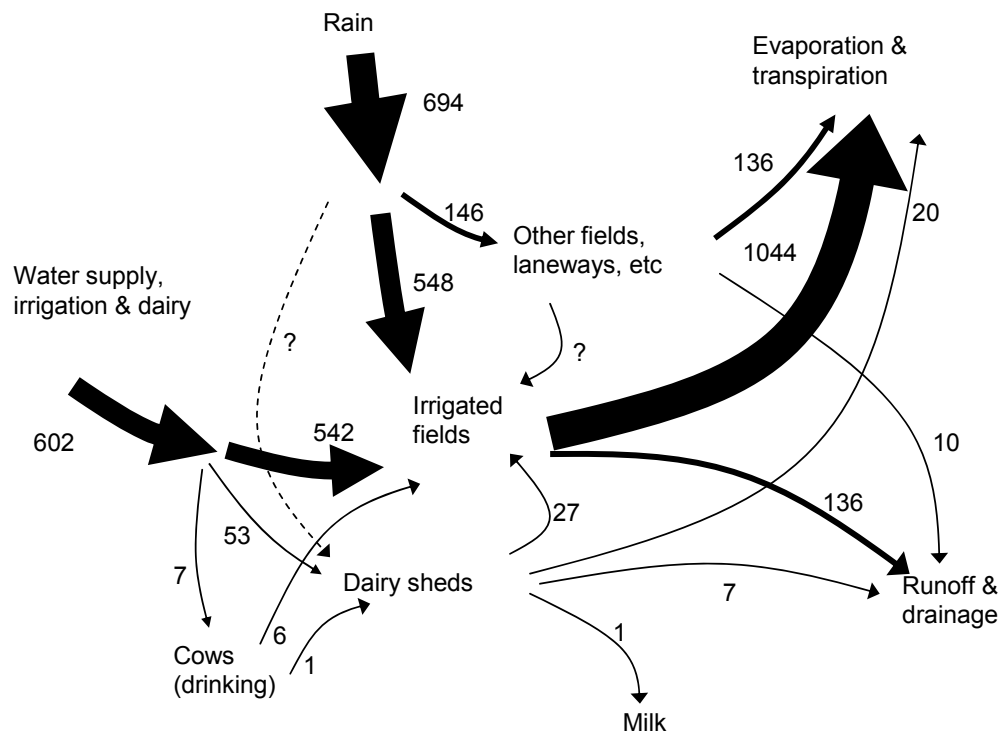
Water is used on a farm for three main activities: growing pastures, dairy shed operations and cleaning, and for drinking by the dairy cattle. Pasture growth may be entirely rainfed, or irrigated in addition to the rain. Many farms have some irrigated pastures and some that are rainfed only (Watson, 2006). We develop a conceptual water balance for an irrigated farm, with figures broadly representative of a farm in the Tatura district of northern Victoria, and for a rainfed farm, with figures broadly representative of a farm in the Burnie district of northern Tasmania. We emphasise that the water balances are conceptual, and the figures illustrative of the regions. Actual water balances will vary from farm to farm according to many factors, including:

- the way the farm is managed
- the extent to which bought-in feed substitutes for pasture grown on the farm
- soil type
- depth to groundwater and
- whether effluent waters are recycled to irrigation.

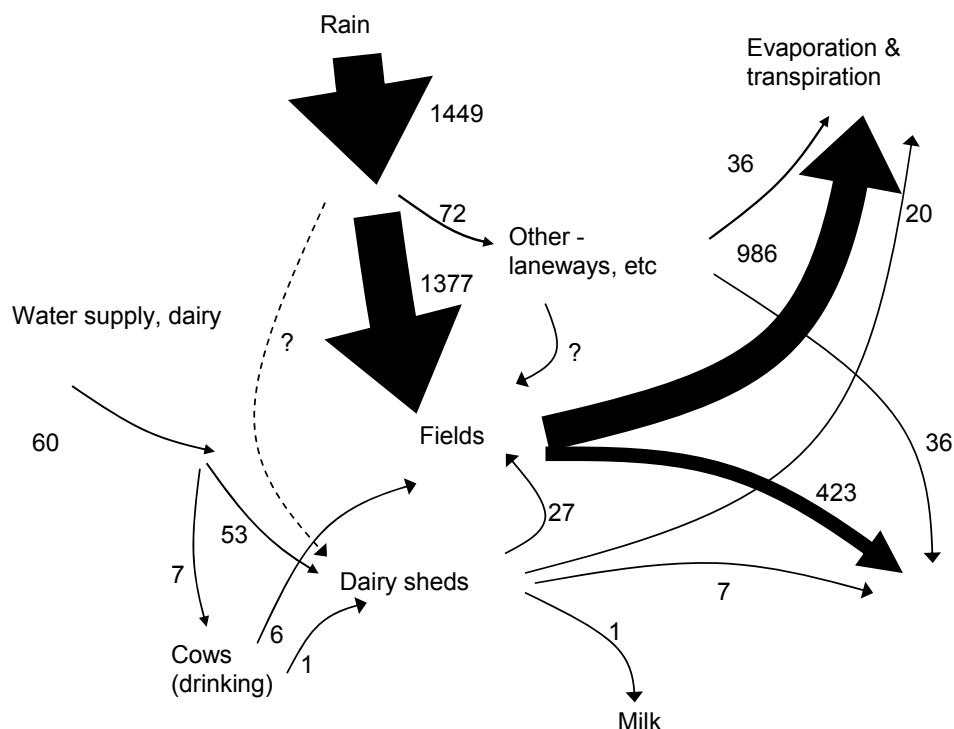
In northern Victoria, the average farm size is around 147 ha with 222 dairy cows, and the average annual rainfall at Tatura is 472 mm (based on 100 years climate figures obtained from SILO). The Murray region as a whole used 1347 GL of supplied water in 2006 on 2238 farms, with an average use of 602 ML, and with an average proportion of 79% of the land irrigated (Watson, 2006). We further assume that: 90% of the supplied water was used for irrigation and 10% for drinking and dairy shed operations (SaveWater, 2009); each cow drank 85 L/day, giving an overall consumption of 7 ML for the year. From these figures, we developed a conceptual water balance (Figure 10). The implied water application (rain plus irrigation) on the irrigated pastures is 938 mm, and the implied evapotranspiration is 899 mm.

The proportions of pasture water use which ends up as evaporation and transpiration to drainage and run-off are based on calculations using the SWAGMAN plant growth / water use model (Xevi et al., 2002), which we used to simulate both irrigated and non-irrigated pasture growth under the climate of the last 100 years (from SILO). Half the shed effluent is assumed to be recycled, with the rest stored in ponds from which it mostly evaporates with some drainage and run-off. Recycling and effluent management varies from farm to farm.

The conceptual water balance of the rainfed farm in the Burnie region is based on an average annual rainfall of 986 mm (SILO figures). We assumed a farm of the same size and same sized herd (147 ha and 222 cows, both of which are close to the average for the area), and further assumed that the water for drinking and shed operations would be the same as at Tatura to develop a conceptual water balance (Figure 11). We simulated that water ending up as evaporation and transpiration using SWAGMAN, and the implied evapotranspiration is 706 mm; as expected, this is somewhat lower than that at Tatura. Also, as expected, the run-off and drainage is greater for the Burnie simulation than for that in Tatura. We emphasise that this is an illustrative calculation, not based on accurate measurements of crop water use and soil water.



**Figure 10. Conceptual water balance for an irrigated dairy farm near Tatura, with illustrative volumes (ML). The larger arrows are approximately proportional in size to the volume of water they portray. The input and output of the dairy shed does not quite match due to rounding.**



**Figure 11. Conceptual water balance for a rainfed dairy farm near Burnie, with illustrative volumes (ML). The larger arrows are approximately proportional in size to the volume of water they portray. The input and output of the dairy shed does not quite match due to rounding.**

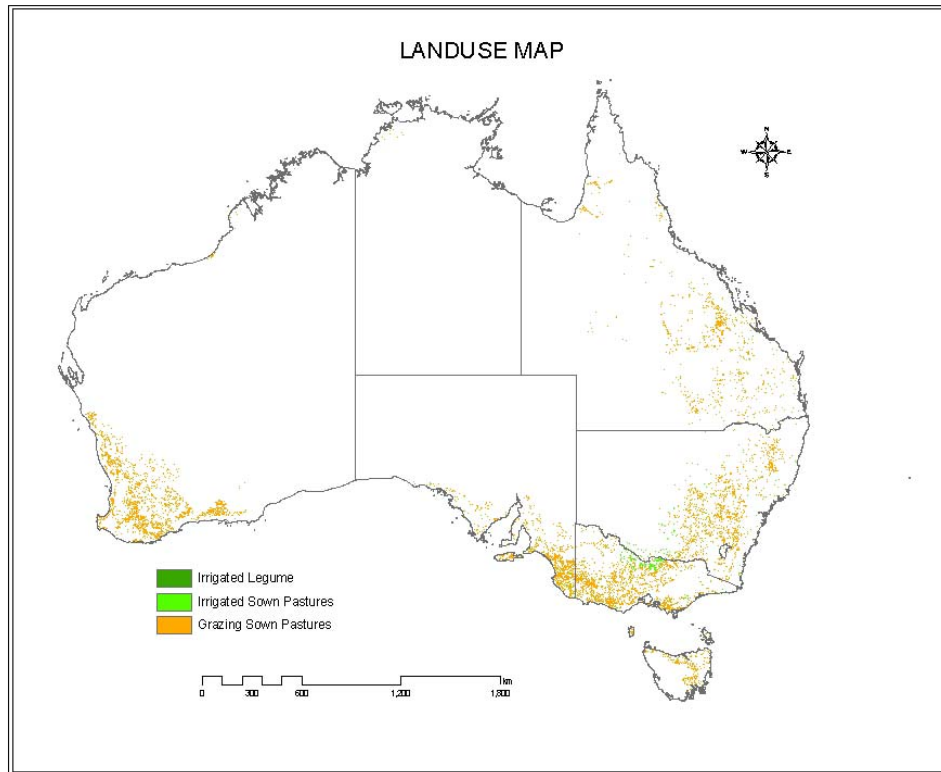
The conceptual water balances illustrate that on both types of farm, the main use of water is in growing pastures. This feature leads to the focus on pasture management for the improvement of water use efficiency on dairy farms (Bethune and Armstrong, 2004).

Most of the water is lost through evapotranspiration, with the next largest loss to drainage and run-off. The run-off may potentially include high levels of nutrients and pollutants from

the pastures and the dairy sheds, and this presents another key management issue for the dairy industry.

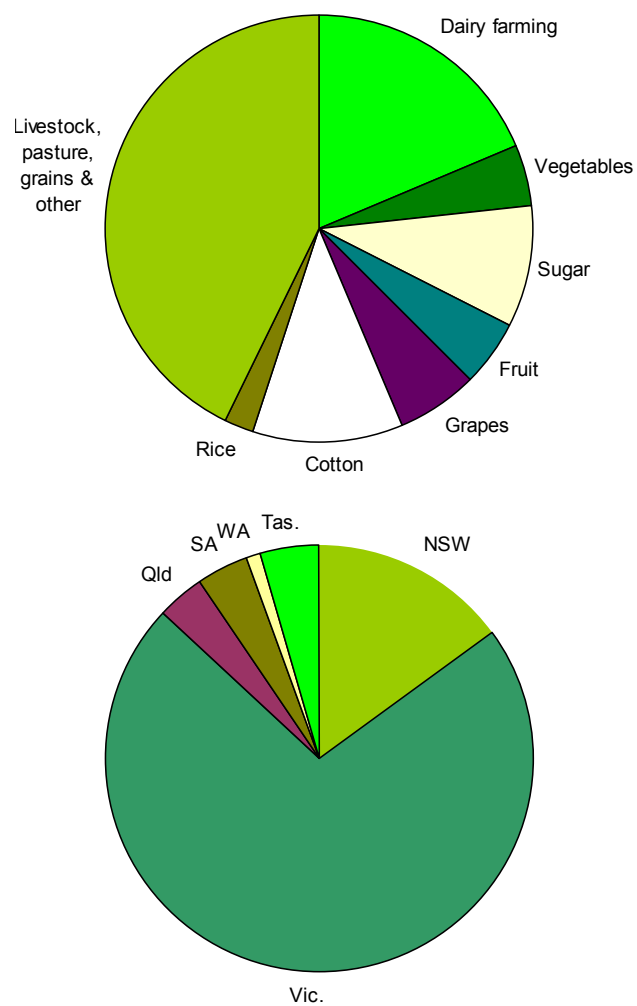
### 3.2. Water use for pastures

#### 3.2.1. Overall industry water use

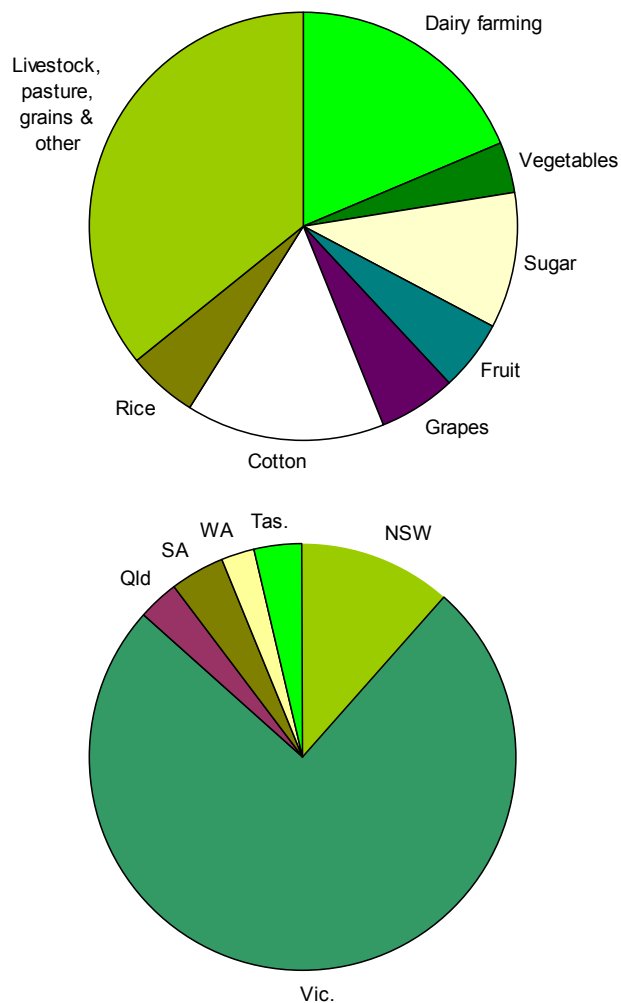


**Figure 12. Irrigated legumes, irrigated pastures and sown pastures in Australia**

For Australia as a whole, the area of irrigated crops and pastures (2.4 million ha in 2004/05 down from 2.6 million ha in 2000/01) is a minute proportion (0.4%) of the total area of agricultural land (about 466 million ha); and it is around 11.7% of the total area of crops and pastures (including irrigated and dryland) (see Figure 12). In the Murray–Darling Basin, which dominates irrigation in Australia, the total area of irrigated crops and pastures is nearly 1.5 million ha. This represents 71.1% of the total area of irrigated crops and pastures in Australia (about 2.1 million ha). Around 443 000 ha of land were under irrigated dairy farming in 2004/05, down from 479 000 ha in 2000/01. Irrigated dairy farming represents 18% of the total irrigated land (Figure 13a). Irrigated dairy farming mostly involves pastures for grazing. Victoria alone accounts for 72% of irrigated dairy farming by land area (Figure 13b).



**Figure 13. a. Distribution of irrigation area by irrigation industry. b. Distribution of area of dairy farming by state.**



**Figure 14. a. Distribution of water use by irrigation industry. b. Distribution of area of dairy farming by state.**

Water use by dairy farming is about the same of the total water use as the land devoted to dairy is of the total irrigated land (compare Figure 13a ad 14a). Rice, in contrast, is a heavy user of water, and its proportion of the water use is greater than its proportion of land area; livestock and other uses proportionally less water. As with the land use, Victoria dominates the water use with in the irrigated dairy industry (Figure 14b). Bethune and Armstrong (2004) described that over 40% of water diverted for irrigation is applied to irrigating pastures in the MDB. The Murray dairy region (northern Victoria and southern New South Wales) consumes 64% of irrigation water used in Australian dairy industry (Pomfret, 2000).

### 3.2.2. Water use in pasture growth

Dairy pastures are mostly irrigated with border-check irrigation systems having 50–60% application efficiency. Border-check irrigated pastures differ from rain-fed pastures in that water is applied by surface flooding; water is ponded in the paddocks for several hours and then run-off is collected from the end of field at the end of irrigation. With this irrigation method, there is a risk of increased deep percolation resulting to high watertable and salinisation. Other options may improve irrigation management to reduce groundwater accessions and to alleviate salinity problems arising from shallow water tables. They are: monitoring soil moisture, irrigation scheduling, swapping to sprinkler irrigation, effluent re-use and agronomic practices.

Dairy pastures in northern Victoria typically require about 800 mm (8 ML/ha) of irrigation water for perennial pastures, whereas winter growing annual forage requires 300–700 mm (3–7 ML/ha) (Armstrong et al., 2000; Bethune and Wang, 2004; Greenwood et al., 2008. Greenwood et al., 2009; Qassim et al., 2008; Stockdale, 1986). More irrigation water is required in a drought. According to Greenwood et al. (2009), in experimental pasture plots



approximately 85% of the applied water (rain plus irrigation) was consumed as transpiration. They conclude that there is therefore little opportunity to reduce water use through more efficient irrigation or better pasture management. Linehan et al. (2004), based on farm surveys in 1994/05 and 1995/06, observed that water use efficiency (defined as milk produced per megalitre of water) did not increase in drier periods, and concluded that tactical options to increase water use efficiency were either limited or not a priority for dairy farms. The main opportunities for increasing water productivity are therefore through selecting more productive pastures, and growing pasture during periods of lower potential evapotranspiration (i.e. in the cooler half of the year) (Greenwood et al. 2009). The greater water requirement in dry years leaves the industry vulnerable to climate change and droughts.

The water balances at the field level reported by Greenwood et al. (2009) and others above give greater water use and irrigation application than those implied by the conceptual whole farm water balance (see Section 3.1). The differences arise because the conceptual farm water balance was calculated 'top-down', using figures for the water supplied to farms at the industry level, and then splitting this into components of water use for a hypothetical average farm. The irrigation water use component is based on the reported percentage of the farm under pasture (Watson, 2006), and makes no attempt to differentiate types of pasture or forage. The values reported by Greenwood et al. (2009) are for experimental plots, whereas those reported by Armstrong are for 1994/05 and 1995/06, and are based on multiplying Class A pan evaporation by 0.8.

### **3.2.3. Managing with water restrictions**

The COAG water reforms of 1994 opened a new era in the market of irrigated agriculture. After the separation of land and water rights, water became a tradable commodity. The highest risk factor for Australian agriculture is extreme, long-lasting droughts. Dairy farmers have to manage water resources under water restrictions and in drought years. Decisions involve balances between short-term and long-term effects. The choices include:

- pasture management – grazing rotations, irrigation management, making better use of fertiliser
- alternatives to pasture management – buying supplementary feed or suffering reduced production
- more difficult choices such as replanting perennial pastures or perhaps culling the herd
- whether to buy or sell water on the temporary market (or, indeed, the selling of entitlement presumably as an exit strategy).

Ho et al. (2007) showed that the best option for managing under reduced water allocations depends on characteristics of the farm. In a comparison of two farms, they found that the impact of reduced water allocations was greater on one than the other largely because the second farm had already implemented changes, including by changing some perennial pasture to annual, that left it less water reliant; but also that it had fewer options open. The first farm could mitigate the impact of lower water allocations by converting some perennial pasture to annual pasture.

Smith and Mallamaci (1994) recommend developing a water budget and considering options. When water is limited, the following stepwise approach to different levels of water shortage is recommended:

- avoid stretching irrigation intervals
- water quickly to reduce deep drainage
- water for short durations, thus giving stress (deficit) irrigation
- purchase more water

- concentrate water on productive parts of the farm, drying paddocks off in the following order:
  - paddocks to be laser levelled in the current season
  - poor performing paddocks in need of renovation
  - other poor performing paddocks
  - paddocks that take a long time to irrigate.

Smith and Mallamaci (1994) outlined a water budgeting process for a drought year.

### 3.3. Water use per litre of milk and a lactating cow

According to the Save Water website (SaveWater, 2009), top operators in the dairy industry produce 2000 litres of milk per megalitre of irrigation water. This means that 500 litres of fresh water is needed to produce 1 litre of fresh milk. The same website shows that the industry average is 1200 litres of milk per megalitre of irrigation water which is 800 litres of fresh water required to produce 1 litre of milk. Reported benefits and costs of irrigation by MDBC (2006) demonstrate that the production of milk from 1 ML of water on irrigated dairy farms ranges from 600 to 2000 L. This is equivalent to 500 to 1666 litres of water needed to produce 1 litre of milk. Most of the water is that used to grow the pasture, as shown by the farm water budgets above. Given the industry average production of 5231 litres of milk per cow (Table 1), this means that between about 2.5 and 8.5 million litres of water is required to sustain the pasture growth and other operations per cow per year.

### 3.4. Water productivity

Estimating the value of agricultural production that results from irrigation water is difficult in the context that water used by crops comes from a variety of sources. In these estimates, rainwater is not included although it is a significant source of water for irrigated crops, especially the grazing pastures for the dairy industry. The timing and intensity of rainfall affect the amount of rainfall being effectively used by the crops.

Dairy farming is the third largest contributor to irrigated agricultural economy. It grew from \$1.5 billion in 2000/01 to \$1.63 billion in 2004/05 (ABS, 2006) (Figure 15). The growth of dairy is in contrast to an overall decrease in gross value of irrigated production, from \$9.6 billion in 2000/01 to \$9.1 billion in 2004/05. Dairy Australia (2008) gives the total farmgate value as \$4.6 billion with an export value of \$2.9 billion.

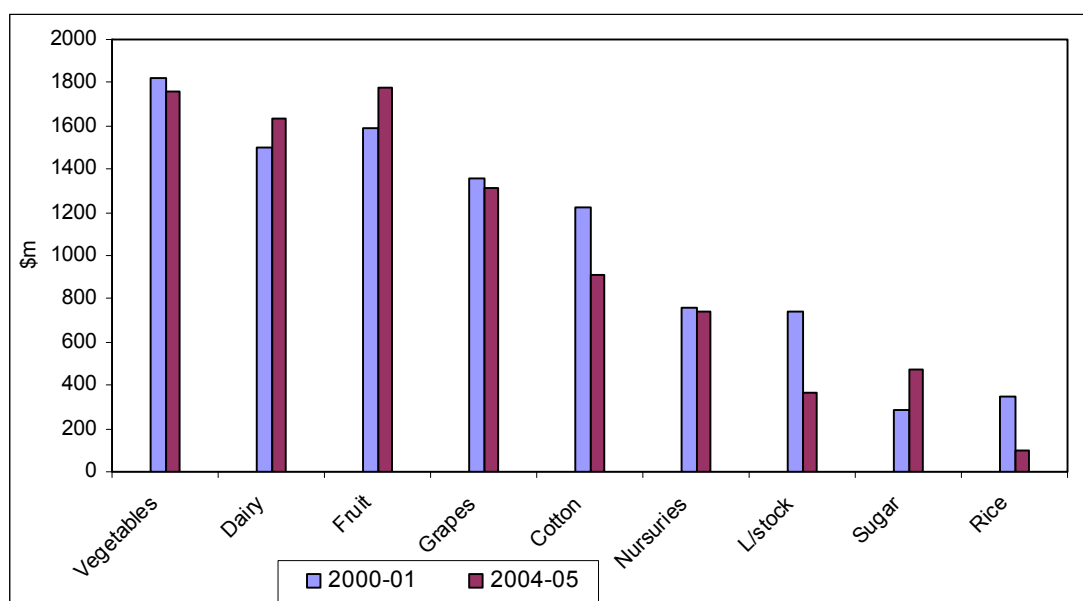


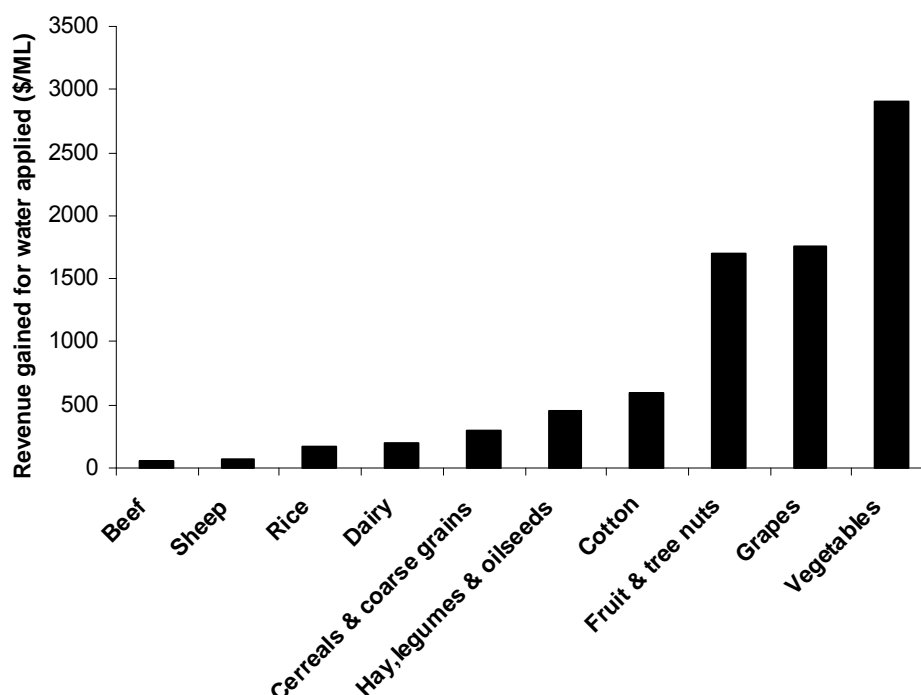
Figure 15. Gross value of agricultural production (Source: ABS, 2006).

Almost 60% of Australian dairy farms have irrigated pastures or fodder crops. This ranges from fully irrigated dairy farms mainly in flood irrigation areas such as the Murray dairy region in Victoria, NSW and South Australia; and the Macalister and Harvey districts, to all other dairy districts where irrigation is used to supplement seasonal rainfall. Victorian dairy has the highest gross values of agricultural commodities when compared to NSW and South Australia (Table 4). Water use figures are somewhat similar in NSW and Victoria. However, South Australian dairy has the highest water use per hectare, but also the highest value per unit of water (Table 4).

**Table 4: Water use and gross value from irrigated agriculture (Source: ABS, 2004).**

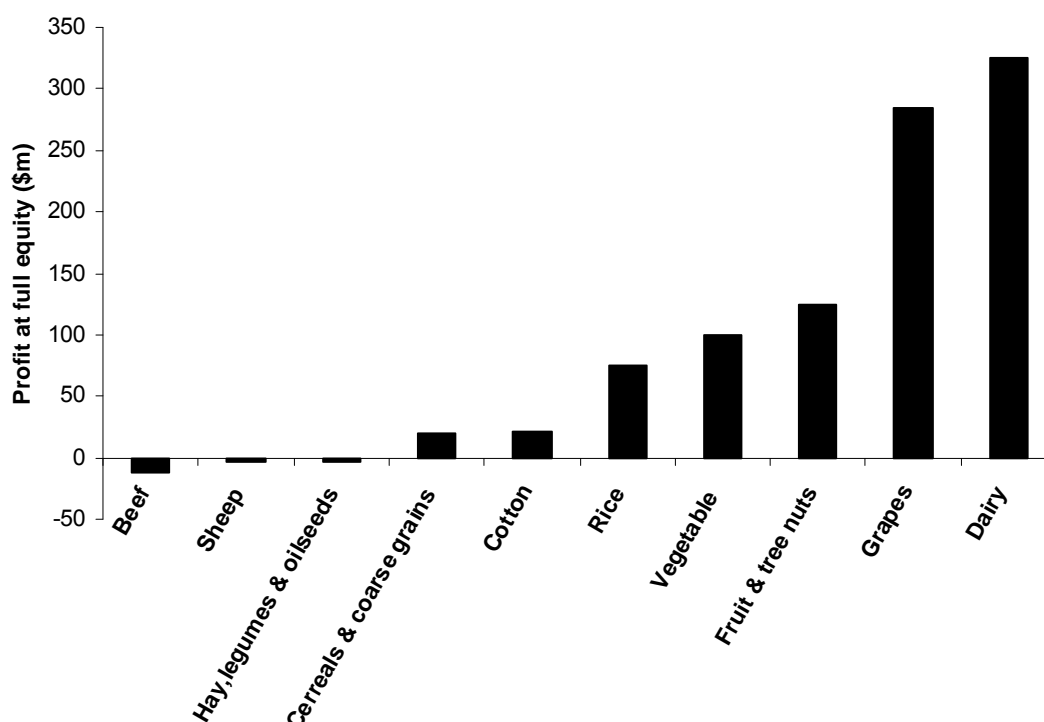
Crops	South Australia		NSW		Victoria	
	ML/ha	\$/ML	ML/ha	\$/ML	ML/ha	\$/ML
Pasture	9	232	5	124	7	315
Dairy	14	394	6	444	5	567
Vegetables	5	3 815	5	2 375	5	3 550
Fruit	9	1 460		1 042	8	1 770
Grapes	5	2 412	5	1 293	7	1 378
<b>Total</b>	<b>8</b>	<b>1 079</b>	<b>6</b>	<b>324</b>	<b>6</b>	<b>691</b>

The revenue (\$/ML) generated from dairy industry is around \$200 /ML of water consumed (Figure 16). From 1997 to 2001, farm revenue generated in the irrigated regions increased by 50%, due to the increased area under cultivation and reasonable commodity prices. In particular, the returns generated by the dairy industry increased by 64%. The largest estimated profit (\$329 million) in 2000/01 was from dairy industry (Figure 17).



**Figure 16. Average farm gate value (Source: CSIRO, 2005).**

Another way of looking at water productivity is the volume required to make \$100 profit. The dairy industry consumes 0.5 ML, which is more than fruit and vegetables, but less than rice (Table 5).



**Figure 17. Profit at full equity from irrigated agriculture (Source: CSIRO, 2005)**

**Table 5: Water required making \$100 profit (Source: Hall et al 1994).**

Agricultural commodities	Water use (ML)
Fruit	0.20
Vegetables	0.46
Dairy products	0.50
Cotton	0.76
Rice	1.85
Pasture	2.78

### 3.5. Environmental challenges

A major environmental challenge in all irrigation areas is shallow water tables, salinity and waterlogging (Bethune and Armstrong, 2004; Meyer, 2005). This results from the combined removal of deep-rooted native vegetation, and application of irrigation water with inadequate drainage of shallow water tables in flat land and has been severe in many areas of the southern Murray–Darling Basin (Meyer, 2005). It reduces farm productivity and increases export of salt into rivers, affecting water quality. In the current drought, with declining rainfall and lesser applications of irrigation water, there is evidence of falling water tables in some areas: Khan et al. (2009) report that the water tables in the Colleambally district have fallen in recent years (though this is mainly a rice farming area, not dairy).

The conceptual water balance (Section 3.1, and Figures 10 and 11) shows that drainage and run-off are the major components of water export from dairy farms after evaporation and transpiration. With an often high input of fertilisers for pasture growth combined with effluent from dairy sheds, the drainage and run-off water is potentially a source of pollution.

Managing the quality of water leaving farms is a major management issue for the industry (Bethune and Armstrong, 2004). Effective management systems are not found on all farms. For example, while 50% of dairy farms in dryland regions of Victoria had suitable dairy effluent systems, only 25% of these were managed effectively in 2000 (IRIS Research, 2000).

Application of waste water to the pasture is the obvious management strategy. Jacobs and Ward (2006) concluded that dairy effluent has the potential to increase dry matter (DM) yields during summer period where feed is often limiting on dryland farms in southern Victoria. However, further work is required to determine long-term sustainable practices for the use of effluent in terms of achieving a balance between production and environmental implications.

Steep land in higher rainfall areas poses special problems. The Queensland dairy industry is mainly in tropical, sub-tropical, coastal and tableland areas with average annual rainfalls greater than 1200 mm. The topography is hilly and often associated with highly permeable red volcanic soils. These conditions limit the use of effluent pond or continuous application systems (Roslyn and Skerman, 2006). In high rainfall areas where the ground is wet for longer periods and steep terrain is common, the risk of effluent entering a watercourse is greater, leading to waste of potentially valuable water and nutrient resources in addition to adverse impacts on the environment (effluent leaching into underlying groundwater).

### **3.6. Information needs of the dairy industry**

The key priority for the industry is to plan for a future in which less water is likely to be available, because climate change is projected to decrease rainfall, which will increase the requirements for irrigation water but simultaneously decrease availability. Water availability will also decrease with the projected return of water to the environment in the Murray–Darling Basin. The industry requires water market, policy and management information (at the catchment or irrigation system level) to adjust to this future. It will continue to require information on options at the farm level, ranging from water management options to whole farm management where alternatives such as selling water and buying feed are considered.

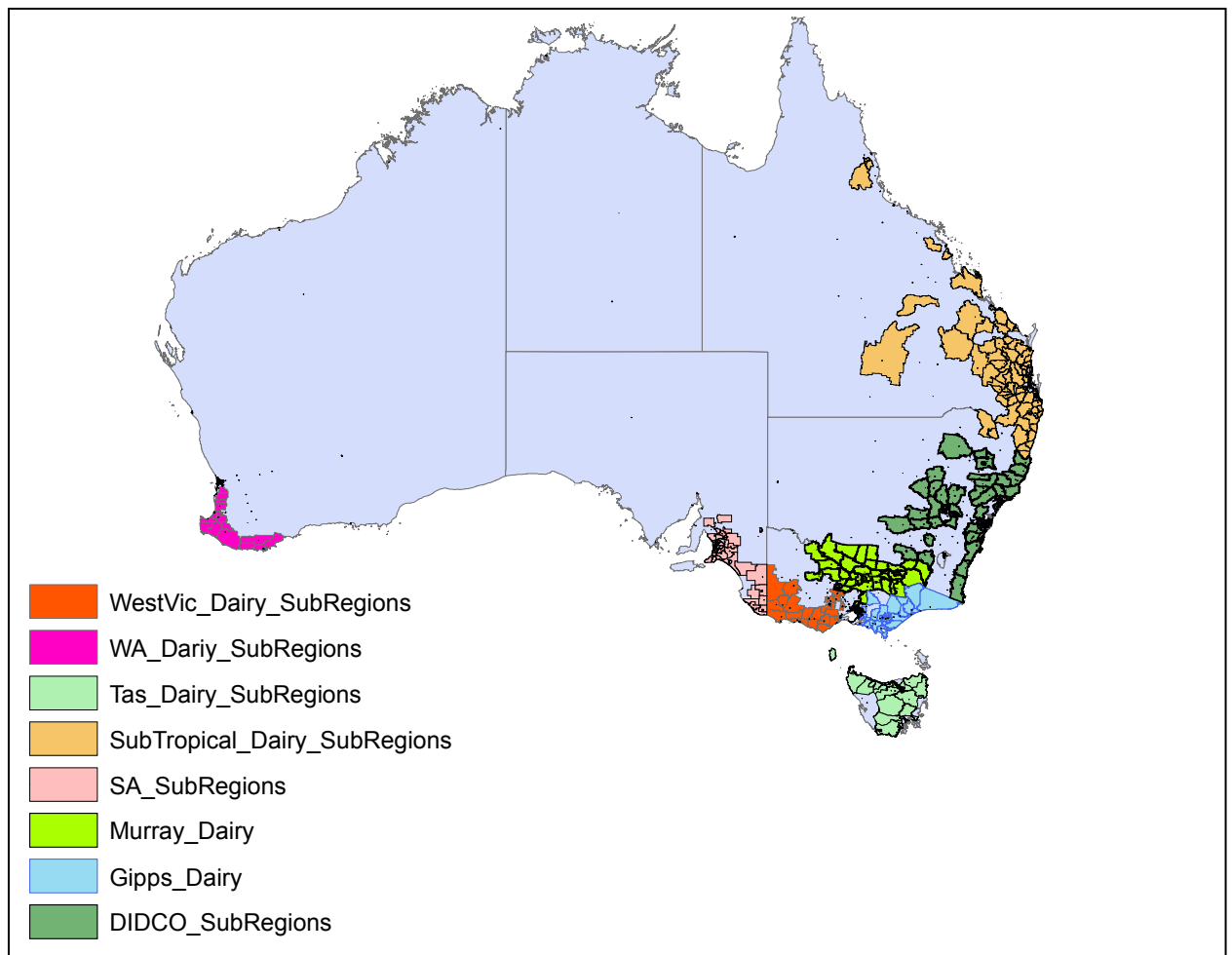
At the field level, Greenwood et al. (2009) showed that dairy pastures can be very efficient in water use. However, there is large range in the amount of irrigation water applied annually, in some cases up to 17.5 ML/ha (i.e. 1750 mm) (Armstrong et al., 2004), indicating scope for improvement in some farms. There is also scope to save water and thus improve irrigation efficiency at the catchment or irrigation system level (Pratt Water, 2004). At both field and system levels, better measurement will enable better management and reduced losses.

The environmental challenges of managing salinity, shallow water tables and farm effluents remain. The industry will continue to need options for managing its environmental impact. As the water available to the industry and to the farm reduces, farm management will change; and there will be a continued need for information and options to adapt to the changes.

## 4. REGIONAL DAIRY PROFILES

Australia has eight dairy regions (Figure 18):

1. Murray dairy region
2. Dairy Industry Development Company (DIDCO) region
3. Gippsland dairy region
4. Sub Tropical Dairy Program (SDP) region
5. South Australia dairy region
6. Tasmanian dairy region
7. Western Victoria dairy region
8. Western Australia dairy region



**Figure 18. Dairy regions in Australia.**

### 4.1. Murray dairy region

#### 4.1.1. Key facts

- The Murray dairy region includes all dairy farming in Northern Victoria and Southern NSW.
- It is Australia's largest dairying region, producing more than 25% of Australian milk.
- The region has approximately 2441 dairy farms that produce nearly 2.56 billion litres of milk per annum.

- It is highly dependent on irrigation with 95% of farms using irrigation and 72% of dairy land under irrigation.

#### 4.1.2. Dairy in the region

Dairying is the region's largest and most important industry. It includes two important irrigation areas: Goulburn Murray Water (GMW) of Victoria and Murray Irrigation Limited of NSW (Figure 19).



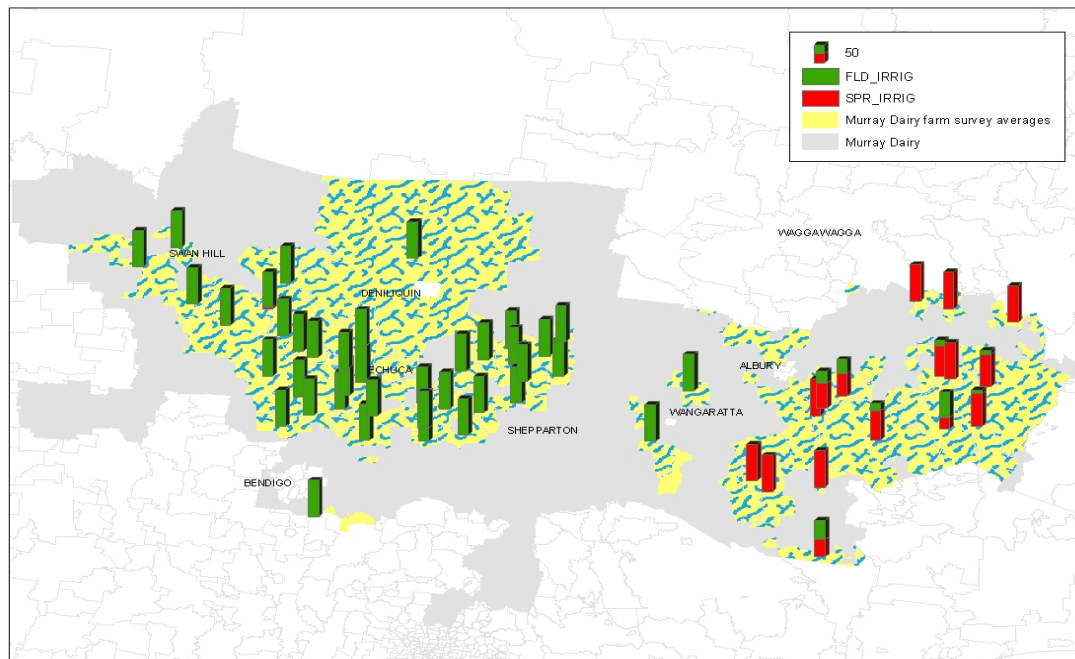
**Figure 19. Murray dairy region location map.**

The total area under irrigation in the Murray region is 234 000 ha. Irrigated pasture (mainly for dairy farming) makes up 65% of the region's total irrigated area. Data taken from the Dairying for Tomorrow dairy farm survey and extrapolated to the region, has been used to quantify irrigated and dryland dairy pasture areas and irrigation water sourced (Table 6).

**Table 6: Dairy region figures based on national dairy farm survey**

2005/06 region statistics	Murray dairy region
Number of dairy farms	2 441
Total grazed area (ha)	354 637
Irrigated pasture (ha)	234 073
Number of milking cows	536 772
Mean milking herd size	222
Water sourced (GL)	
Average rainfall year	1 392
2005/2006	1 349
Irrigation intensity (ML/ha)	
Average rainfall year	5.4
2005/2006	5.2

Most water use is through regulated, border check surface water irrigation. Groundwater and diversion from drains also make up an important component of the total water use. The dominant irrigation system is border check (flood irrigation). A growing number of farms are implementing more efficient irrigation technologies such as sprinkler irrigation system (Figure 20).



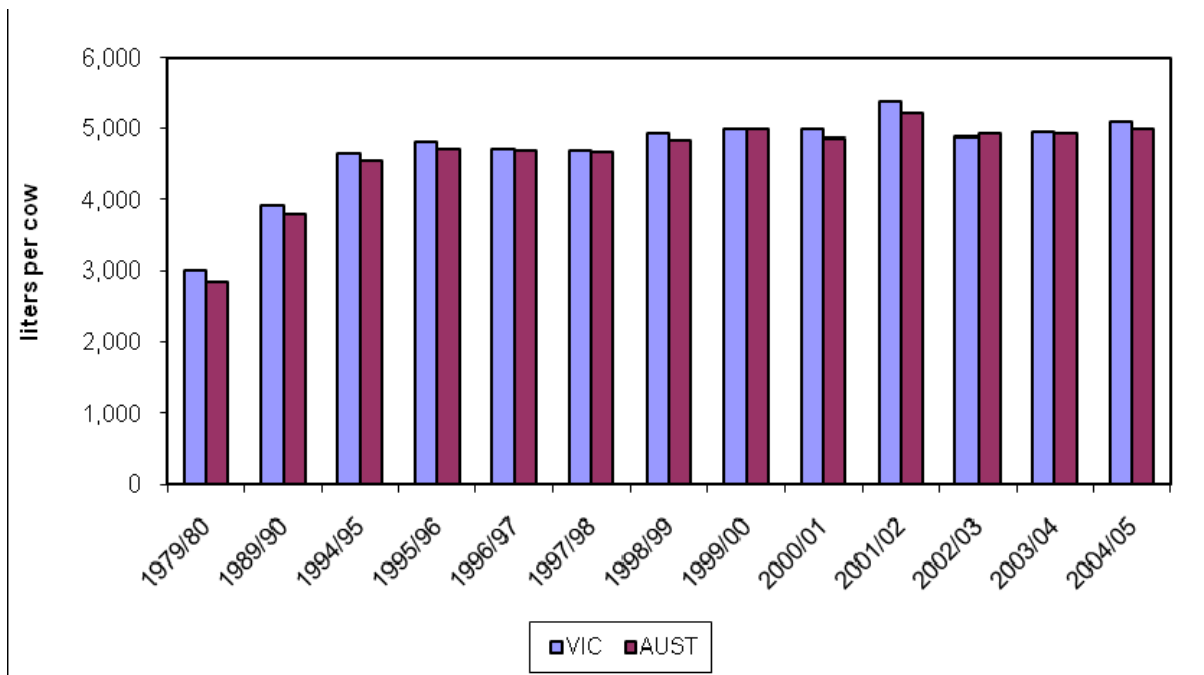
**Figure 20. Common irrigation methods in the surveyed (yellow) dairy region.**

Since 2002, the industry has faced a number of seasonal and economic challenges that have brought about water reforms and industry restructuring. Persistent drought has also reduced farmers' confidence and limited industry growth.

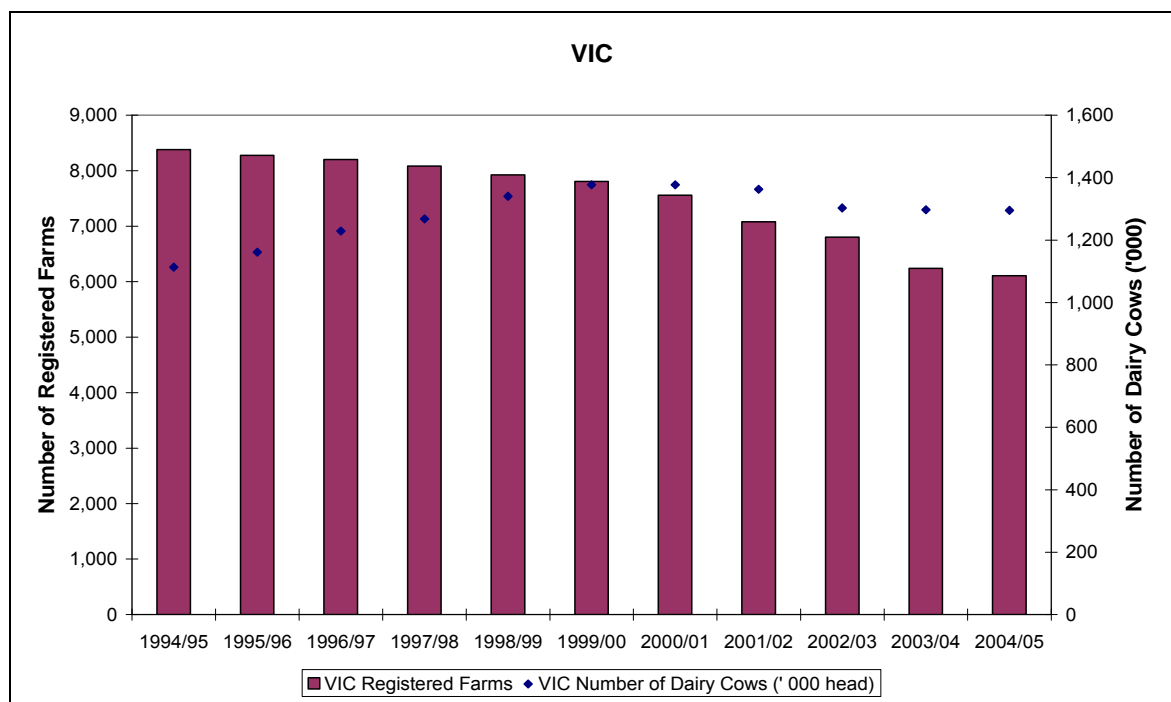
A favourable outlook for dairy exports and improved seasonal conditions has seen confidence begin to return with 65% of dairy farmers (Dairy Australia, 2005) indicating that they intend to expand their businesses. While the operating environment will continue to change, flexibility in resource use can create opportunities for dairy farmers to expand their businesses or for new farmers to enter the industry. The dairy industry in Northern Victoria and Southern NSW is poised for growth.

Milk production rates for Victoria since 1995/96 have remained steady at an average of 4944 litres per milking cow per one lactation period (Figure 21). The dairy industry of the Murray region has a milk production of 2.56 billion litres. . The number of Victorian dairy farms has declined over a ten-year period although the number of dairy cows over the same time has increased ( Figure 22).



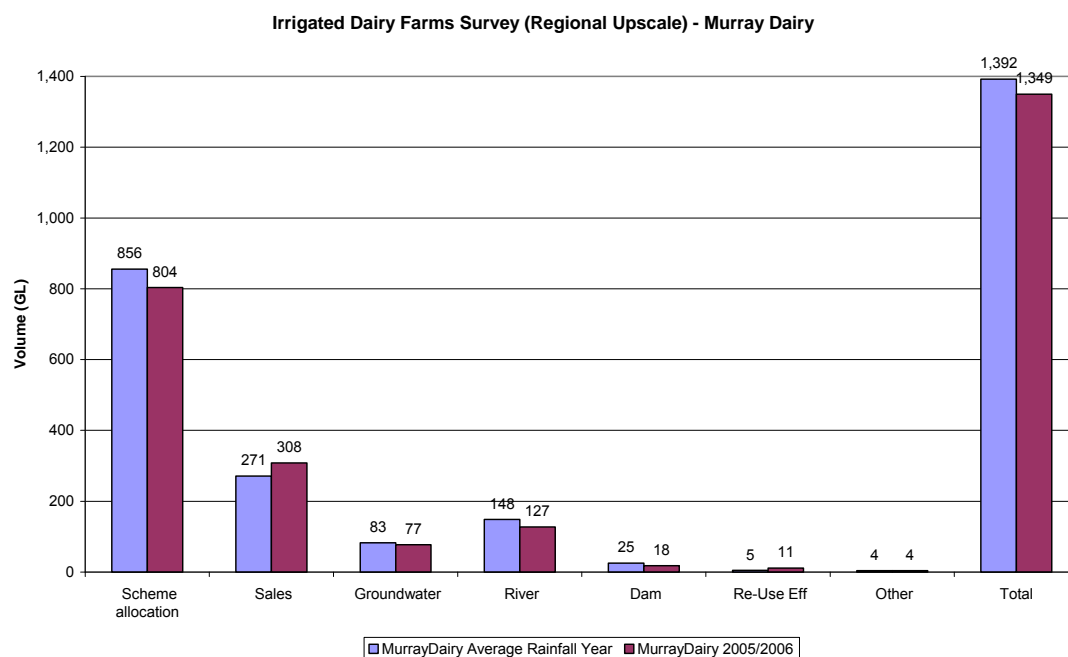


**Figure 21. Victorian milk production rates (L per cow) compared to national average.**



**Figure 22. Number of Victorian registered dairy farms compared to total number of dairy cows (Source: ABS and Dairy Australia).**

The survey data of Watson (2006) have been extrapolated to a regional level. A total of 260 farms were surveyed. Regional water source breakdown figures were estimated for irrigated dairy farms (see Figure 23). Average yearly rainfall data comprises the volume of water sourced by dairy farms in an average rainfall year. The total water use during 2005/06 was 1349 GL of which 59.5% is met from scheme allocations. Twenty-three percent was through water trading. Use of effluent – 11 GL during 2005/06 – increased. . The frequency analysis of the area grazed shows that most farms had a grazing area up to 200 ha (Table 7, Figure 24). Approximately 90 farms had a herd size of 200 (Table 7, Figure 24).



**Figure 23. Regional water sources breakdown figures.**

**Table 7: Statistics of Murray dairy region.**

Statistical Parameter	Area Grazed (ha)	Cows in herd
Number of Farms Surveyed	260	260
Mean	147.07	221.64
Std. Deviation	179.156	133.263
Skewness	9.384	2.672
Std. Error of Skewness	0.151	0.151
Minimum	16	20
Maximum	2,501	1,200

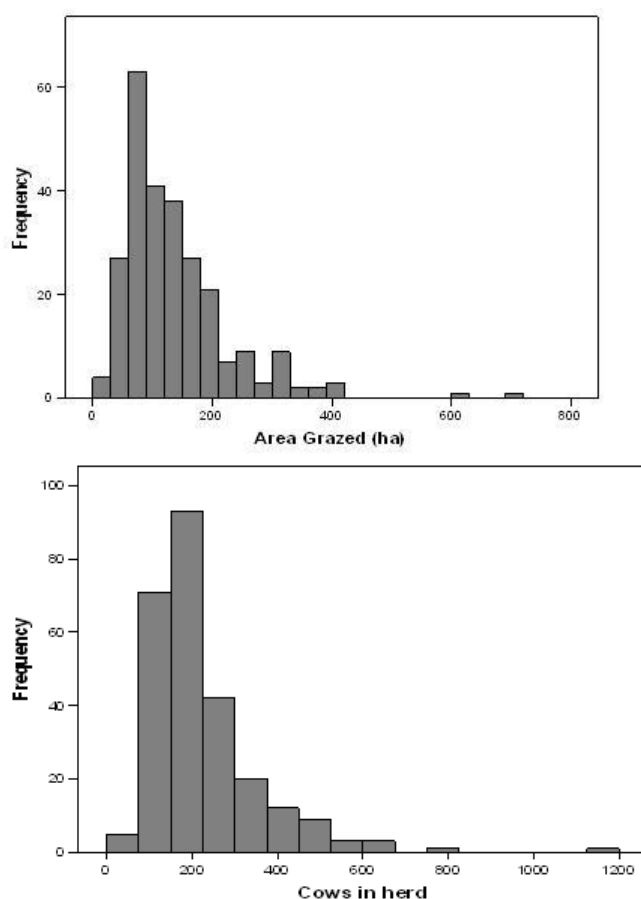


Figure 24. a. Area grazed in the Murray dairy region. b. Number of cows in Murray dairy region milking herd.

#### 4.1.3. Crop water requirements

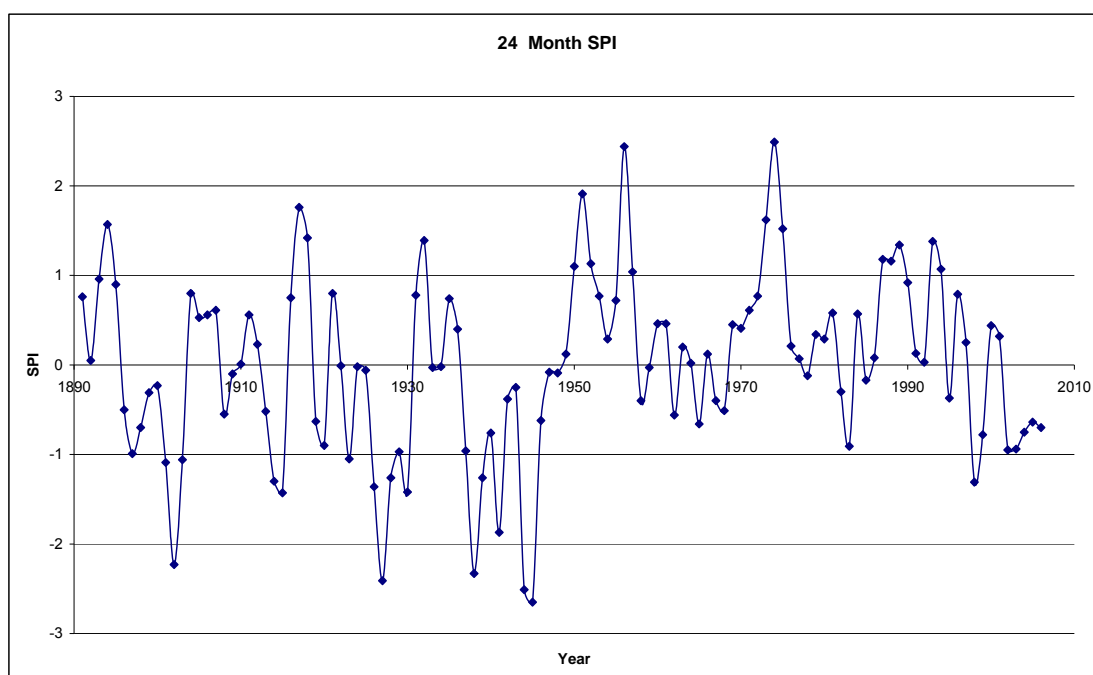
Net CWR and calculations were carried out over Echuca for ten-year period (Table 8).

Table 8: Net crop water requirement for Murray dairy region.

Year	CWR (mm)	Eff rain (mm)	Net CWR (mm)
1995/96	843	330	587
1996/97	908	307	634
1997/98	927	286	641
1998/99	903	339	604
1999/00	893	368	543
2000/01	918	324	616
2001/02	919	263	667
2002/03	982	252	737
2003/04	928	329	632
2004/05	910	365	560

#### 4.1.4. Climate change and impact of drought

The 24-month SPI (Appendix B) for city of Echuca were applied to compare precipitation totals for 1880–2006 with similar periods in history. Large positive SPIs of 24-month intervals across the region were recorded in 1956 and 1974 indicating the extremely wet conditions to severely wet conditions in 1894, 1917, 1918, 1932, 1950, 1951, 1952, 1957, 1973, 1975, 1987, 1988, 1989, 1993 and 1994 (Figure 25). Similarly, large negative SPIs of 24 months indicating extremely dry conditions in 1902, 1927, 1938, 1944 and 1945 to severely dry in 1901, 1903, 1941 and 1999 were recorded (Figure 25).



**Figure 25. Twenty-four-month SPI index of Murray dairy region.**

#### **4.1.5. Key water issues**

Given the region's high reliance on irrigation, high priority was placed on collective investment leading to improved water security, sustainable pricing of water resources, and monitoring the performance of irrigation authorities/companies. This region has been hard hit by the drought. Projects to drive confidence and recovery from drought, and to manage milk price volatility were seen as high priority for future growth and investment. In 2006, RMCG consultants carried out extensive workshops to find out the major water issues related to dairy farming with the local stakeholders and dairy industry people across Australia (RMCG, 2006). The overall objective of the workshops was to consult with the industry across Australia and to develop an irrigation blueprint.

Key issues for this region are:

##### *Goulburn System*

- Pressure on dairy water entitlements with increasing urban water needs
- Uncertainty about water reforms – need to inform and educate farmers
- Lack of understanding about water reforms and the challenge of engaging farmers
- Capital costs of infrastructure and competition on water price by corporate agriculture downstream with tax benefits
- Need to improve the delivery to farm and integrate with on-farm systems
- Smaller systems challenged – Campaspe and Mokoan
- Lack of understanding that properly designed and managed border check irrigation could be efficient on many of the soil types in the region
- Impact of trading on the asset base of the irrigation system
- Impact of trading – review has never been done
- Impact of climate change – longer-term implications on reliability and reconfiguration of dairying
- Equitable loss of water (if less run-off due to climate change) between the environment and consumptive use

- Future environmental flows

#### *Murray Valley*

- Groundwater management plans – Katunga under a new management plan and farmers needing to adjust
- Uncertainty around water reforms and impacts on water entitlements
- Annual water costs – GMW cannot just push costs onto irrigators
- Price per megalitre – a major influence on future water use
- Needs to have a greater uptake of farm automation
- Concern over the management of delivery infrastructure – change in culture at GMW and reversion to a ‘government department’
- Need to improve on-farm infrastructure to increase water use efficiency
- Barmah choke provides some limit to trade downstream from the Murray Valley region. Concern about confidence if choke does not become a limit in the future.
- Impact of trade to NSW if water trading rules are not on a level playing field
- Trading market on the Murray ‘less mature’ than on the Goulburn and more to learn, especially when water is more freely traded

#### *Southern NSW*

- Increased prices if government enters water market
- Long irrigation system and impacts on rainfall events – need some on-route storage
- Need to implement more automation to reduce labour pressure
- Assumption that no water leaving the delivery system is efficient and focus on reducing outflows resulting in poor service standards leading to inefficiency on-farm – need to be able to account for outflows and run the system efficiently
- Dethridge wheel is very old technology – need more effective on-farm measurement to obtain an accurate measure, especially at low flow rates
- Need to ensure rules are set appropriately to ensure no party is disadvantaged during interstate trade

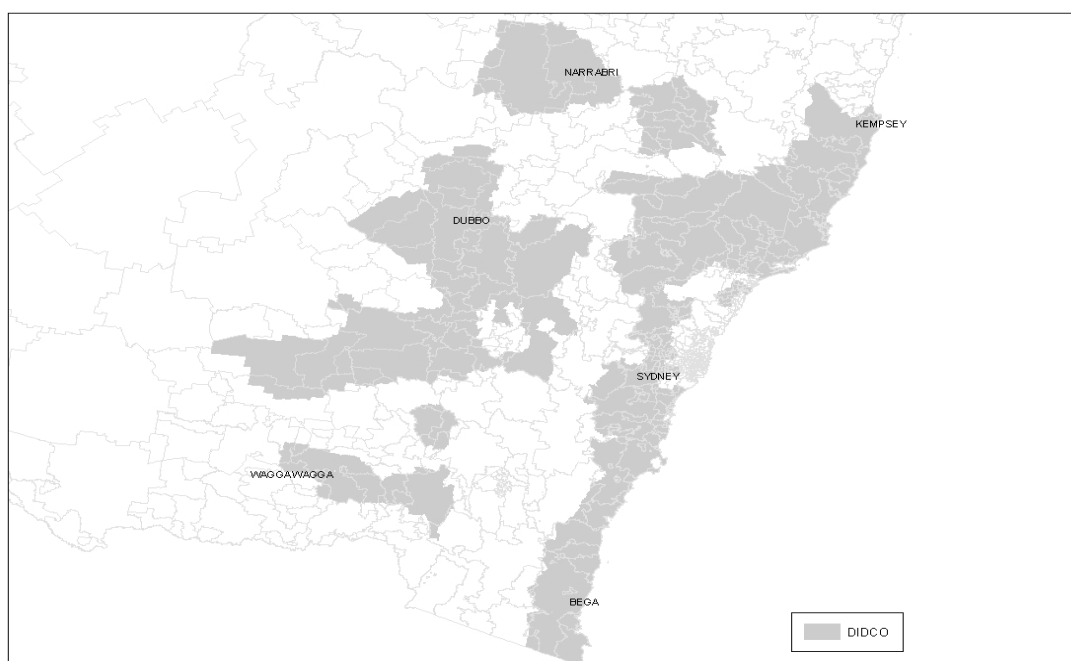
## **4.2. Dairy Industry Development Company (DIDCO) region**

### **4.2.1. Key facts**

- The region has 612 farms producing 0.80 billion litres of milk each year.
- Average farm herd size is 220 cows with average production of around 5000 litres per milking cow

### **4.2.2. Dairy in the region**

The DIDCO includes Central NSW (Wagga Wagga to Tamworth), NSW North Coast (Richmond River System), Hunter Valley, and Southern NSW (Bega) (see Figure 26). The region has a high reliance on irrigation with 22% of the dairy land area in southern and central NSW and 39% of dairy farms dependant on irrigation (Dairy Australia, 2006a).



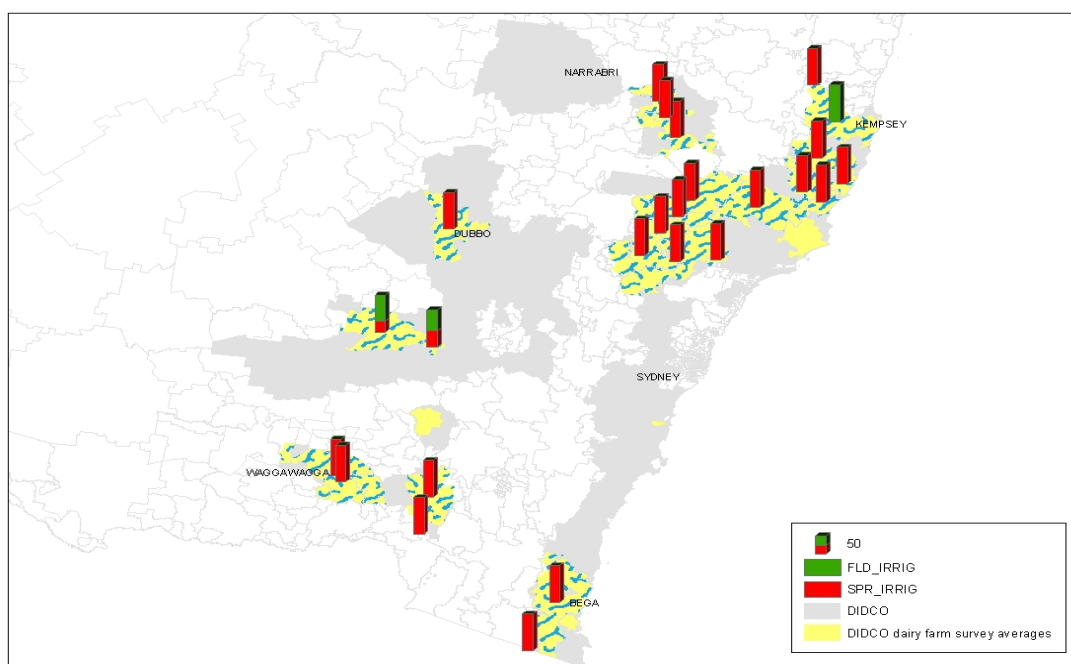
**Figure 26. Location of the DIDCO region.**

Irrigation water is sourced from both regulated and unregulated streams, groundwater and on-farm storage. Irrigation is dominated by pressurised sprinkler systems including other irrigation systems. Many of the on-farm irrigation systems are old and inefficient; pressure on the systems to improve their efficiency will therefore continue. An average sized dairy herd in the region in 2005 was 221 cows – slightly less than the national average of around 228 (Table 9).

**Table 9: Dairy region figures based on national dairy farm survey.**

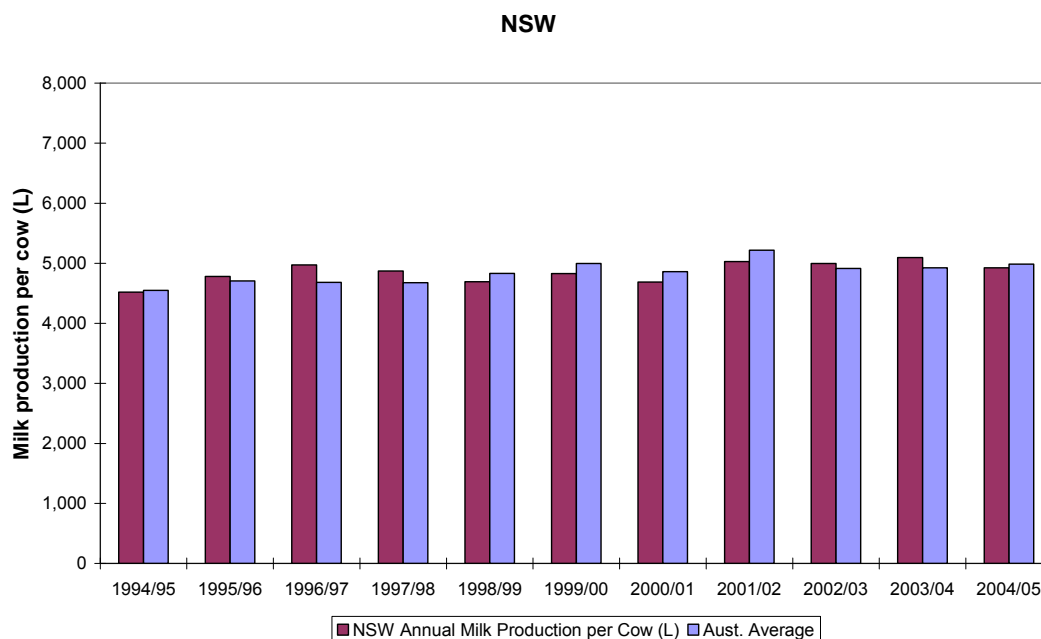
2005/06 region statistics	DIDCO region
Number of dairy farms	612
Total grazed area (ha)	88 850
Irrigated pasture (ha)	31 704
Number of milking cows	135 262
Mean milking herd size	221
<b>Water sourced (GL)</b>	
Average rainfall year	171
2005/2006	123
<b>Irrigation intensity (ML/ha)</b>	
Average rainfall year	4.9
2005/2006	3.5

Raw data from Dairying for Tomorrow 2006 survey (Watson, 2006) has been extrapolated to the region (Figure 27). Sprinkler irrigation (red bar) is the most common method in the region while flood irrigation (green bar) is not concentrated in any single region.

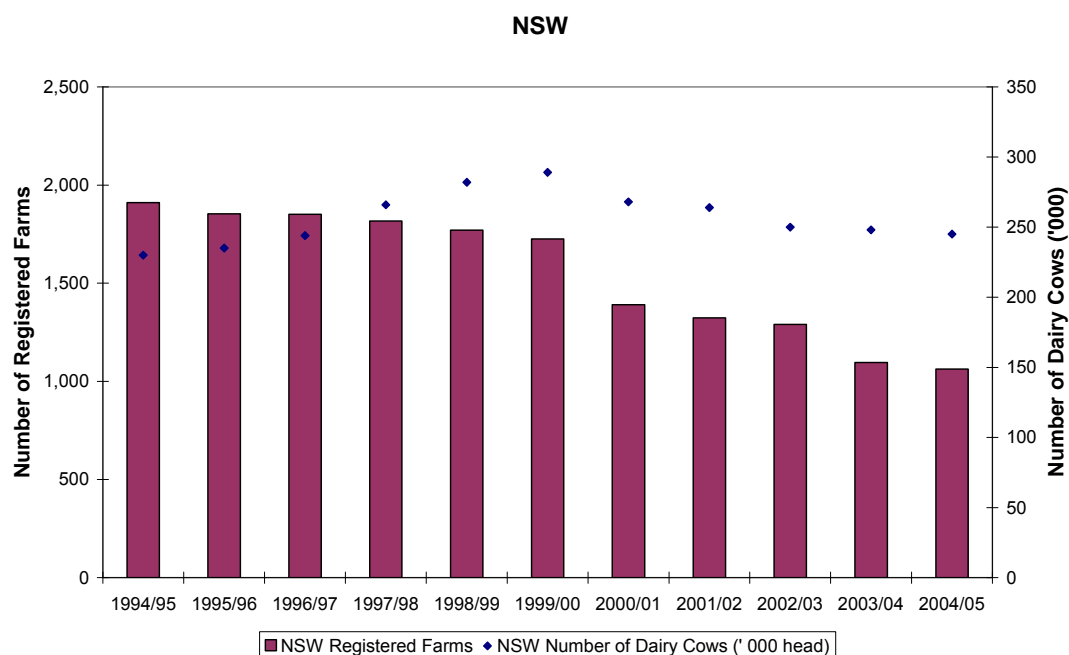


**Figure 27. Common irrigation methods in the surveyed (yellow) dairy region.**

The milk production rates for NSW State have remained steady over ten years (Figure 28). The dairy industry of DIDCO region has a milk production of 0.80 billion litres, In NSW, on average, it has been 4887 litres per milking cow per one lactation period since 1995/96. However, a decline in registered NSW dairy farms has occurred over a ten-year period, similar to national trends, as well as an increase of dairy cow numbers in the state over the same period of time (Figure 29).

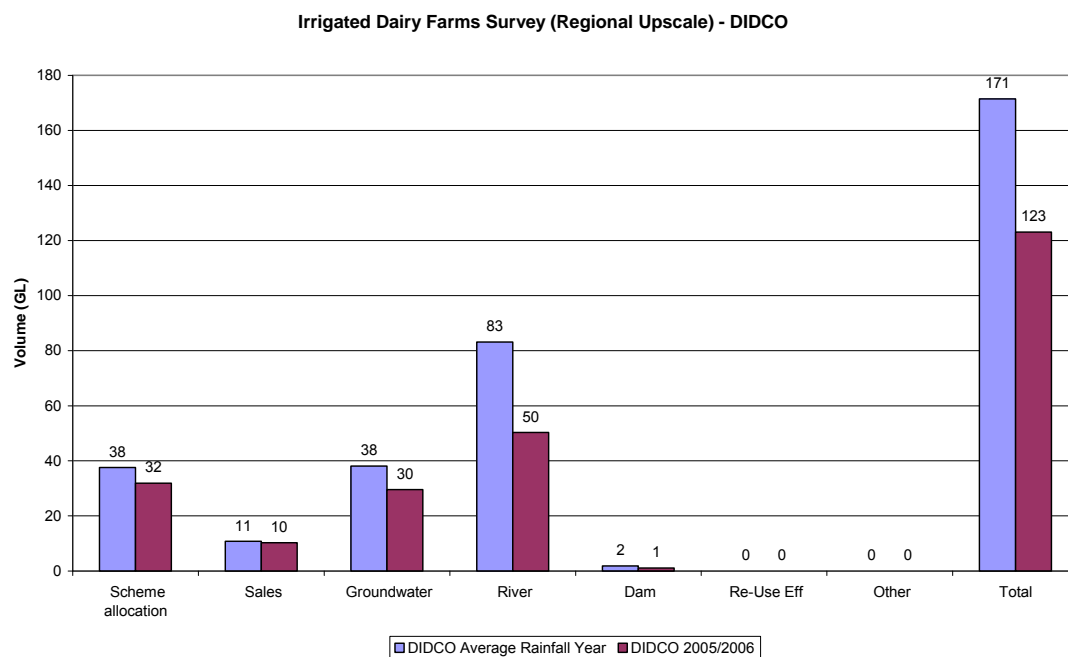


**Figure 28. NSW milk production rates (L per cow) compared to national average.**



**Figure 29. Number of NSW registered dairy farms compared to total number of dairy cows (Source: ABS and Dairy Australia).**

A total of 61 farms were surveyed (Watson, 2006) and the data have been extrapolated to the region. The regional water source breakdown figures were estimated for irrigated dairy farms (see Figure 30). Average rainfall year data is the volume of water sourced by dairy farms in an average rainfall year. Total water use during 2005/06 was 123 GL of which 26.01% was met from scheme allocations. Approximately 8% was through water trading. No effluent was used in DIDCO region. The area grazed and cows in herd for the region are shown in Table 10. The frequency analysis of the area grazed shows that majority of the farms have grazing area between 30 ha to 120 ha (Figure 31). There are about 23 farms with a herd size of 150 cows (Figure 31).



**Figure 30. Regional water sources breakdown figures.**

**Table 10: Statistics of the DIDCO region.**



Statistical Parameter	Area Grazed (ha)	Cows in herd
Number of Farms Surveyed	61	61
Mean	145.18	221.02
Std. Deviation	111.918	163.551
Skewness	1.743	1.959
Std. Error of Skewness	0.306	0.306
Minimum	24	53
Maximum	607	850

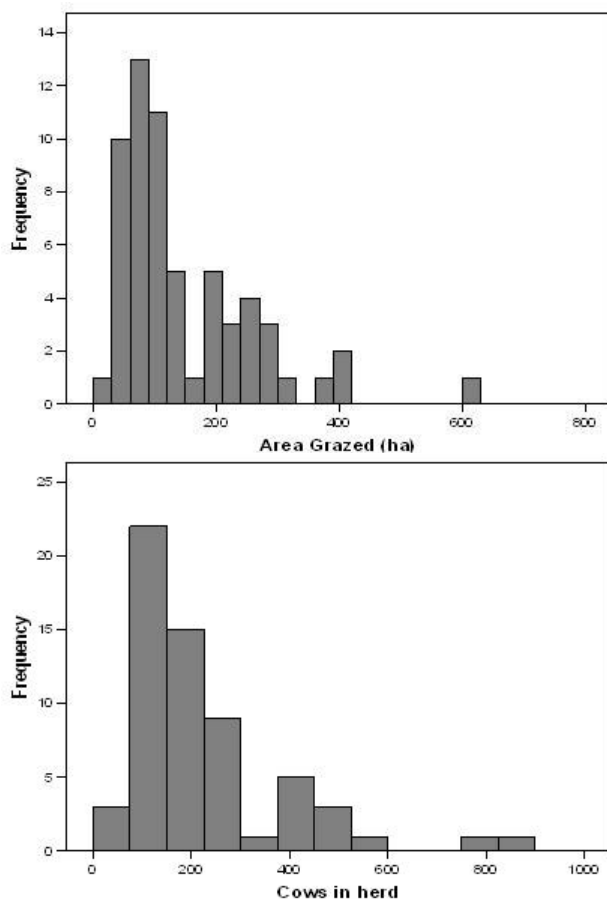


Figure 31. a, Area grazed in the DIDCO region. b. Number of cows in the DIDCO region milking herd.

#### 4.2.3. Crop water requirements

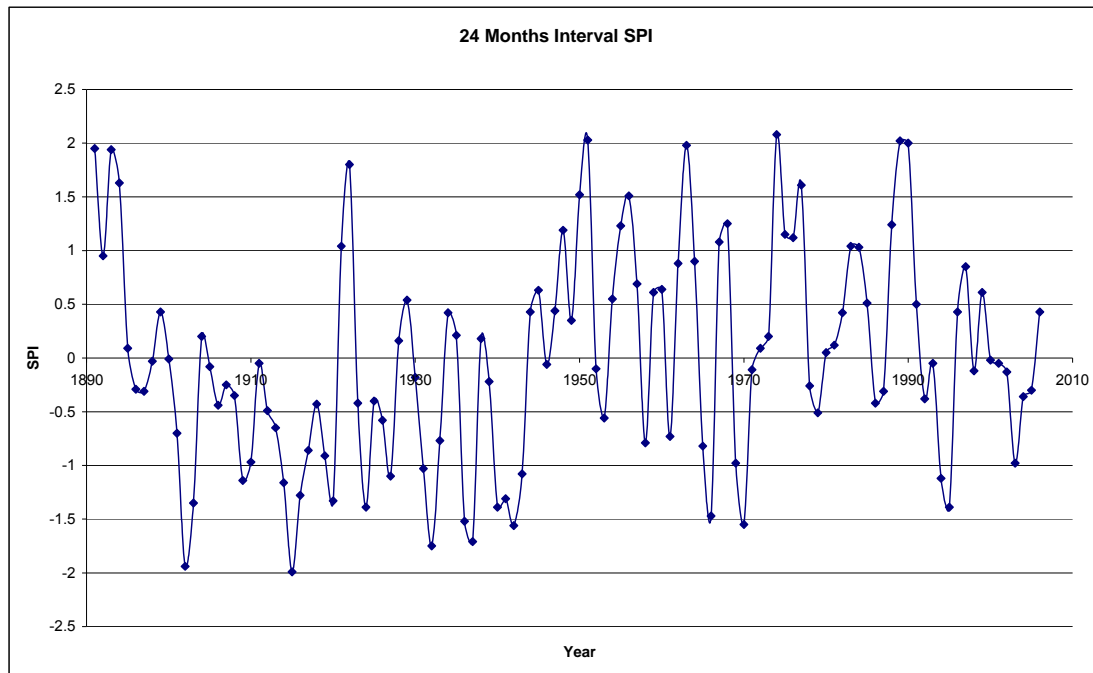
Net CWR and calculations were carried out in Tamworth region for ten-year period (Table 11) (see Appendix A for method).

Table 11: Net crop water requirement (mm) for DIDCO region.

Year	CWR (mm)	Eff rain (mm)	Net CWR (mm)
1995/96	952	469	504
1996/97	949	613	376
1997/98	1 002	398	661
1998/99	873	621	407
1999/00	938	523	449
2000/01	985	505	570
2001/02	1 000	423	596
2002/03	1 049	453	596
2003/04	1 038	605	493
2004/05	1 027	561	552

#### 4.2.4. Climate change and impact of drought

The 24-month SPI (Appendix B) for the city of Tamworth were applied to compare precipitation totals for 1880–2006 with similar periods in history. Large positive SPIs of 24-month intervals across the region were recorded in 1951, 1952, 1974, 1989 and 1990 indicating extremely wet conditions to severely wet conditions in 1891, 1893, 1894, 1922, 1950, 1956, 1963 and 1977. Similarly, the large negative SPIs of 24 months indicating severely dry conditions in 1902, 1915, 1932, 1937, 1942 and 1970 were recorded for Tamworth (Figure 32).



**Figure 32. Twenty-four-month SPI index of Tamworth in the DIDCO region.**

#### 4.2.5. Key water issues

In 2006, RMCG consultants carried out extensive workshops to find out the major water issues related to dairy farming with local stakeholders and dairy industry people across Australia (RMCG, 2006). The overall objective of the workshops was to consult with the industry and to develop an irrigation blueprint.

Key issues for this region are:

*North Coast (Richmond River District)*

- Lack of long-term security and access to entitlements causing uncertainty
- Increasing urban water requirements and urban water demand not included in the water sharing plans (WSPs).
- Full cost recovery and impact on affordability
- Annual cost of water in relation to production/profit
- Land values impacting on viability of dairy operations
- Off-river storage – still possible but uncertain about the future
- Limited information about measuring and monitoring water
- Uncertainty from WSP – must be able to influence
- Value of entitlements unknown therefore little trading
- Restrictions in the one river system – only able to trade with a limited number of other users

- ‘Cease to pump’ rules impacting on access of water when needed
- Over-allocation and concern about how it will be managed
- Recycled water from townships provides opportunities

#### *Hunter Valley*

- Reduced reliability of supply due to climate change and uncertainty around security of entitlements
- Annual cost of water surging ahead of inflation – impact on profitability and annual cost – power, annual water charges.
- Competition for water from other agriculture plus industry (electricity generation)
- Pressure on margins impacting farm viability
- Only 1% of unregulated system metered
- Groundwater converted to volumetric but still not metered
- Dairy uncompetitive and cannot effectively trade
- Increase in subdivisions is increasing water use resulting in over-allocation

#### *Central Region*

- New applications for groundwater providing some opportunities
- Reliability of water as a consequence of climate change
- Cost to implement best management practices – affordability of improved technology
- Challenges in upkeep of infrastructure along the Murrumbidgee
- Trading is very limited
- Local planning rules restricting farm development
- Need to have effective integration of dairy effluent with irrigation systems, along with appropriate guidelines

#### *Bega*

- Need security of supply at an affordable price and currently both under question
- Region highly reliant on irrigation, with 70% of farms using at least some
- High costs of power and annual water charges impacting on-farm viability with flow-on impacts to local communities
- Full cost recovery – a big issue and how it is determined needs to be questioned
- Extra storage required but cost of implementation will be a challenge
- Only 4% of river flows are diverted for the environment therefore opportunities exist
- Short river flows have different issues to address

### **4.3. Gippsland dairy region**

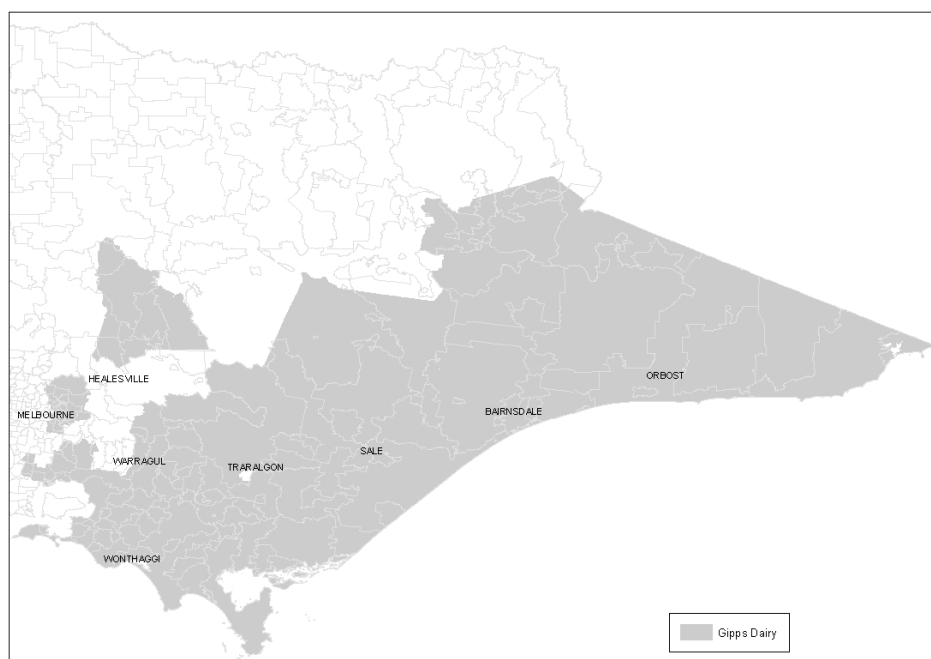
#### **4.3.1. Key facts**

- Gippsland is one of the major contributors to the Australian dairy industry and the Victorian economy.
- Gippsland region has 2030 dairy farms that produce 30% of Victoria's milk and around 20% of the total Australian production.

- In 2003/04, Gippsland dairy farms produced more than 1.96 billion litres of milk with a farm gate value in excess of \$505 million.
- The dairy sector provides direct employment to more than 4700 people, with a further 40 000 deriving a portion of their income from dairying in the region.
- Dairying in Gippsland employs more than 40% of the Victoria's total agriculture, forestry and fishing workforce.

#### 4.3.2. Dairy in the region

Gippsland dairy region is located in the north-eastern part of Victoria (Figure 33). Most farms rely on their own infrastructure to pump directly from regulated and unregulated streams, groundwater systems or on-farm storage. Data taken from the Dairying for Tomorrow dairy farm survey have been used to quantify regional dairy pasture areas and irrigation water sourced at a regional scale (Table 12).

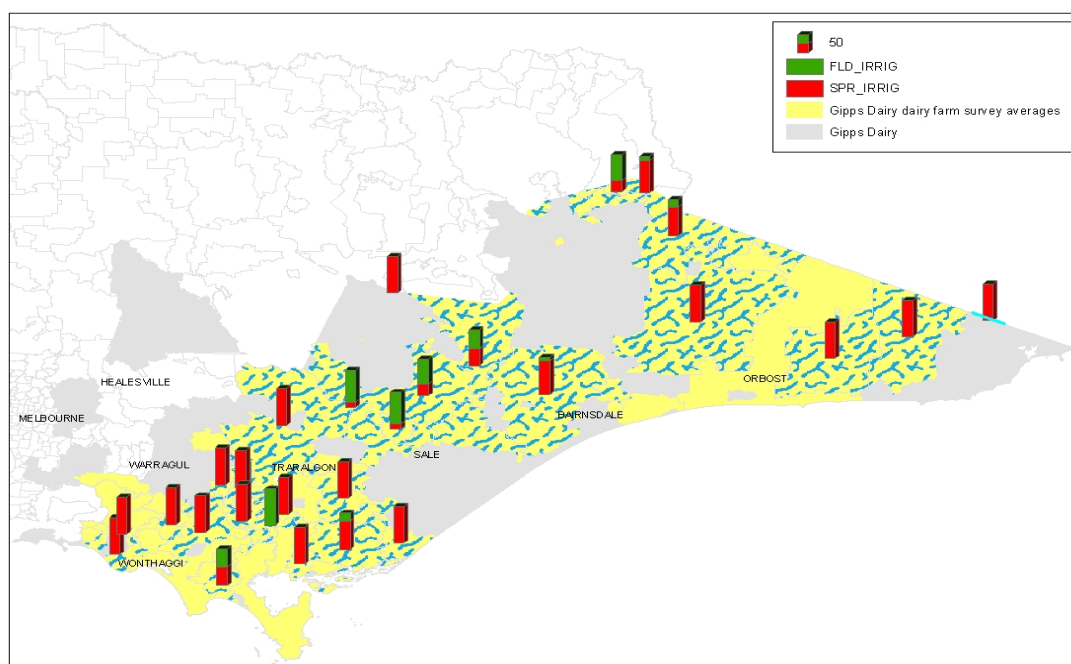


**Figure 33. Gippsland dairy region.**

**Table 12: Dairy region figures based on national dairy farm survey.**

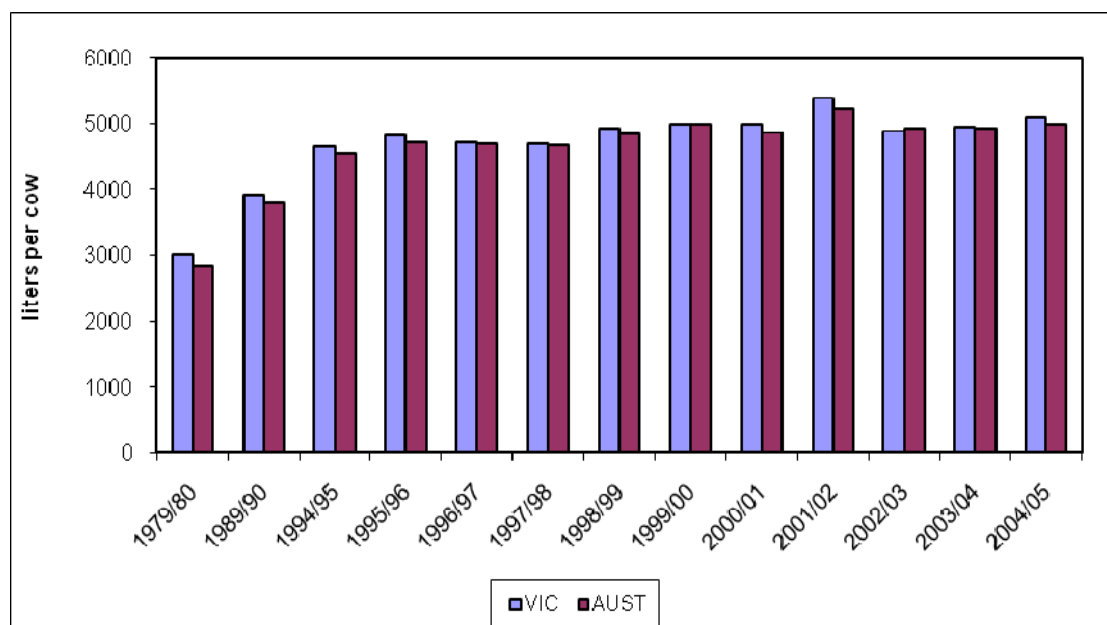
2005/06 region statistics	Gippsland region
Number of dairy farms	2 030
Total grazed area (ha)	266 638
Irrigated pasture (ha)	41 689
Number of milking cows	479 998
Mean milking herd size	236
<b>Water sourced (GL)</b>	
Average rainfall year	184
2005/2006	177
<b>Irrigation intensity (ML/ha)</b>	
Average rainfall year	4.0
2005/2006	3.8

Most farm irrigation systems pump directly from the water source and use a range of sprinkler systems. Raw data from Dairying for Tomorrow 2006 survey (Watson, 2006) have been extrapolated to the region. Sprinkler irrigation is the dominant form of irrigation application method in Gippsland region (Figure 34).

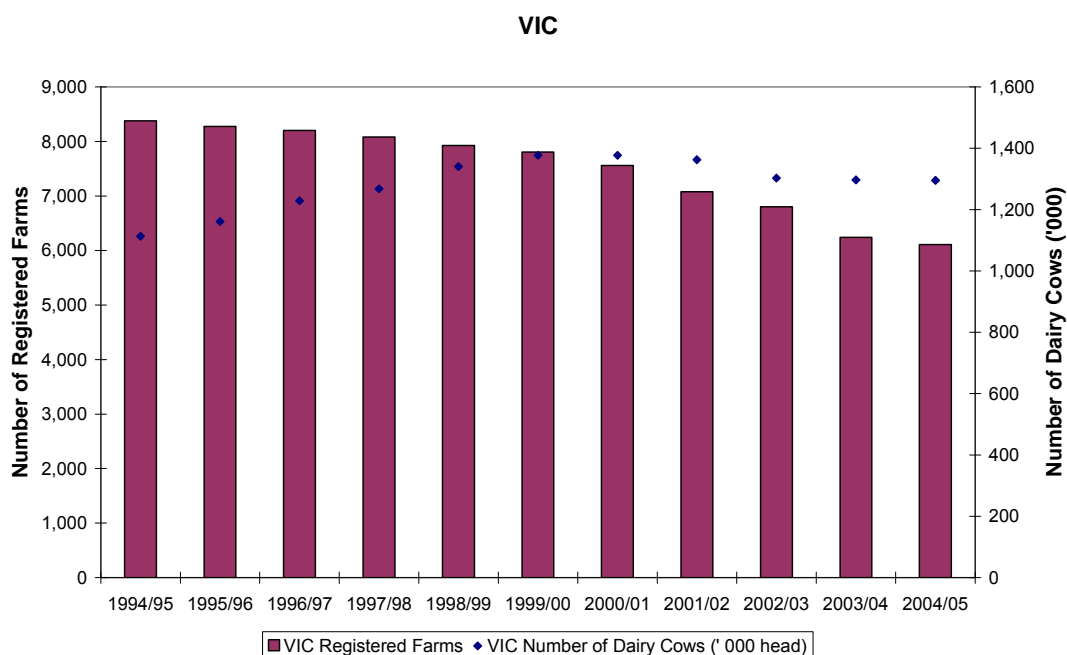


**Figure 34. Common irrigation methods in the surveyed (yellow) dairy region.**

Gippsland has a milk production of 1.96 billion litres. Milk production rates for Victoria have remained steady over ten years (Figure 35) with, on average, 4994 litres per milking cow per one lactation period since 1995/96 (Figure 36). In general, a decline in the number of Victorian dairy farms over a ten-year period is similar to national trend, with an increase in the number of dairy cows over the same time (Figure 36).

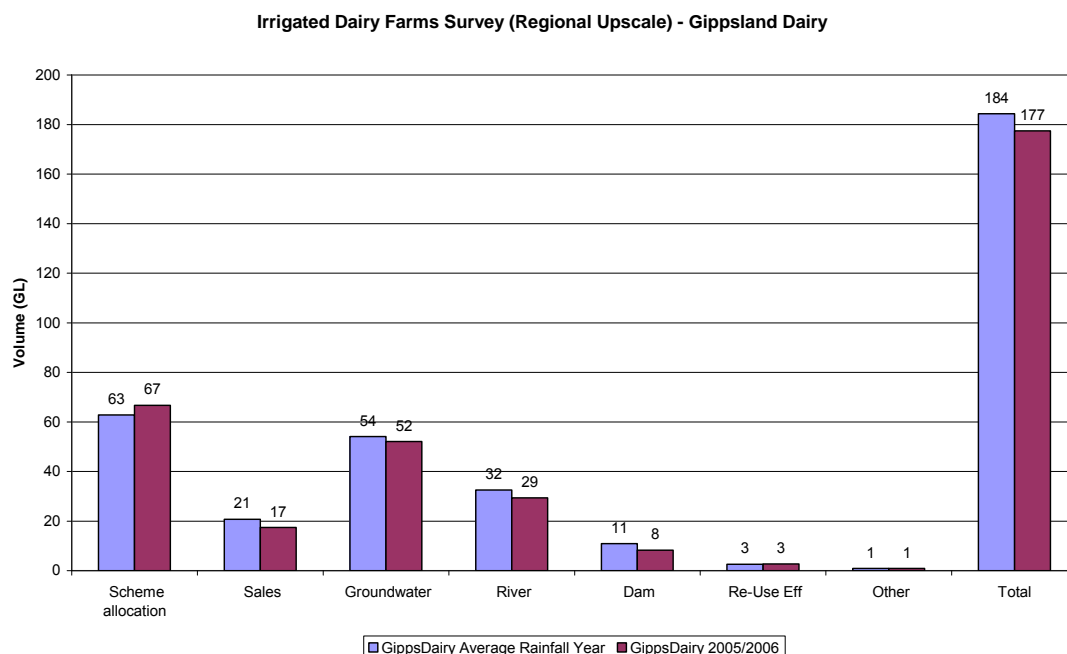


**Figure 35. Victoria milk production rates (L per cow) compared to national average.**



**Figure 36. Number of Victorian registered dairy farms compared to total number of dairy cows (Source: ABS and Dairy Australia).**

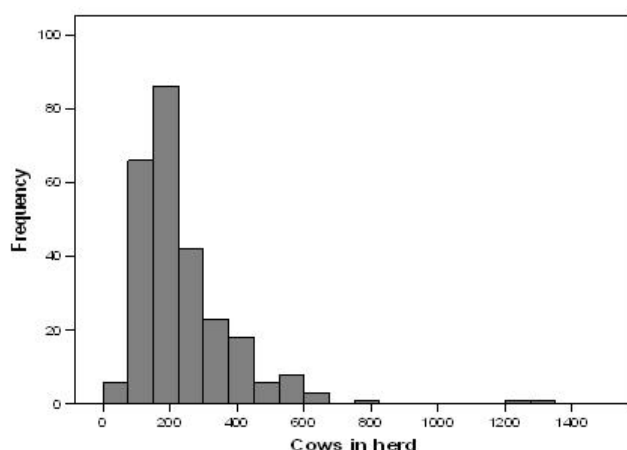
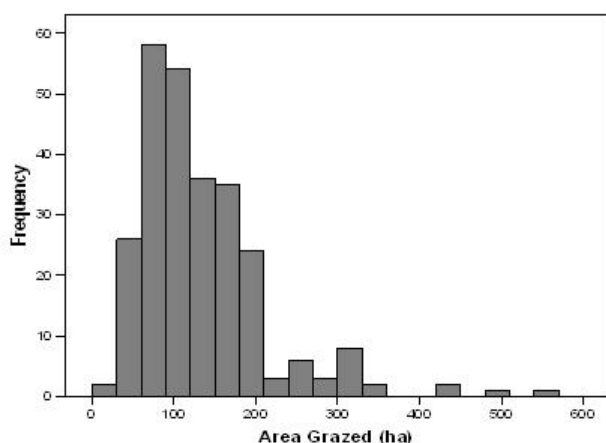
A total of 261 farms were surveyed and the data were extrapolated to the region. Regional water source breakdown figures were estimated for irrigated dairy farms (Figure 37). Average rainfall year data is the volume of water sourced by dairy farms in an average rainfall year. Total water use during 2005/06 was 177 GL of which 37.8% was met from scheme allocations. Nine point six percent was though water trading. Very little effluent was used in Gippsland. . Most farms have grazing area between 60 to 180 ha (Table 13, Figure 38). Some 90 farms have a herd size of 150 (Table 13, Figure 38).



**Figure 37. Regional water sources breakdown figures.**

**Table 13: Statistics of the Gippsland region.**

Statistical Parameter	Area Grazed (ha)	Cows in herd
Number of Farms Surveyed	261	261
Mean	131.35	236.45
Std. Deviation	78.676	152.118
Skewness	1.977	2.943
Std. Error of Skewness	0.151	0.151
Minimum	28	31
Maximum	566	1,300



**Figure 38. a** Area grazed in the Gippsland region. **b** Number of cows in Gippsland region milking herds.

#### 4.3.3. Crop water requirements

Net CWR and calculations were carried out for Wonthaggi for ten-year period (Table 14).

**Table 14: Net crop water requirement for Gippsland**

Year	CWR (mm)	Eff rain (mm)	Net CWR (mm)
1995/96	632	896	60
1996/97	679	741	258
1997/98	660	631	191
1998/99	663	724	164
1999/00	697	719	185
2000/01	695	845	204
2001/02	654	811	205
2002/03	683	633	230
2003/04	663	811	168
2004/05	665	767	172

#### 4.3.4. Climate change and impact of drought

The 24-month SPI (Appendix B) for city of Wonthaggi were applied to compare precipitation totals for 1880–2006 with similar periods in history. Large positive SPIs of 24 months across the region were recorded in 1918, 1936, 1952, 1953 and 1956 indicating the extremely wet conditions to severely wet conditions in 1900, 1901, 1912, 1917, 1919, 1924, 1925, 1935, 1947, 1954, 1955, 1957, 1990 and 1991 (Figure 39). Similarly, the large negative SPIs of 24 months indicating extremely dry conditions in 1998 and 2006 to severely dry in 1898, 1927, 1945, 1966, 1967, 1968, 1983, 1997, 1999, 2001, 2002, 2003, 2004 and 2005 were recorded for Wonthaggi (Figure 39). The climate change shows a clear trend of drought and less water available since 2000 for this region.

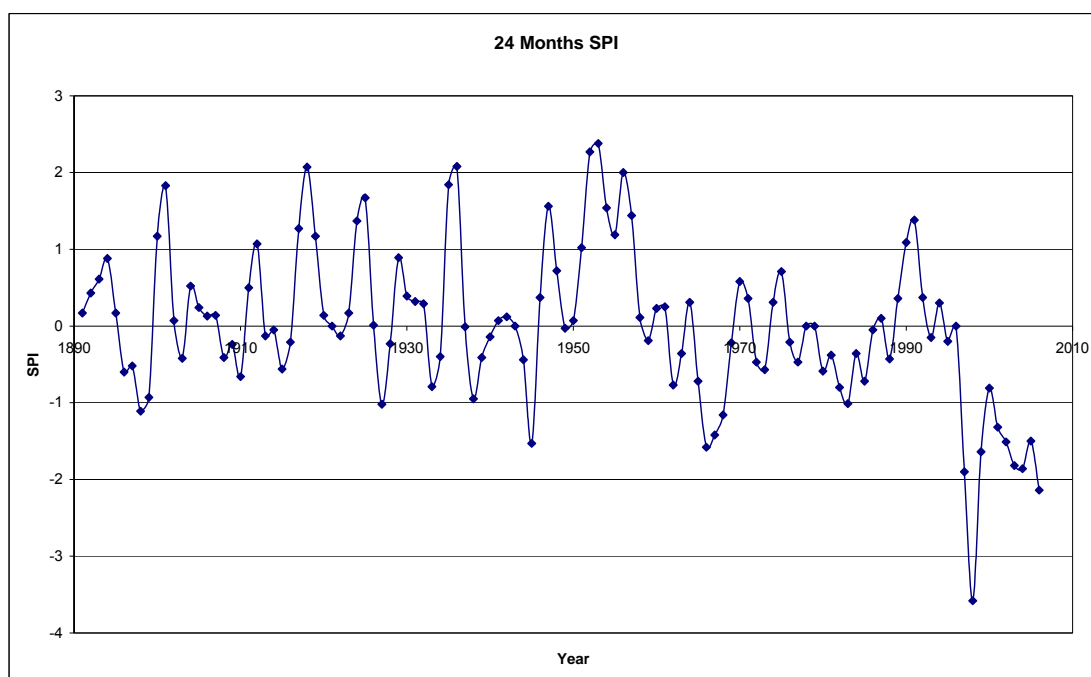


Figure 39. Twenty-four-month SPI index of Gippsland dairy region.

#### 4.3.5. Key water issues

In 2006, RMCG consultants carried out extensive workshops to find out the major water issues related to dairy farming with the local stakeholders and dairy industry people across Australia (RMCG, 2006). The overall objective of the workshops was to consult with the industry across Australia and to develop an irrigation blueprint. Key issues for this region are:

- Limited long-term certainty of supply and access to entitlements impacting on confidence to invest
- Rising pumping costs, particularly in the Latrobe aquifer with water depth dropping due to oil and gas extraction – no compensation provided for increased pumping costs.
- Government's attitude to dam construction restricting opportunities on short-flow streams
- Moratoria on water supply restricting farmers' confidence to invest in required on-farm infrastructure
- Limited trading due to incomplete water supply protection plans
- Impact of climate change to availability of water in both surface and groundwater systems
- Oil and gas extraction impacting on water depth of the Latrobe aquifer – involves both state and Australian governments, and this slows the process to develop an appropriate solution to the issue



## 4.4. Sub Tropical Dairy Program (SDP) region

### 4.4.1. Key facts

- The region has approximately 1150 dairy farmers with production systems having generally intensified over the last five years with more milk being produced on fewer, more intensively managed farms.
- Average herd size is 156 cows per farm.
- Regional milk production is approximately 751 million litres each year (Dairy Australia, 2006b).

### 4.4.2. Dairy in the region

SDP region extends from Kempsey on the mid-north coast of NSW to the Atherton Tablelands in North Queensland and west to Chinchilla on the Western Darling Downs (Figure 40).



**Figure 40. SDP region covering northern NSW and Queensland.**

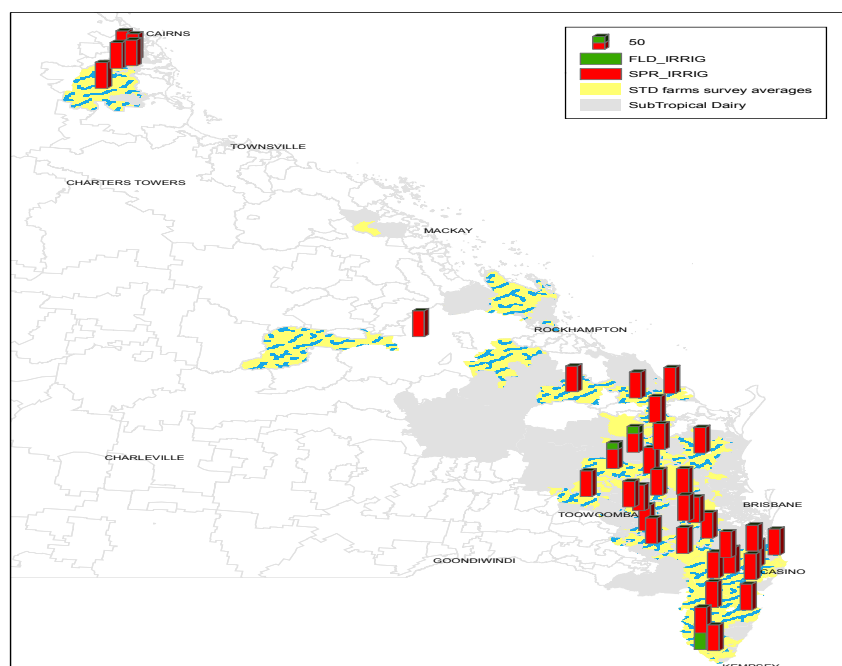
In this region, 59% of farms are specialised operators drawing their sole income from dairying. The average size of farms is 159 ha. Some 45% of farms in the region employ staffs that include family members. Data taken from the Dairying for Tomorrow dairy farm survey have been used to quantify regional irrigated and dryland dairy pasture areas and irrigation water sourced on a regional basis (Table 15).

**Table 15: Dairy region figures based on national dairy farm survey.**

2005/06 region statistics	SDP region
Number of dairy farms	1 146
Total grazed area (ha)	171 246
Irrigated pasture (ha)	26 730
Number of milking cows	179 922
Mean milking herd size	156
<b>Water sourced (GL)</b>	
Average rainfall year	114

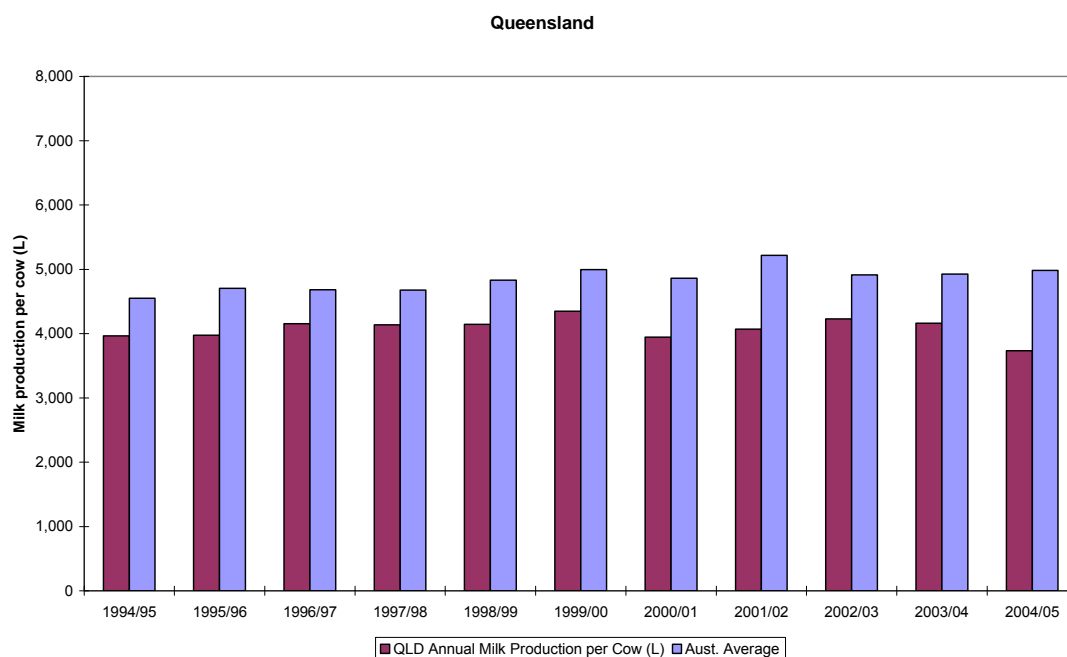
2005/2006	93
<b>Irrigation intensity (ML/ha)</b>	
Average rainfall year	3.8
2005/2006	3.1

The region has a moderate reliance on irrigated feed production, with 15% of dairy land being irrigated. Some 26% of the farms are dependant on irrigation compared with 17% in the far north. Irrigation water is sourced from both regulated and unregulated streams, groundwater, and on-farm storage. Major sources of water include regulated and unregulated streams, on-farm storage, and smaller groundwater systems. Pressurised sprinkler systems, varying in age and efficiency, are the most dominant irrigation system in the region (Figure 41). Sprinkler irrigation (red bar) including pressurised sprinkler system is the most common irrigation method in most of the region while border check flood irrigation method (green bar) is only practised on a few farms.

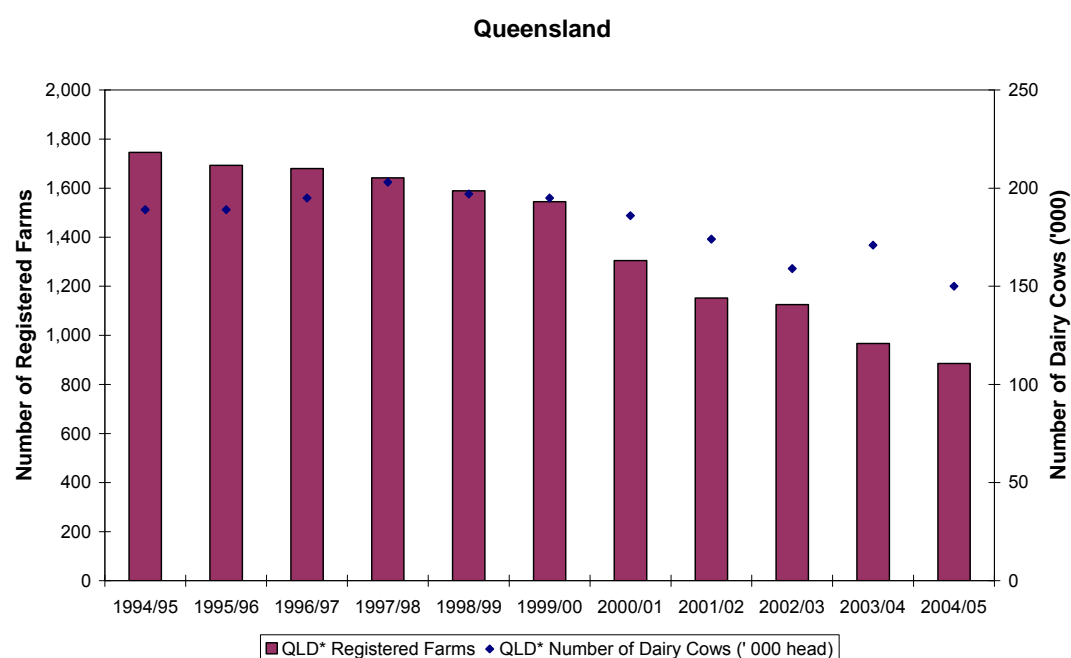


**Figure 41. Common Irrigation methods in the surveyed (yellow) dairy region.**

Milk production rates for Queensland have remained steady but are always less than the national average per milking cow (Figure 42). The dairy industry of Queensland region had a milk production of 679 million litres in 2004/05 with on average, 4089 litres per milking cow per one lactation period since 1995/96. The number of registered farms in Queensland decreased from 1746 in 1994/95 to 885 in 2004/05, while total Queensland dairy cow numbers dropped from 189 000 to 150 000 (Figure 43).

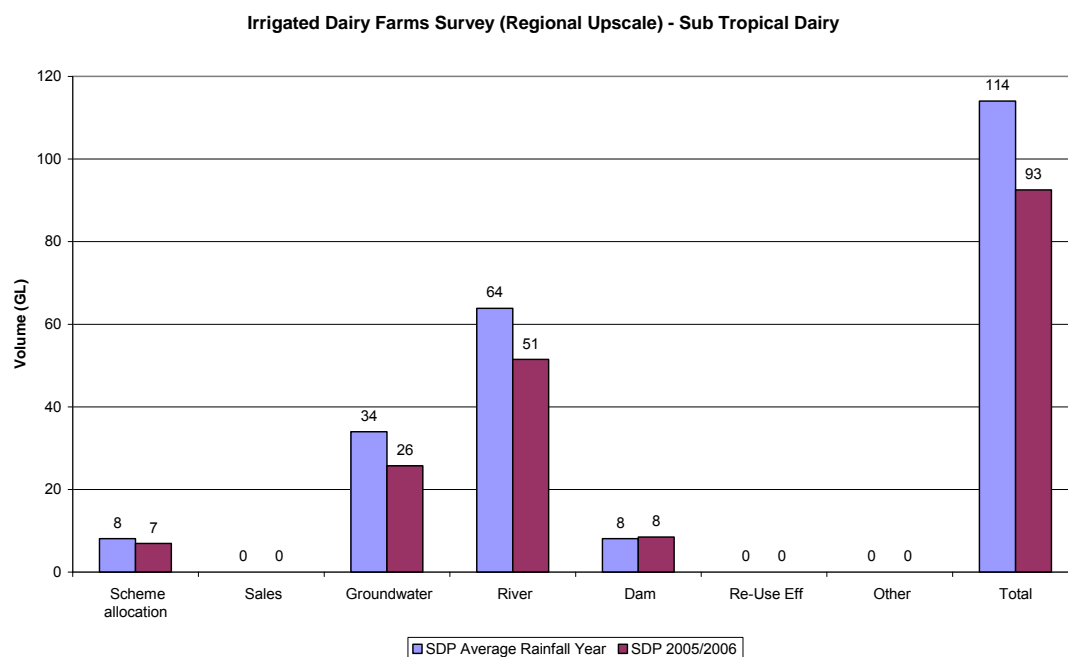


**Figure 42. Queensland milk production rates (L per cow) compared to national average.**



**Figure 43. Number of Queensland registered dairy farms compared to total number of dairy cows (Source: ABS and Dairy Australia).**

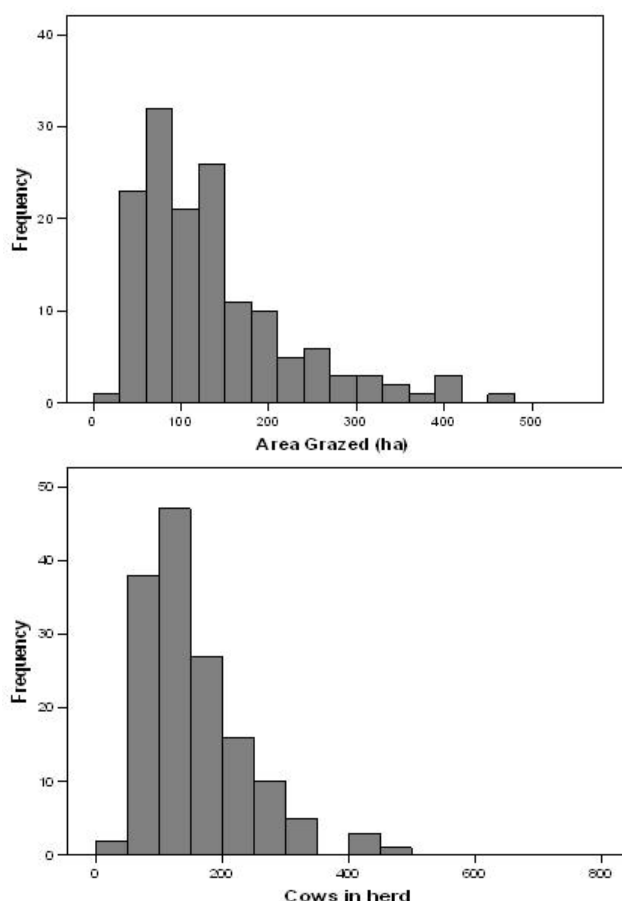
A total of 150 farms were surveyed and data (Watson, 2006) have been extrapolated to the region. Regional water source breakdown figures were estimated for irrigated dairy farms (Figure 44). Total water use during 2005/06 was 93 GL of which 54.8% was met from direct river diversions – the main source of irrigation water for dairy farming in SDP. The second largest source was groundwater, with abstractions at 28% of the total use (93 GL). Irrigation use from scheme allocations and dam storages was more or less similar (7 GL and 8 GL respectively). The average size of grazed area is 140 ha with most farms between 60 and 160 ha (Table 16, Figure 45). Some 50 farms have a herd size of 150 (Table 16, Figure 45). Such statistical analysis is a clear evidence of the numbers on national average.



**Figure 44. Regional water sources breakdown figures.**

**Table 16: Statistics of SDP region.**

Statistical Parameter	Area Grazed (ha)	Cows in herd
Number of Farms Surveyed	150	150
Mean	140.57	156.28
Std. Deviation	104.547	117.351
Skewness	2.083	5.136
Std. Error of Skewness	0.198	0.198
Minimum	20	40
Maximum	640	1,200



**Figure 45. a Area grazed in the SDP region. b Number of cows in the SDP region milking herd.**

#### 4.4.3. Crop water requirements

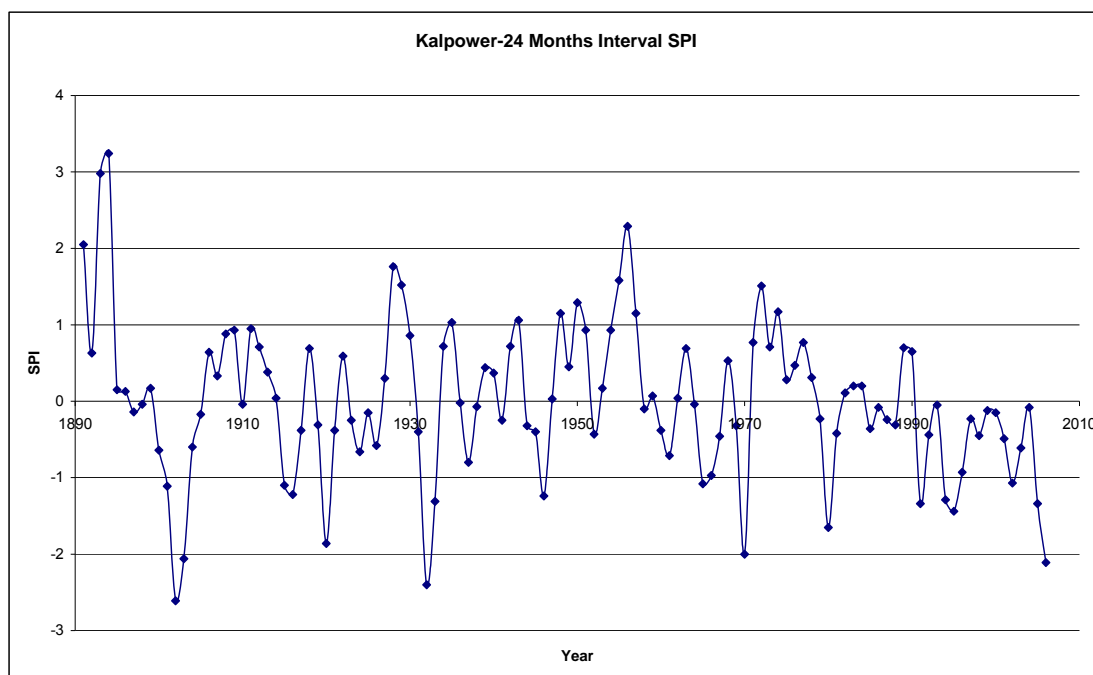
Net CWR and calculations were carried out for Toowoomba area for ten-year period (Table 17).

**Table 17: Net crop water requirement for SDP region.**

Year	CWR (mm)	Eff rain (mm)	Net CWR (mm)
1995/96	968	714	494
1996/97	961	575	451
1997/98	990	593	481
1998/99	851	744	211
1999/00	860	671	327
2000/01	971	500	532
2001/02	978	609	478
2002/03	969	493	481
2003/04	969	554	480
2004/05	973	484	581

#### 4.4.4. Climate change and impact of drought

The 24-month SPI (Appendix B) was applied to compare the precipitation totals for 1890–2006 with similar periods in history. Large positive SPIs of 24 month intervals across the region were recorded in 1891, 1893, 1894 and 1956 indicating the extremely wet conditions to severely wet conditions in 1928, 1929, 1955, and 1972 for Kalpower (Figure 46). Similarly, large negative SPIs of 24 months indicating extremely dry conditions in 1902, 1903, 1932, 1970 and 2006 to severely dry in 1920, and 1980 were recorded for Kalpower (Figure 46).



**Figure 46. Twenty-four-month SPI index of SDP dairy region.**

#### **4.4.5. Key water issues**

In 2006, RMCG consultants carried out extensive workshops to find out the major water issues related to dairy farming with the local stakeholders and dairy industry people across Australia (RMCG, 2006). The overall objective of the workshops was to consult with the industry across Australia and to develop an irrigation blueprint. Key issues for this region are:

##### *Coastal South East Region*

- Long-term security due to impact of increases in urban demand and hobby farms
- Reliability of supply with impact of climate change
- Increasing annual water costs and impact to farm viability
- Costs of pumping water and potential increases to power costs with privatisation
- Land values and input price increases impacting on viability of dairy operations
- Need the ability to 'harvest' water during periods of flood
- Inconsistent rules in relation to on-farm storage

##### *South East Region*

- The lack of access, reliability and security of water impacting on the confidence to invest
- Population growth in south east putting pressure on water resources
- Cost of water in regulated systems challenging
- Competition from other users (i.e. urban sector)
- Perception that level of innovation and use of improved technology is lower in dairy compared to horticulture
- Need to improve on-farm infrastructure to increase water use efficiency

##### *Far North Region*

- Security of entitlements and impacts when converting from per hectare to per megalitre

- Lack of water requiring more storage infrastructure both on- and off-farm
- Need to improve farm water use efficiency and measure actions through better measuring and monitoring systems
- Must be able demonstrate environmental credentials
- Negative public perceptions of water use in the dairy industry: 'We don't irrigate grass – we irrigate and harvest crops and pasture'
- Need to redirect urban recycled water for irrigation and is supported by public investment

## **4.5. South Australia dairy region**

### **4.5.1. Key facts**

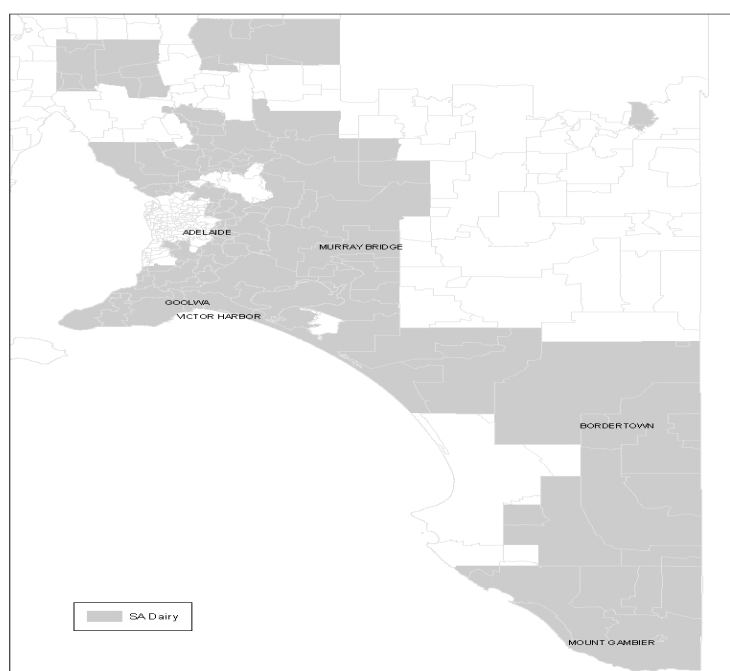
- The South Australian dairy industry produced 672 million litres of milk from an average of 424 dairy farms during 2004/05, a decrease of 3.3% on 2003/04 production.
- South Australia has 14% (23 000 ha) of the state's irrigated land for dairy farming.
- The average water used for dairy farming in the region is 25% (320 GL) of the total water diverted for irrigation in the region.
- The lower Murray dairy industry contributes approximately \$225 million to the local economy.
- The South East and Fleurieu, Adelaide Hills and Mid North regions produce approximately 80% of the state's milk production, with the remaining 20% produced in the Lower Murray and Lakes region.

### **4.5.2. Dairy in the region**

The dairy industry in South Australia is spread across the state with farms located in the Adelaide Hills and Fleurieu Peninsula, Lower Murray Swamps and Lakes, South East and Mid North (Figure 47). Major sources of water include:

- large groundwater systems in the south east
- farm storage, surface unregulated stream diversions and smaller groundwater systems in the Fleurieu, Adelaide Hills and Mid North
- regulated river systems in the Lower Murray region.

Fleurieu, Adelaide Hills and Mid North use irrigation to complement predominately rain-fed dairy enterprises.



**Figure 47. South Australian dairy region.**

The South East and Lower Murray regions depend on irrigation. Figures based on extrapolating the national dairy farm survey data (Table 18). The dairy industry has been affected by the drought, resulting in reduced feed reserves and high prices for feed, and causing a reduction of cow numbers. Farmers have left the industry due to cost-price pressures as milk prices did not increase significantly during 2004/05. During 2004/05 farm numbers decreased by 10.1% from 447 to 402 at 30 June 2005 (Dairy Authority of South Australia, 2005).

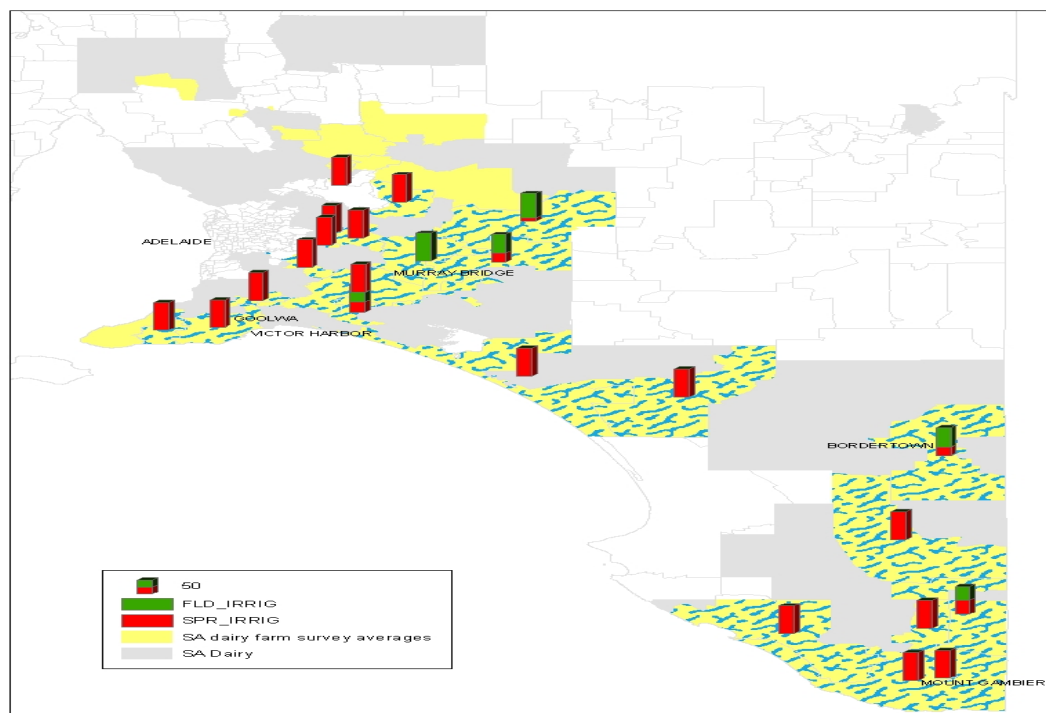
**Table 18: Regional dairy figures.**

2005/06 region statistics	South Australia dairy region
Number of dairy farms	447
Total grazed area (ha)	82 928
Irrigated pasture (ha)	23 184
Number of milking cows	117 636
Mean milking herd size	266
<b>Water sourced (GL)</b>	
Average rainfall year	92
2005/2006	90
<b>Irrigation intensity (ML/ha)</b>	



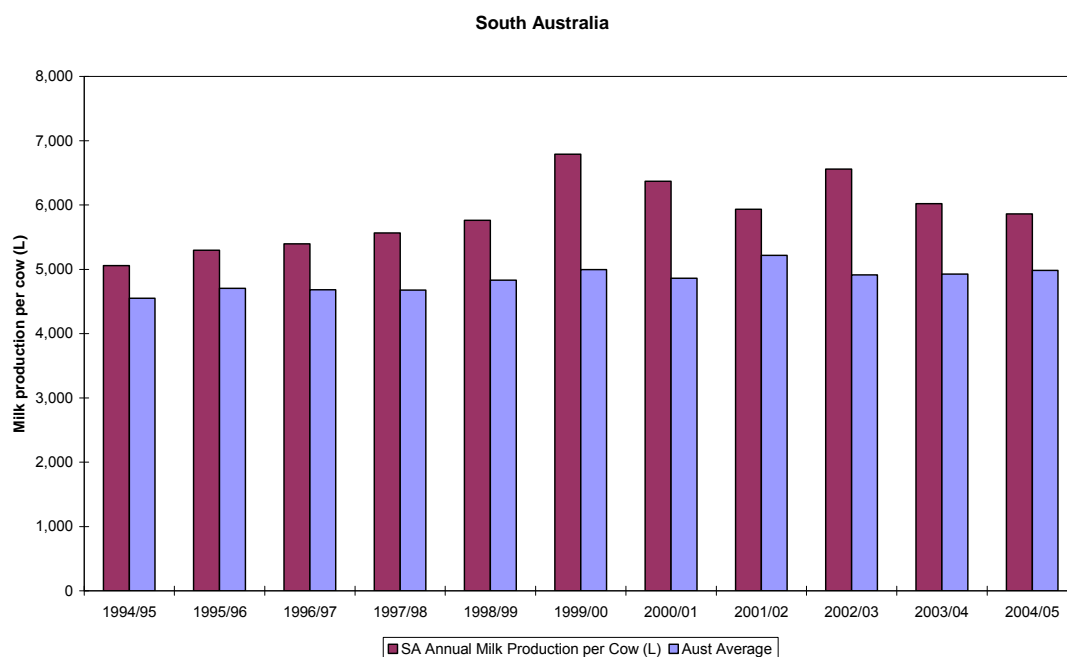
Average rainfall year	3.6
2005/2006	3.5

Irrigation technology includes large centre pivot irrigators, smaller sprinkler and fixed sprinkler systems, and border check flood irrigation. Sprinkler irrigation is the most common irrigation method in most of the region while border check flood irrigation method (green bar) is not concentrated in any single region (Figure 48).

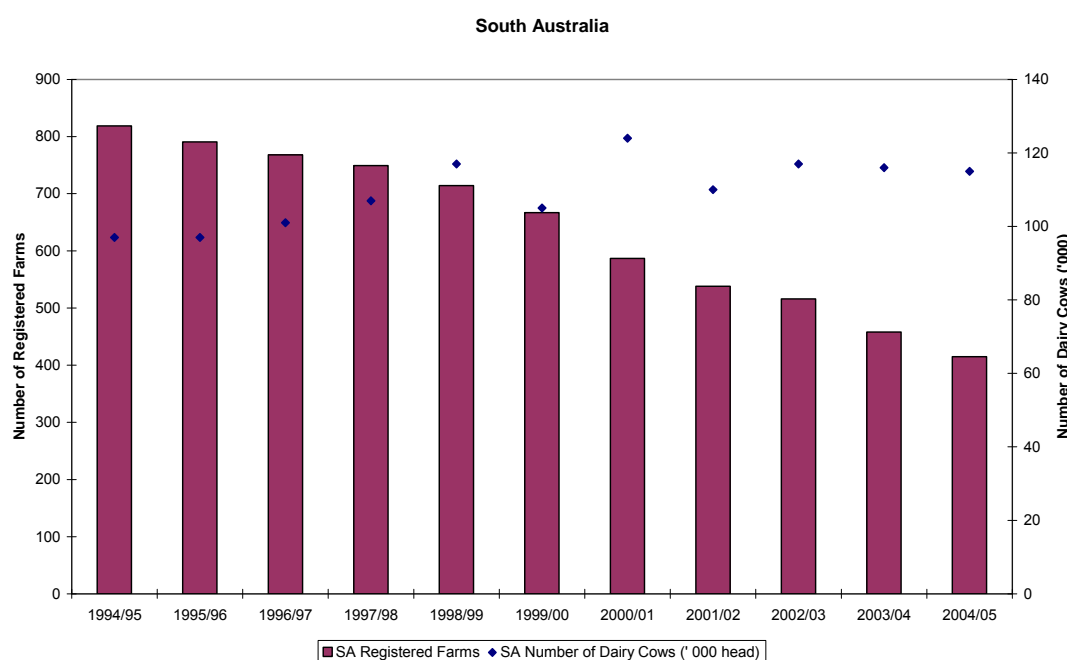


**Figure 48. Common irrigation methods in the surveyed (yellow) dairy region.**

Average production per cow in 2004/05 was 6236 L, an increase of 3.1% and is very productive and efficient in the terms of milk production per cow as compared to national average (Figure 49). Cow numbers as at 30 June 2005 decreased 6.1% to 104 368 compared with the previous year (Figure 50). In general, a decline in the number of South Australian dairy farms has occurred over a ten-year period as well as an increase in the number of dairy cows over the same time (Figure 50).

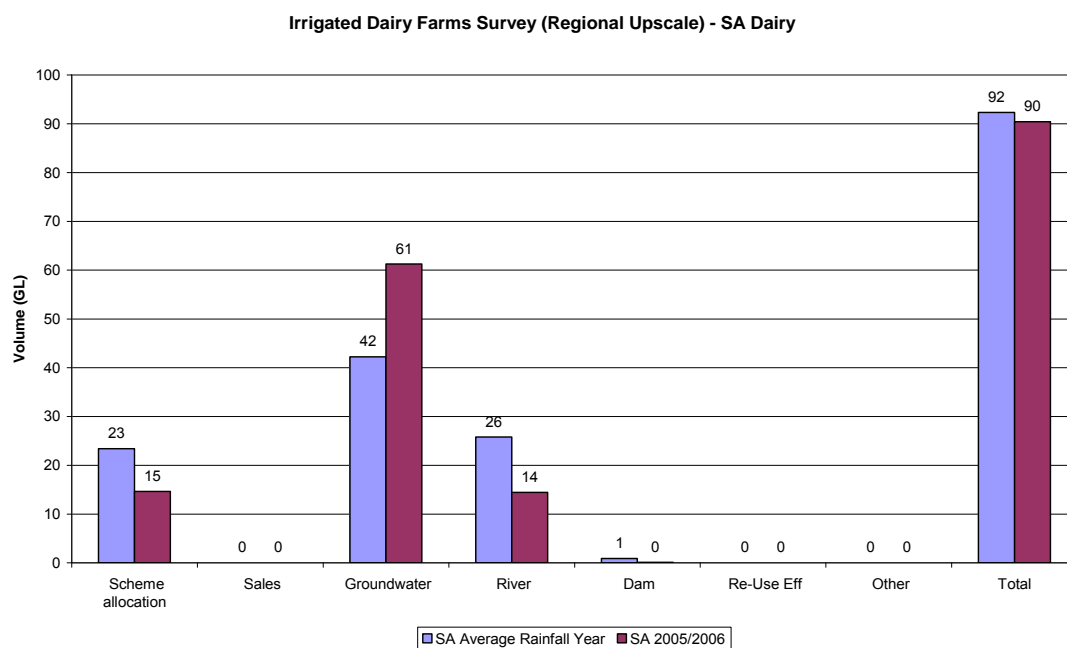


**Figure 49. South Australian milk production rates (L per cow) compared to national average.**



**Figure 50. Number of South Australia registered dairy farms compared to total number of dairy cows (Source: ABS and Dairy Australia).**

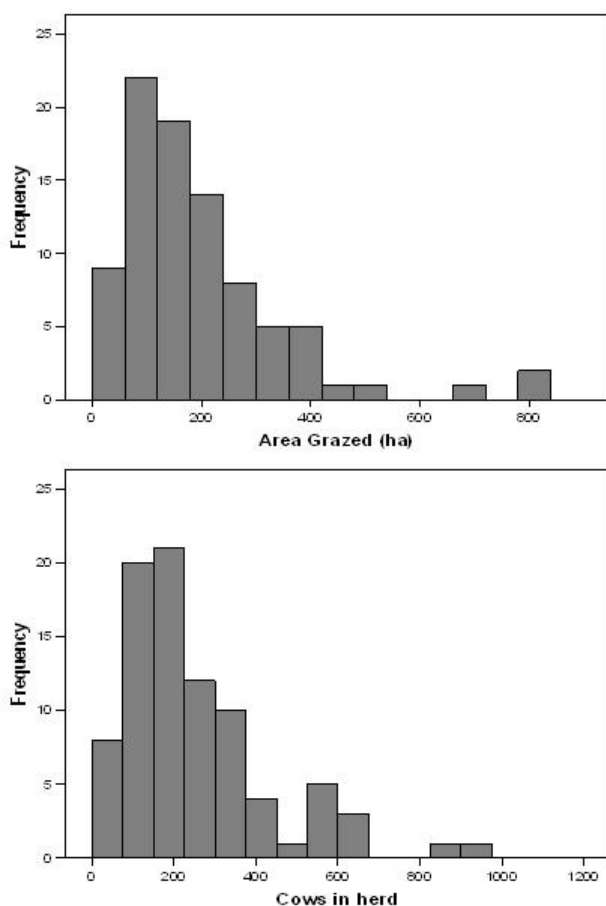
Survey data (Watson, 2006) have been extrapolated to the region and a total of 87 farms were surveyed. The regional water source breakdown figures were estimated for irrigated dairy farms (Figure 51). The total water use during 2005/06 was 90 GL of which 67.8% was met from groundwater. The second largest source was scheme allocation amounting to 15 GL (16.7% of the total use in dairying). Irrigation use from scheme allocations and river diversions was more or less similar (15 GL and 14 GL respectively). The average size of grazed area is 188 ha with about 22 farms having grazed area of 150 ha (Table 19, Figure 52). Some 21 farms have a herd size of 200 (Table 19, Figure 52).



**Figure 51. Results from a survey giving the regional water sources breakdown.**

**Table 19. Statistics of the South Australia dairy region.**

Statistical Parameter	Area Grazed (ha)	Cows in herd
Number of Farms Surveyed	87	87
Mean	187.66	266.03
Std. Deviation	153.835	228.670
Skewness	2.103	2.931
Std. Error of Skewness	0.258	0.258
Minimum	1	40
Maximum	809	1,600



**Figure 52. a Area grazed in the South Australia region. b Number of cows in the South Australia region milking herd.**

#### 4.5.3. Crop water requirements

Net CWR and calculations were carried out over Mt. Gambier for ten-year period (Table 20)

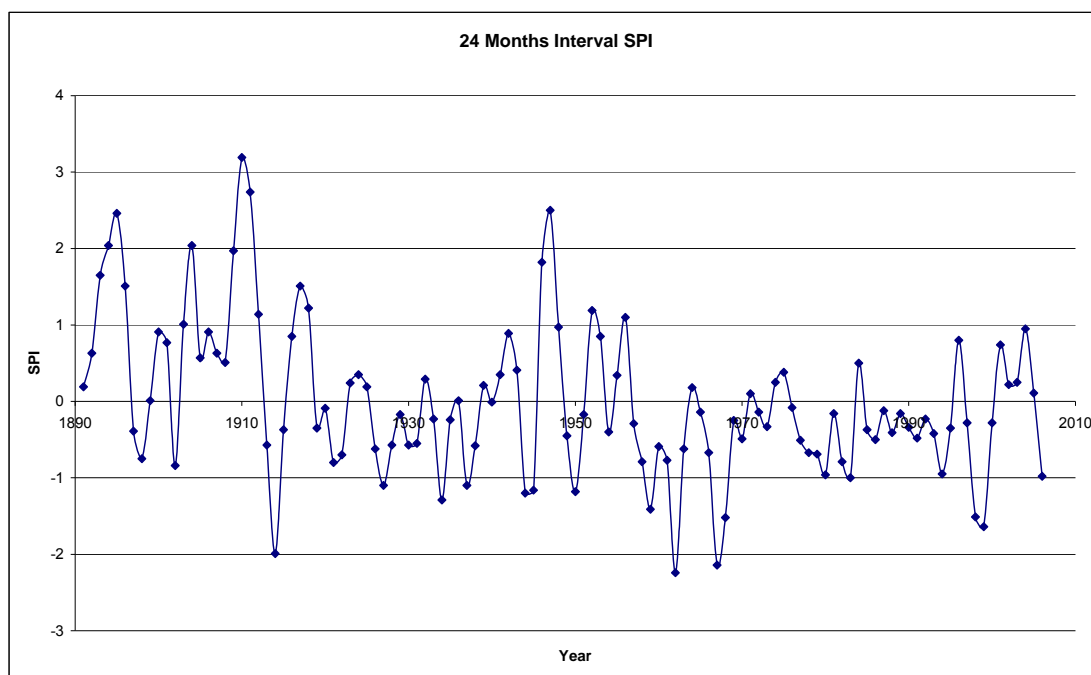
**Table 20: Net crop water requirement (mm) for South Australia dairy region.**

Year	CWR (mm)	Eff rain (mm)	Net CWR (mm)
1995/96	668	524	315
1996/97	706	613	375
1997/98	683	514	317
1998/99	702	520	348
1999/00	723	554	316
2000/01	725	613	342
2001/02	675	600	289
2002/03	702	619	281
2003/04	683	651	249
2004/05	711	554	341

#### 4.5.4. Climate change and impact of drought

The 24-month SPI (Appendix B) for city of Mount Gambier was applied to compare precipitation totals for 1890–2006 with similar periods in history. For Mt Gambier, the large positive SPI of 24 months were showing extremely wet conditions in 1894, 1895, 1904, 1910,

1911 and 1947 to severely wet conditions in 1893, 1896, 1909, 1917 and 1946. Similarly, the large negative SPIs of 24 months indicated extremely dry conditions in 1962 and 1967 to severely dry conditions 1968, 1998 and 1999 (Figure 53).



**Figure 53. Twenty-four– month SPI index in the South Australia dairy region.**

#### **4.5.5. Key water issues**

In 2006, RMCG consultants carried out extensive workshops to determine the major water issues related to dairy farming with the local stakeholders and dairy industry people across Australia (RMCG, 2006). The overall objective of the workshops was to consult with industry across Australia and to develop an irrigation blueprint. Key issues for this region are:

##### *South East Region*

- Opportunities for development but uncertainty about water access and availability in the future
- Support services in non-traditional dairy areas possess limitations to growth
- Impacts of hobby farms close to major centres associated with 'right to farm' issues
- Moving from area-based licences to volumetric, but still a perception that water is tied to land even though the government have 'separated' the two
- Competition for resources from developments that are supported by tax-effective investment schemes
- Can only trade within groundwater management areas, and combined with uncertainty about future water availability, trade opportunities are limited
- High level of concern about the impact of blue gum plantations on the recharge of groundwater aquifers – not considered to date
- Underground ecosystems need to be sustained – very difficult to understand and manage

##### *Fleurieu, Adelaide Hills and Mid North Region*

- Hobby farms present a threat to dairy practices and dairy water resources

- Cost effectiveness of smaller irrigation systems limited
- Cost of growing feed via irrigation comparable to purchasing feed
- Moratoria on dam developments causing frustration and limiting development
- Blue gums and their impact an emerging environment issue
- Full environmental impact of dam construction needs to be understood
- Low-flow bypass dams provide some opportunity to reduce the level of environmental impact

#### *Lower Murray and Lakes Region*

- Significant restructure of dairy industry in recent years
- Decreasing allocations and impact on farm viability
- Concern about uptake of sleeper entitlements and impact on future allocations
- Competition from SA Water paying \$1400 /ML which is price prohibitive for dairy operations
- Moving towards system that is 100% metered through better measuring and monitoring systems
- No drainage water allowed back into the river by 2008 placing pressure on some farms
- Dairy farmers seen as the source of all the water quality problems in the Lower Murray region
- A heavy EPA regulatory presence and high level of government control on development is restricting farm growth

#### *General Issues*

- Minimise /eliminate dairyshed effluent return to any water body
- Water saving/ reduce water diversion from the river by increasing irrigation efficiency as current water consumption is high
- Reduce drainage water volume and total nitrogen, phosphorous and bacteria returned to the rivers
- Rehabilitate irrigation infrastructure to a current best practice system
- Ensure all new irrigation has no significant impact on the river
- Increasing pasture production and use
- Moratoria on water use
- Uncertainty of water access
- Impact of blue gum plantations
- Increasing environmental compliance

## **4.6. Tasmanian dairy region**

### **4.6.1. Key facts**

- Tasmanian region has 543 dairy farmers producing approximately 6% of Australia's milk.
- Processed dairy and confectionary earnings are \$270 million and \$400 million respectively.

- Dairying contributes approximately 25% of the gross value of agriculture in Tasmania.
- The dairy sector contributes around \$200 million in direct value to the Tasmanian economy each year.

#### 4.6.2. Dairy in the region

Tasmanian dairy farms are primarily located in the north with a small number in the south (Figure 54). The land formerly used for extensive grazing has been converted to dairy production by corporate farmers in the far north west and north east. The dairy business option is being considered as a viable conversion for beef or cropping enterprises.



**Figure 54. Tasmanian dairy region.**

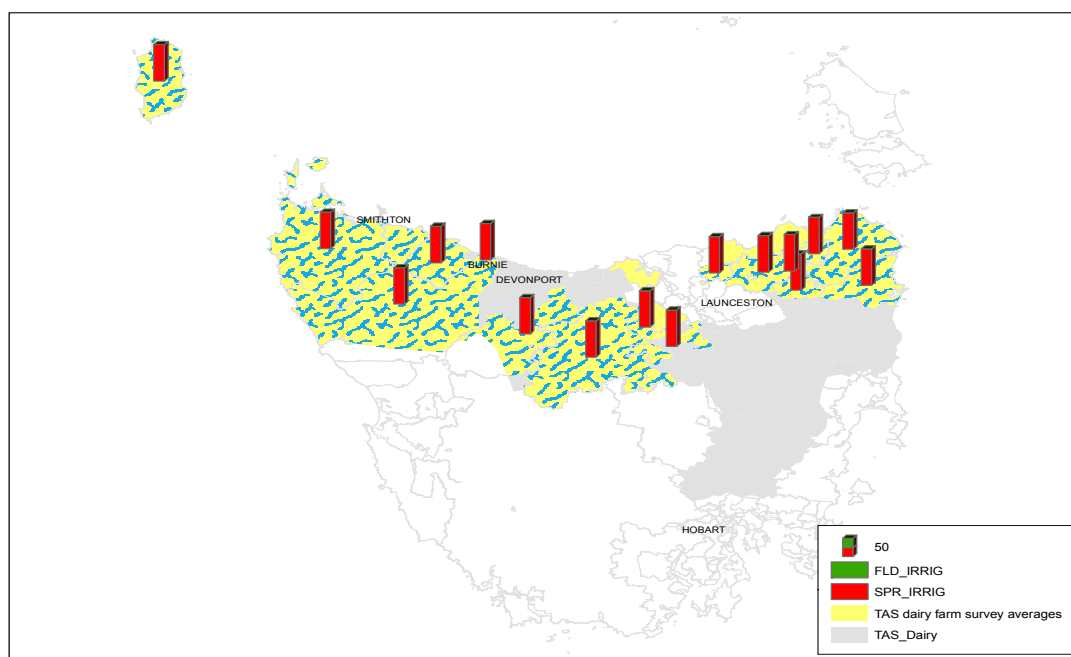
The Tasmanian dairy industry is pasture based and unlike other states has limited access to cost-effective, off-farm feed sources such as grain. Hence many farms rely on access to irrigation water to fill feed gaps during times of low rainfall. This allows farms to maintain stocking rates and achieve high pasture use. Approximately 70% of farms have some irrigation and 30% of the dairy land area is irrigated (Dairy Australia, 2006a).

The total area under irrigation in Tasmania has risen from around 40 000 ha in 1985 to some 70 000 ha in 2009. Irrigated pasture (mainly for dairy farming) makes up 40 to 45% of the total area irrigated and 55 to 60% of total irrigation water used. The extrapolated national survey data are shown in Table 21.

**Table 21: Dairy region figures based on national dairy farm survey.**

2005/06 region statistics	Tasmania dairy region
Number of dairy farms	531
Total grazed area (ha)	77 376
Irrigated pasture (ha)	21 921
Number of milking cows	135 246
Mean milking herd size	255
<b>Water sourced (GL)</b>	
Average rainfall year	64
2005/2006	55
<b>Irrigation intensity (ML/ha)</b>	
Average rainfall year	2.6
2005/2006	2.3

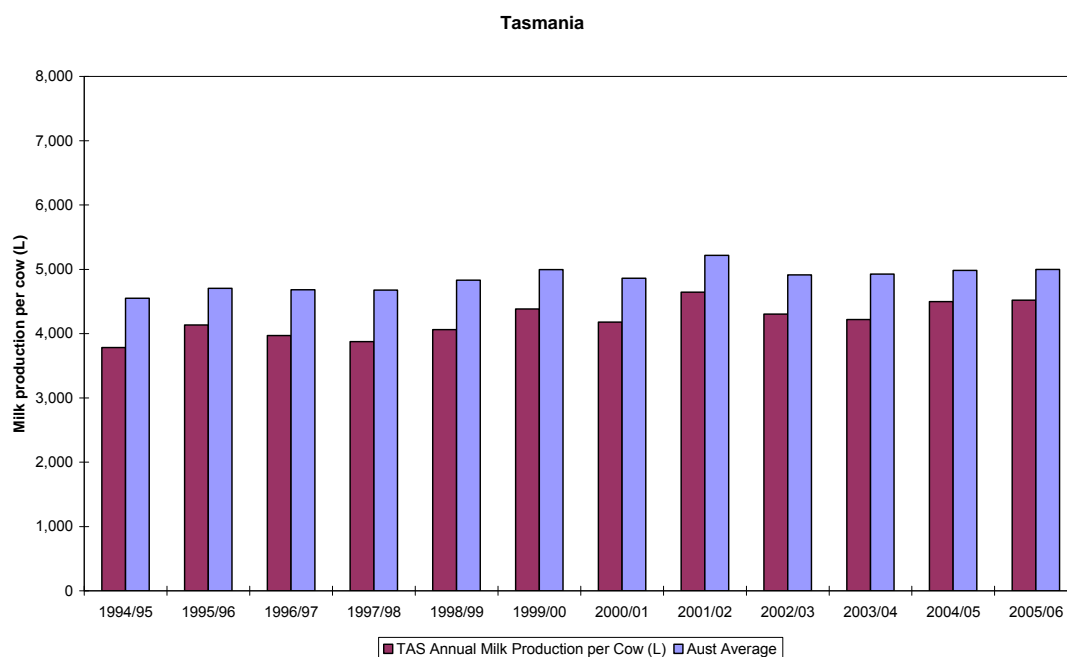
A small number of local area irrigation schemes are sourced from streams, farm storage and groundwater. Most irrigation systems involve pumping directly from a water source using a range of sprinkler systems (centre pivots, travelling guns and K-lines). Sprinkler irrigation is the dominant form of irrigation application method in Tasmania (Figure 55).



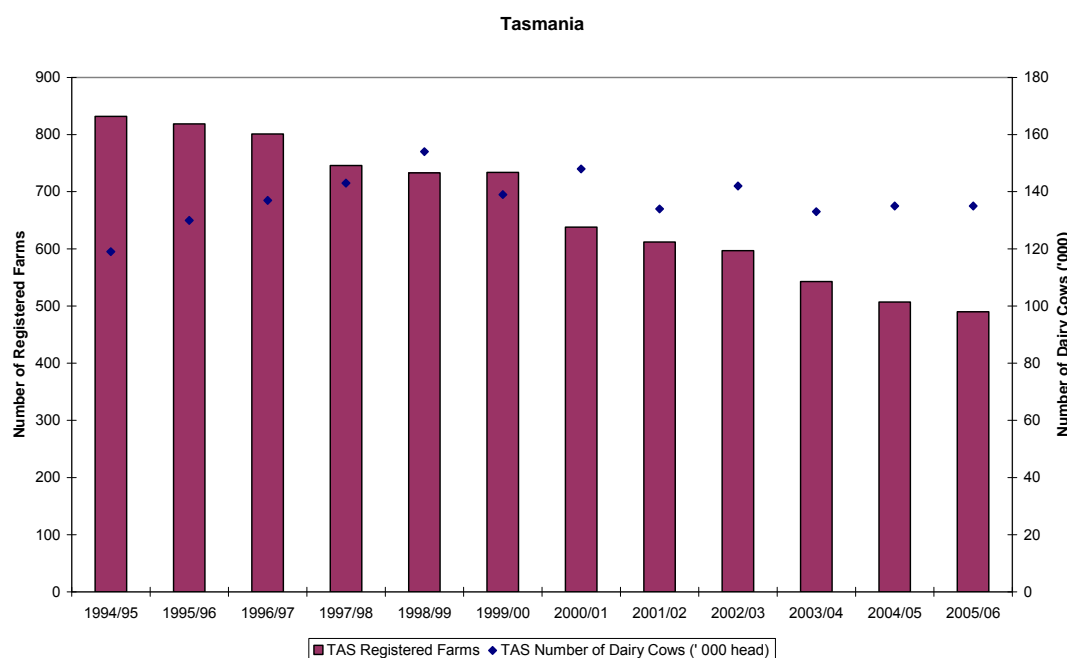
**Figure 55. Common irrigation methods in the surveyed (yellow) dairy region.**

Milk production rates per cow have increased recently (Figure 56) as a result of better feeding with increases in irrigation and nitrogen application, and increased grain feeding. The number of dairy farms in Tasmania has decreased over the past 12 years, while total dairy cow numbers have remained stable (Figure 57). This is possibly due to the combination of smaller farms exiting the industry with larger farms increasing cow herds.





**Figure 56. Tasmanian milk production rates (L per cow) compared to national average.**

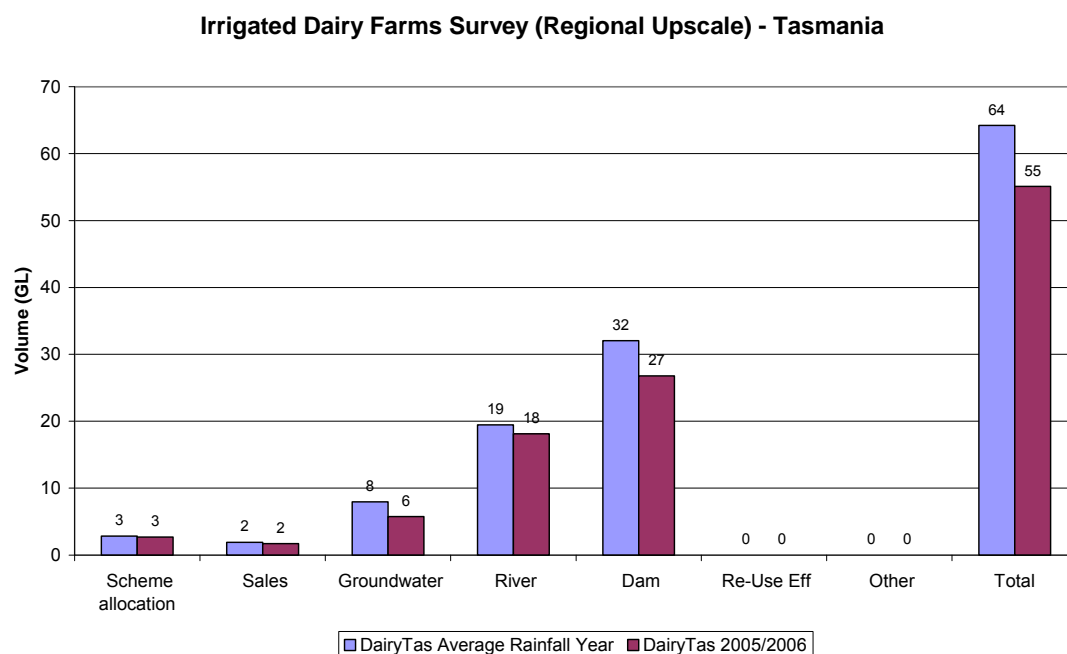


**Figure 57. Number of Tasmanian registered dairy farms compared to total number of dairy cows (Source: ABS and Dairy Australia).**

The survey data (Watson, 2006) have been extrapolated to the region. A total of 260 farms were surveyed. Regional water source breakdown figures were estimated for irrigated dairy farms (Figure 58). Approximately half the total volume of irrigation water was accessed from dams (27 GL), with scheme allocation and sales accounting for 5 GL of water sourced. Private river extraction (18 GL) and groundwater pumping (6 GL) accounted for the remainder of water sourced (Figure 58). The average size of grazed area is 146 ha with about 16 farms having grazed area of 130 ha (

Table 22, Figure 59). Some 12 farms have a herd size of 280 head (

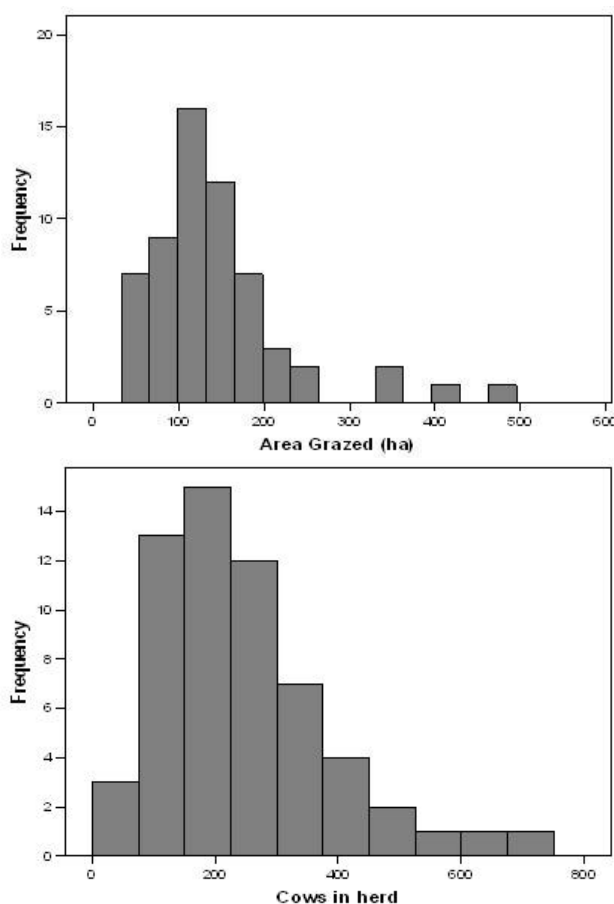
Table 22, Figure 59).



**Figure 58. Regional water sources breakdown figures.**

**Table 22: Statistics of the Tasmanian dairy region.**

Statistical Parameter	Area Grazed (ha)	Cows in herd
Number of Farms Surveyed	60	60
Mean	145.72	254.70
Std. Deviation	84.686	164.771
Skewness	2.009	1.626
Std. Error of Skewness	0.309	0.309
Minimum	46	36
Maximum	485	900



**Figure 59. a Area grazed in the Tasmania region. b Number of cows in the Tasmania region milking herd.**

#### 4.6.3. Crop water requirements

Net CWR and calculations were carried out over Launceston for ten-year period (Table 23) (see Appendix A for method).

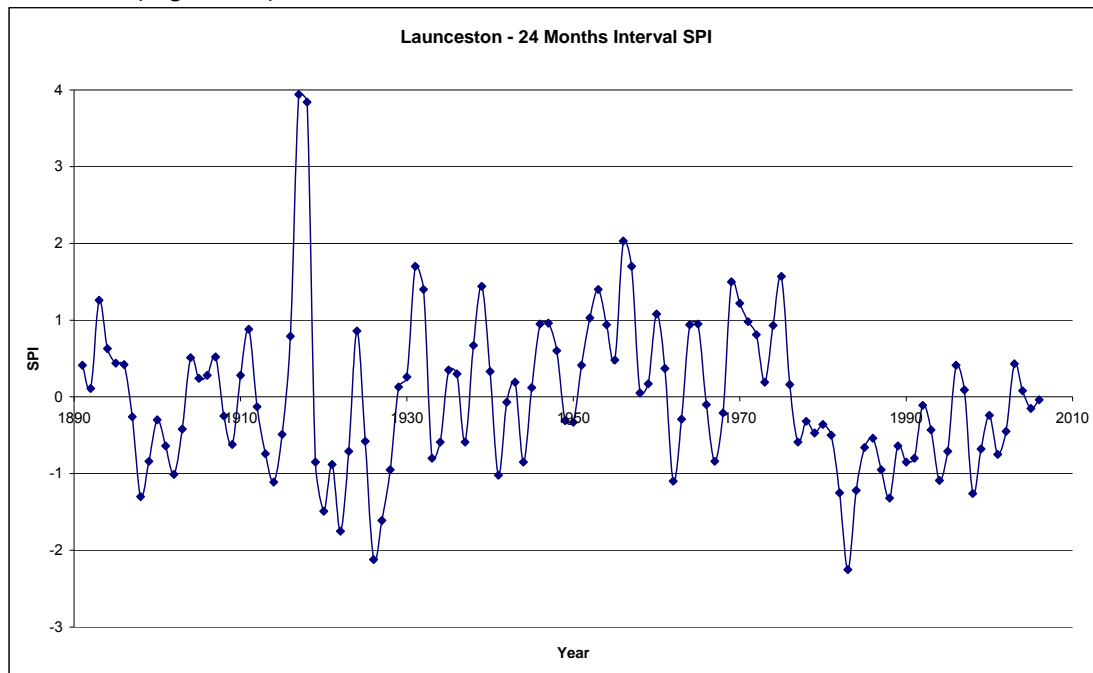
**Table 23: Net crop water requirement for Tasmanian dairy region.**

Year	CWR (mm)	Eff rain (mm)	Net CWR (mm)
1995/96	614	550	152
1996/97	635	624	254
1997/98	670	408	332
1998/99	641	631	171
1999/00	670	483	313
2000/01	671	587	287
2001/02	637	480	286
2002/03	669	616	298
2003/04	630	609	241
2004/05	626	418	315

#### 4.6.4. Climate change and impact of drought

The 24-month SPI (Appendix B) for city of Launceston was applied to compare precipitation totals for 1880–2006 with similar periods in history. Large positive SPIs of 24 months across the region were recorded in 1917, 1918 and 1956 indicating the extremely wet conditions to severely wet conditions in 1893, 1931, 1932, 1939, 1953, 1957, 1969, 1970 and 1975. Similarly, the large negative SPIs of 24 months indicated extremely dry conditions in 1926

and 1983 to severely dry in 1898, 1914, 1920, 1922, 1927, 1962, 1983, 1984, 1988, 1994 and 1998 (Figure 60).



**Figure 60. Twenty-four-month SPI index of the Tasmania dairy region.**

#### **4.6.5. Key water issues**

In 2006, RMCG consultants carried out extensive workshops to determine the major water issues related to dairy farming with the local stakeholders and dairy industry (RMCG, 2006). The overall objective of the workshops was to consult with the industry and develop an irrigation blueprint. Key issues for this region are:

- Concern about the impact of water sharing plans on farmers' access to water entitlements – pumping restrictions have the potential for significant impact and farmers may have the entitlement but not be able to access the water
- Approximately one-third of the state's catchment area is allocated to power generation with a 99-year licence – hydro has a big influence on what can and cannot happen with water extraction
- Potential expansion of the irrigation industry in Tasmania with up to a 50 % increase in water supplies by 2015 (DPIPWE, 2009)
- Groundwater use is totally unregulated with no general basin and very patchy water sources. The level of resources available is poorly defined and even though 'no licences required' sounds good to farmers, it also means no protection.
- Limited tenure on licences and having to apply for a temporary licence every year
- Long-term availability of water resources creating investment 'wariness'
- Growing concern about water cost and moving to a per megalitre charge
- Infrastructure:
  - potential dam sites have been mapped across the state but many sites will fail on environmental grounds and will limit opportunities.
  - investment in farm dams compromised due to the slow approval process and level of red tape
  - most infrastructure on-farm with limited government infrastructure
- Limited metering on irrigation use makes it difficult to manage water resources

- Need to measure and monitor so that the industry can demonstrate improved water use efficiency
- Research demonstrates that there can be big improvements in water use efficiency
- Limited trading due to size of catchments – no formal trading processes and the limited trade that occurs is farmer to farmer
- Potential to access recycled water from Hobart
- Capturing winter flows to support growth in water demand is a challenge – need 150 000 to 200 000 ML extra water (40% increase) to meet expected growth in agriculture
- Groundwater use estimated at only 10% of sustainable yield indicating opportunities, although overuse in some locations needs to be managed through water plans and licensing
- Impact of forestry on water resources – forestry hasn't been included as a water user in the past
- Water quality leaving farms varies significantly across catchments
- Groundwater quality variable

## 4.7. Western Victoria dairy region

### 4.7.1. Key facts

- The Western Victoria dairy industry comprises a major portion of dryland farms with a limited number of irrigated farms.
- The region has approximately 1632 dairy farms producing nearly 2.03 billion litres of milk each year.
- Majority of dairy farms are dependent on rainfall for growing pasture.
- Only 18% (450) of dairy farmers have licences to irrigate land through surface diversions from rivers, dams or groundwater extraction.

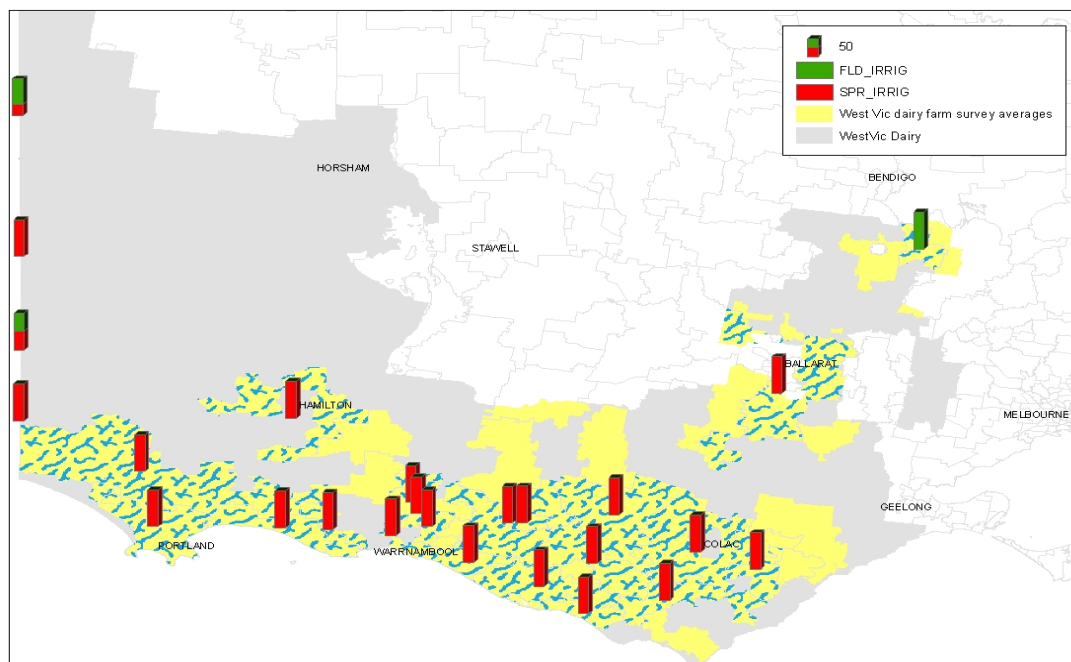
### 4.7.2. Dairy in the region

The region spreads from Ballarat to the Hamilton and Horsham area in Victoria (Figure 61). Ryegrass / white clover are irrigated perennial pastures in the region.



**Figure 61. Western Victoria dairy region.**

Even though many of the farms in these areas are located in higher rainfall zones and thus less reliant on irrigation water, access to water resources is still important to the industry. Farms that do have access to irrigation typically irrigate only 20–30% of their grazing area, but this still makes a significant contribution to their farming system. Sprinkler irrigation is the most common irrigation method (Figure 62).



**Figure 62. Common irrigation methods in the surveyed (yellow) dairy region.**

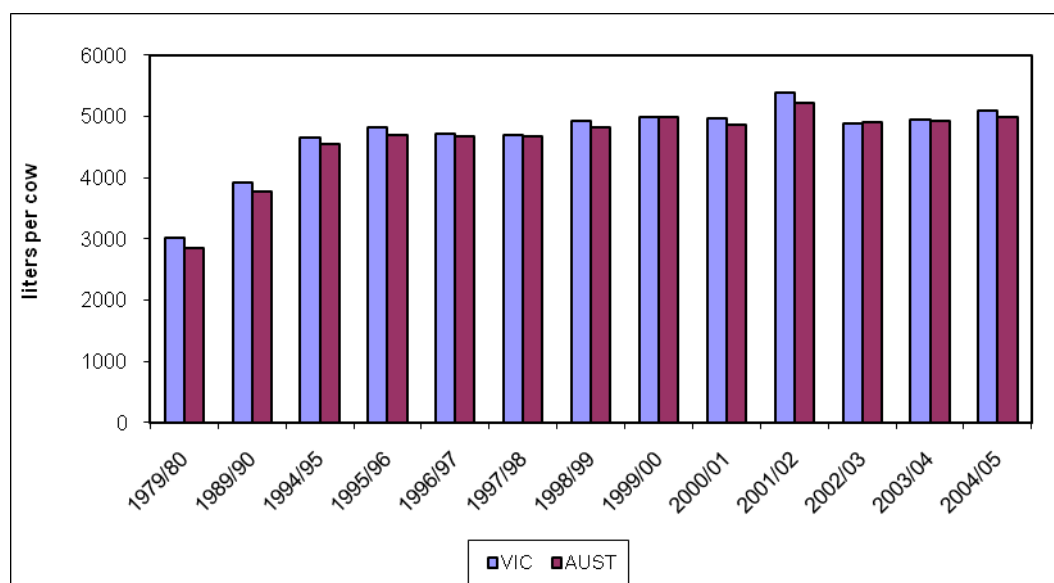
An average sized dairy herd in the region in 2007 was 271 cows – well ahead of the national average of around 236 (Western Dairy, 2008) (Table 24).

**Table 24: Dairy region figures based on national dairy farm survey.**

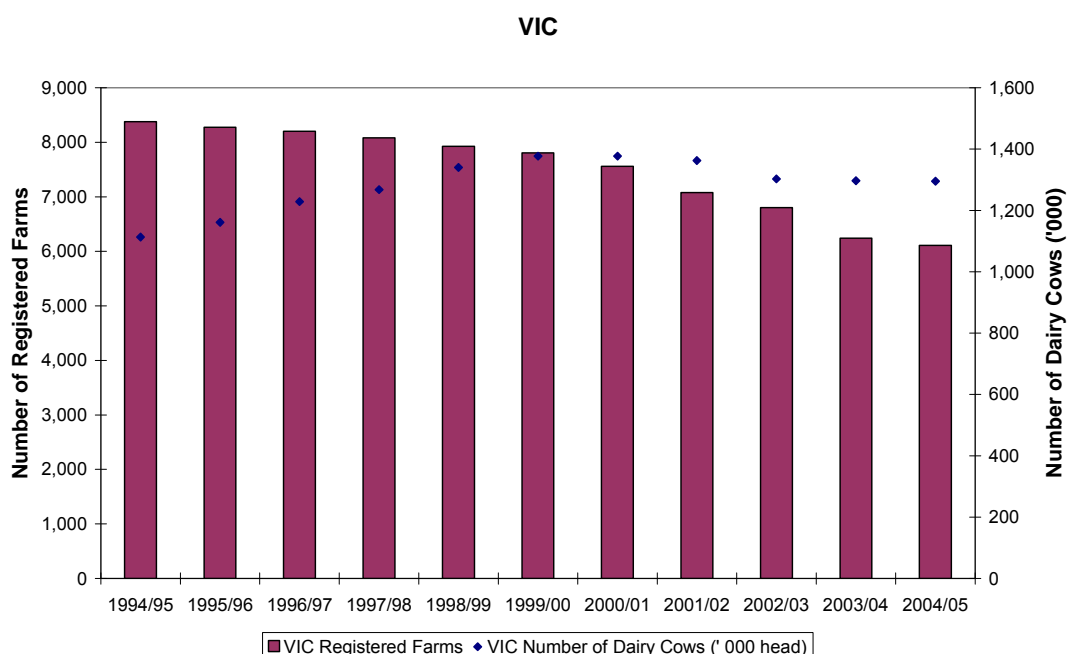
2005/06 region statistics	West Victoria dairy region
Number of dairy farms	1 632
Total grazed area (ha)	286 447
Irrigated pasture (ha)	13 376
Number of milking cows	460 561
Mean milking herd size	282
<b>Water sourced (GL)</b>	
Average rainfall year	52
2005/2006	37
<b>Irrigation intensity (ML/ha)</b>	
Average rainfall year	3.5
2005/2006	2.5

The dairy industry of Western Victoria region has a milk production of 2.08 billion litres, however it is a very productive and efficient dairy region nationally in terms of milk production per cow. Milk production figures presented in this report (see

Figure 63 are from the whole of Victoria). An overall decline in the number of Victorian dairy farms occurred over a ten-year period while at the same time the number of dairy cows increased (Figure 64).



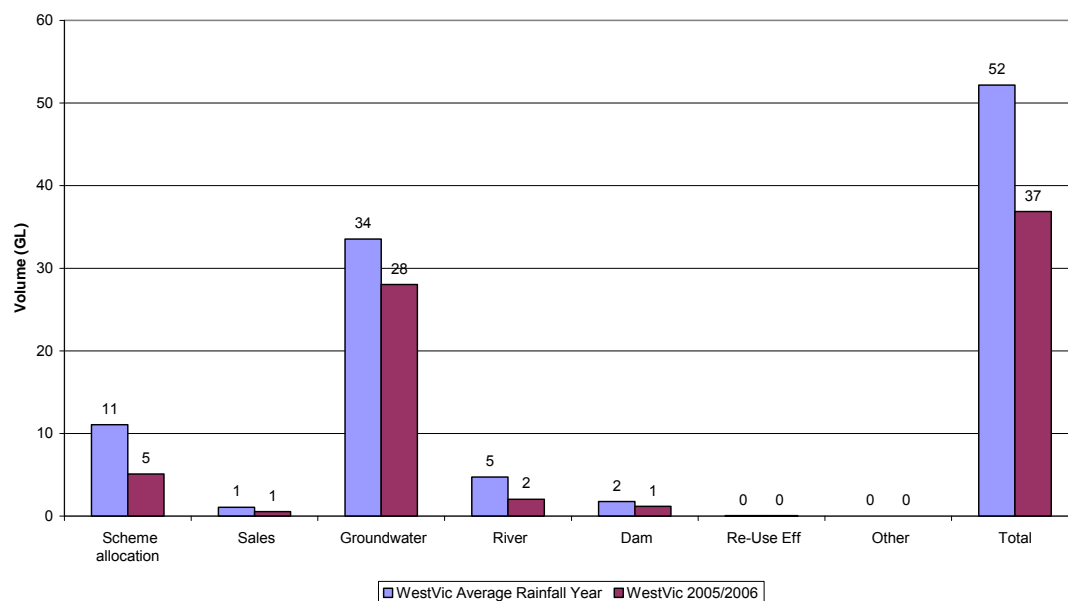
**Figure 63. Victoria milk production rates (L per cow) compared to national average.**



**Figure 64. Number of Victorian registered dairy farms compared to total number of dairy cows (Source: ABS and Dairy Australia).**

The survey data (Watson, 2006) have been extrapolated to a regional level. A total of 262 farms were surveyed. Regional water source breakdown figures were estimated for irrigated dairy farms (Figure 65). Total water use during 2005/06 was 37 GL of which 75.6% was met from groundwater. The second largest source was scheme allocation amounting to 5 GL (13.5% of the total use in dairying). River diversions were only 2 GL. . The average size of grazed area is 175 ha with about 70 farms having grazed area of 120 ha (Table 25, Figure 66). Some 85 farms have a herd size of 200 (Table 25, Figure 66).

# Irrigated Dairy Farms Survey (Regional Upscale) - Western Victoria

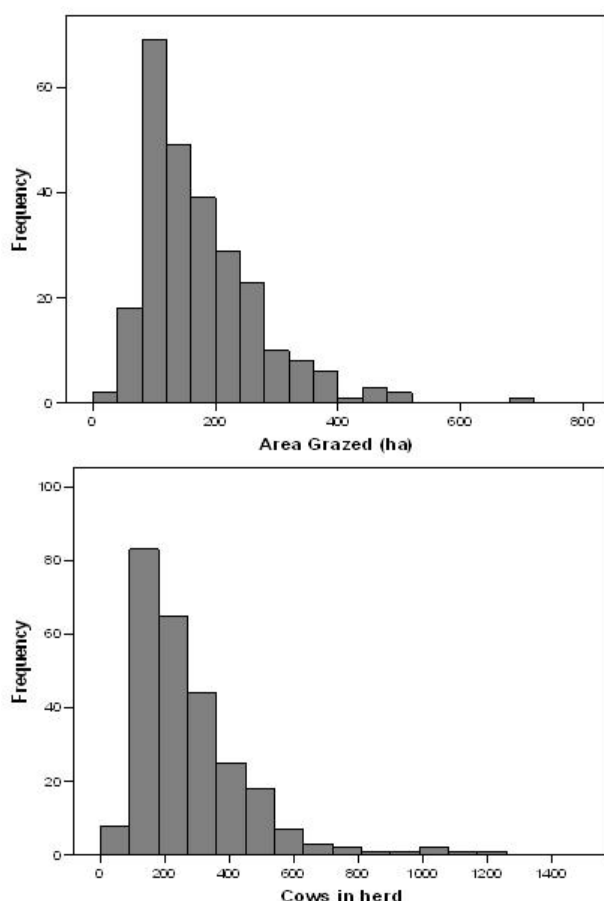


**Figure 65. Regional water sources breakdown figures.**

**Table 25: Statistics of Western Victoria dairy region.**

Statistical Parameter	Area Grazed (ha)	Cows in herd
Number of Farms Surveyed	262	262
Mean	175.35	281.25
Std. Deviation	118.871	210.317
Skewness	3.286	3.314
Std. Error of Skewness	0.150	0.150
Minimum	19	0
Maximum	1,000	2,000





**Figure 66. a Area grazed in the Western Victoria region. b Number of cows in the Western Victoria region milking herd.**

#### 4.7.3. Crop water requirements

Net CWR and calculations were carried out over Horsham for ten-year period (Table 26).

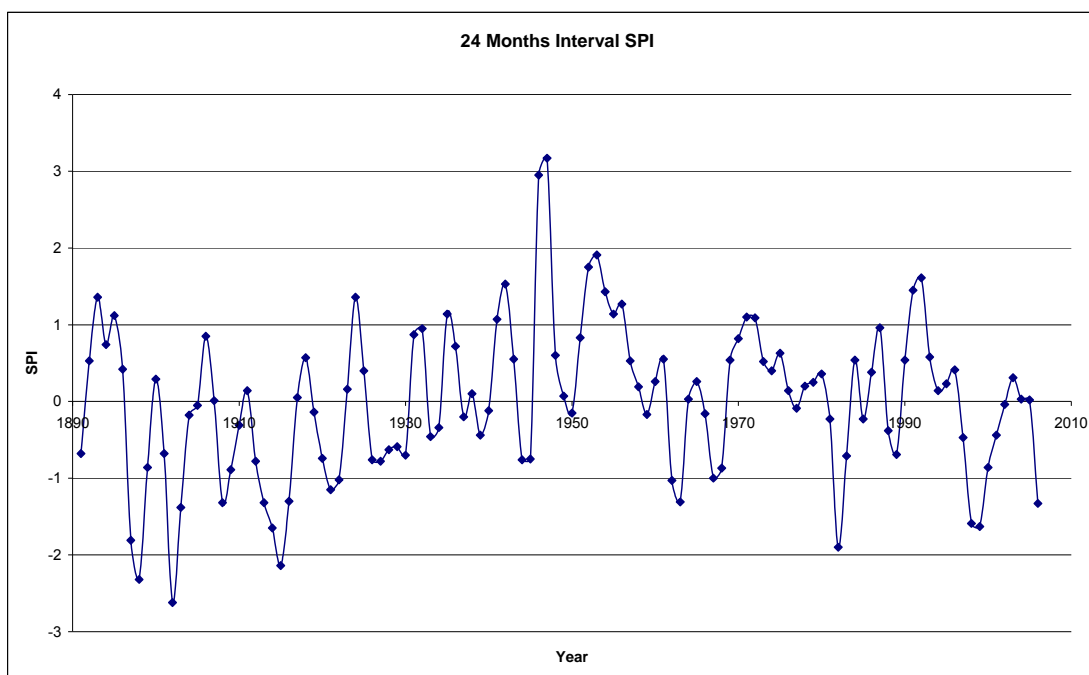
**Table 26: Net crop water requirement for Western Victoria.**

Year	CWR (mm)	Eff rain (mm)	Net CWR (mm)
1995/96	796	371	559
1996/97	829	375	546
1997/98	808	353	496
1998/99	816	337	515
1999/00	842	379	479
2000/01	858	345	551
2001/02	820	360	487
2002/03	887	322	598
2003/04	852	324	599
2004/05	837	354	515

#### 4.7.4. Climate change and impact of drought

The 24-month SPI (Appendix B) for the city of Horsham were applied to compare precipitation totals for 1880–2006 with similar periods in history. Large positive SPIs of 24 months across the region were recorded in 1946 and 1947 indicating the extremely wet conditions to severely wet conditions in 1893, 1895, 1924, 1935, 1941, 1942, 1952, 1953, 1954, 1955, 1956, 1971, 1972, 1991 and 1992 (Figure 67). Similarly, the large negative SPIs of 24 months indicated extremely dry conditions in 1898, 1902 and 1915 to severely dry in

1897, 1903, 1908, 1913, 1914, 1916, 1921, 1922, 1963, 1982, 1998, 1999 and 2006 for Horsham (Figure 67).



**Figure 67. Twenty-four-month SPI index of the Western Victoria dairy region.**

#### **4.7.5. Key water issues**

In 2006, RMCG consultants carried out extensive workshops to determine the major water issues related to dairy farming with the local stakeholders and dairy industry people across Australia (RMCG, 2006). The overall objective of the workshops was to consult with the industry across Australia and to develop an irrigation blueprint. Key issues for this region are:

- Sleeper licences in groundwater districts a concern due to uncertain water access in the future
- Still areas with entitlements based on land area rather than amount of water needed
- Lack of knowledge on the level of water resources available
- Government red tape making it prohibitive for farmers to assess opportunities to develop on-farm storage
- Rising costs of power for pumping impacting on profitability
- Farms have been investing in improved irrigation technology but high cost is limiting uptake
- Most bores are metered but accuracy of meters low
- Need to ensure that work completed by Sinclair Knight Merz (SKM) looking at impacts on water resources of changed land use is used effectively
- Limited trading between users due to limitation on effective mechanisms for trade and uncertainty about future access to water resources
- Trade restricted by incomplete water sharing plans
- Change in land use with resulting impact on stream flows and groundwater recharge
- Potential conflict between non-irrigation users of groundwater systems (stock and domestic use) and irrigators

- Limited knowledge and understanding of the impact of river environmental flows

## 4.8. Western Australia dairy region

### 4.8.1. Key facts

- The region has approximately 280 dairy farms that produce nearly 400 million litres of milk per annum representing 4% of the national milk production.
- The dairy industry contributes more than \$94.6 million per annum (GDP) to the state economy.
- The value of the dairy exports is almost \$78 million.
- The average amount of water used for dairy farming in the region is 12% (65 GL) of the total water diverted for irrigation.
- Western Australia has 13% (6000 ha out of 46 000 ha) of the state's irrigated land for dairy farming respectively.

### 4.8.2. Dairy in the region

The Western Australia dairy industry comprises a mix of irrigated and dryland farms that spread from Byford just south of Perth and hug the coast around to Albany. The largest concentration of dairy farms extends in a 200 km radius from Bunbury with 72 of the farms located in the Harvey irrigation area (Figure 68). The irrigated dairy industry faced a dramatic change in operating environment between 2000/01 and 2005/06. The drought resulted in a substantial decrease in the availability of irrigation water and supplementary feed for cows. It is imperative to look to improved management systems for increasing water use efficiency in irrigated agriculture particularly in the dairy sector where 0.5 ML of water is used to produce just \$100 of goods.



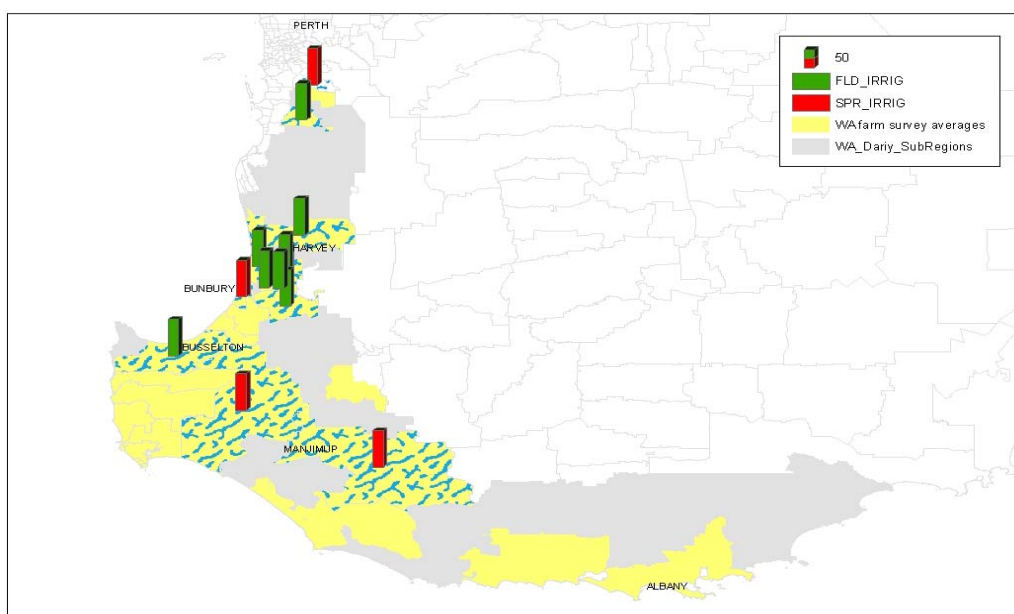
**Figure 68. West Australian dairy region.**

Western Australia's dairy farmers run larger operations than the national average (Table 27). An average sized dairy herd in the region in 2005 was 260 cows – well ahead of the national average of around 228 (Western Dairy, 2006/07).

**Table 27: Dairy region figures based on national dairy farm survey.**

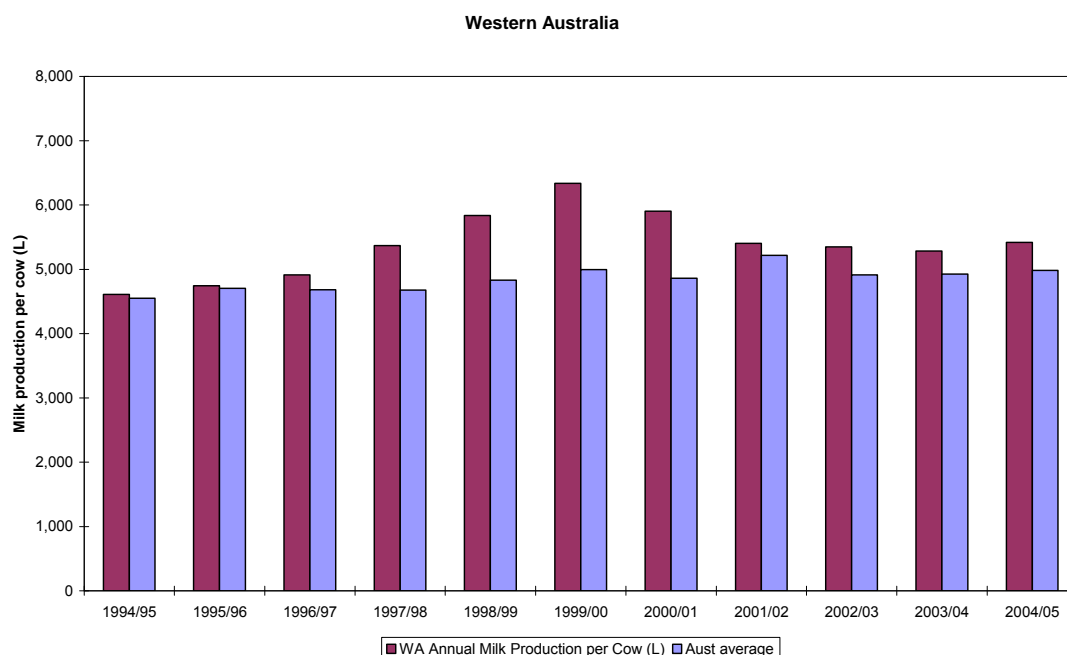
2005/06 region statistics	Western Australia dairy region
Number of dairy farms	270
Total grazed area (ha)	54 090
Irrigated pasture (ha)	4 167
Number of milking cows	61 560
Mean milking herd size	228
<b>Water sourced (GL)</b>	
Average rainfall year	39
2005/2006	25
<b>Irrigation intensity (ML/ha)</b>	
Average rainfall year	8.5
2005/2006	5.5

Traditionally, the most common irrigation method in Harvey irrigation area is border check irrigation supplied by an open channel system. Sprinkler irrigation is the dominant system in areas outside the Harvey scheme. Flood irrigation (green bar) is the most common method in Harvey while sprinkler irrigation method (red bar) is not concentrated in any single region (Figure 69).

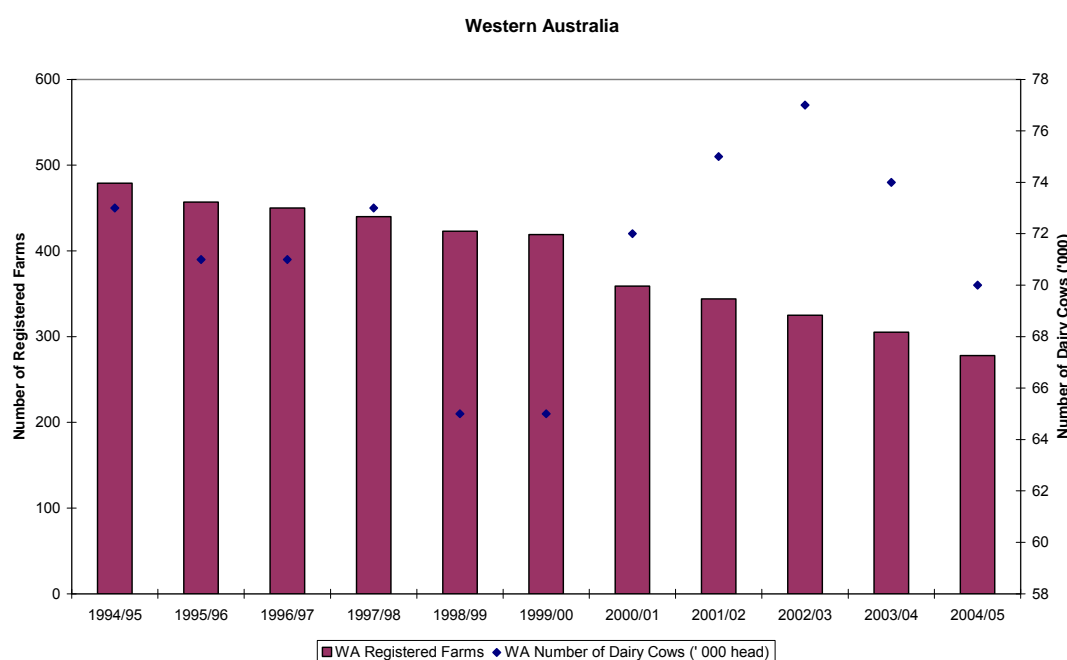


**Figure 69. Common irrigation methods in the surveyed (yellow) dairy region.**

The dairy industry is comparatively small with annual average milk production of 387.6 million litres since 1995/96. The milk production rate for Western Australia has increased from 4609 litres in 1994/05 to 6388 litres in 1990/00. A decline to 5418 litres occurred during 2004/05 (Figure 70). Average milk production per cow per 300 days (lactating time) has been 5535 litres since 1995/96 (Figure 71).

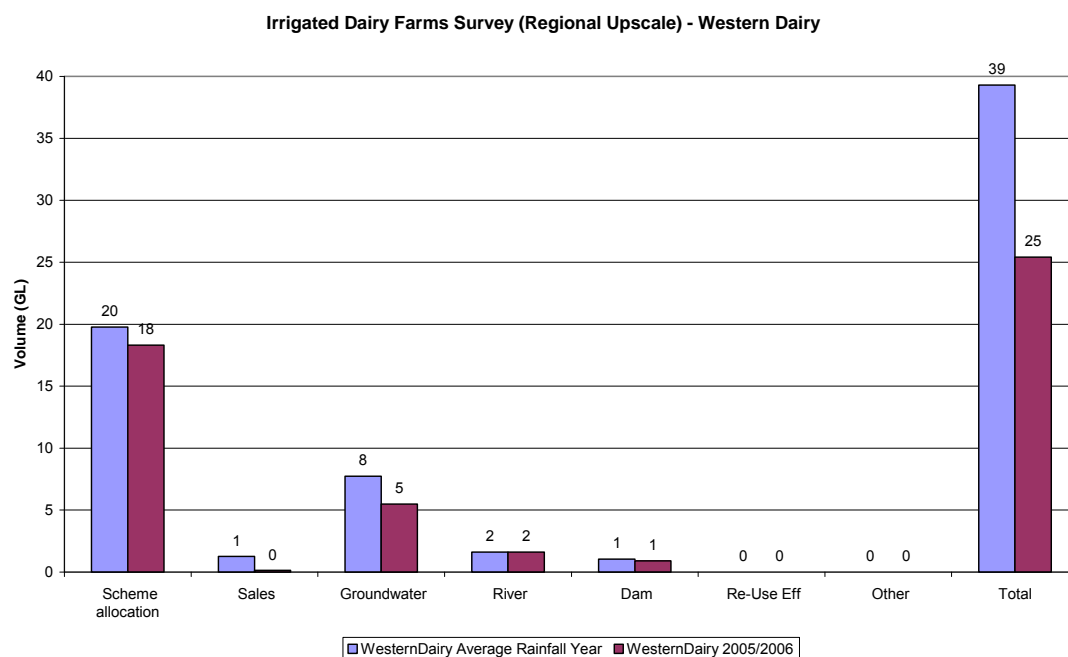


**Figure 70. West Australian milk production rates (L per cow) compared to national average.**



**Figure 71. Ten-year data on registered dairy farms and total dairy cows in Western Australia.**

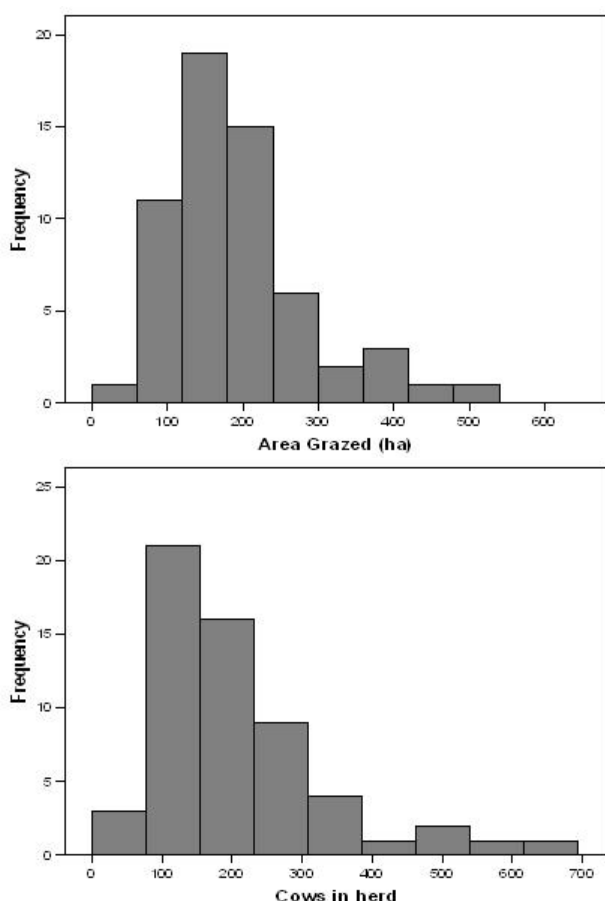
A total of 60 farms were surveyed (Watson, 2006) and the data have been extrapolated to the region. Regional water source breakdown figures were estimated for irrigated dairy farms (Figure 72). Average rainfall year data is the volume of water sourced by dairy farms in an average rainfall year. The total water use during 2005/06 was 25 GL of which 72% was met from scheme allocations. The second largest source was groundwater which met approximately 25% of the total needs in dairy. Eight percent was from river diversions. No effluent was used in Western Australia region. Most farms had a grazing area between 100 ha to 200 ha (Table 28, Figure 73). Twenty-three farms have a herd size of 100 head (Table 28, Figure 73).



**Figure 72. Regional water sources breakdown figures.**

**Table 28: Statistics of the Western Australia dairy region.**

Statistical Parameter	Area Grazed (ha)	Cows in herd
Number of Farms Surveyed	60	60
Mean	200.37	228.00
Std. Deviation	143.755	169.741
Skewness	3.427	2.144
Std. Error of Skewness	0.309	0.309
Minimum	40	64
Maximum	1,011	850



**Figure 73. a Area grazed in the Western Australia region. b Number of cows in the Western Australia region milking herd.**

#### 4.8.3. Crop water requirements

Net CWR and calculations were carried out over Albany for ten-year period (Table 29).

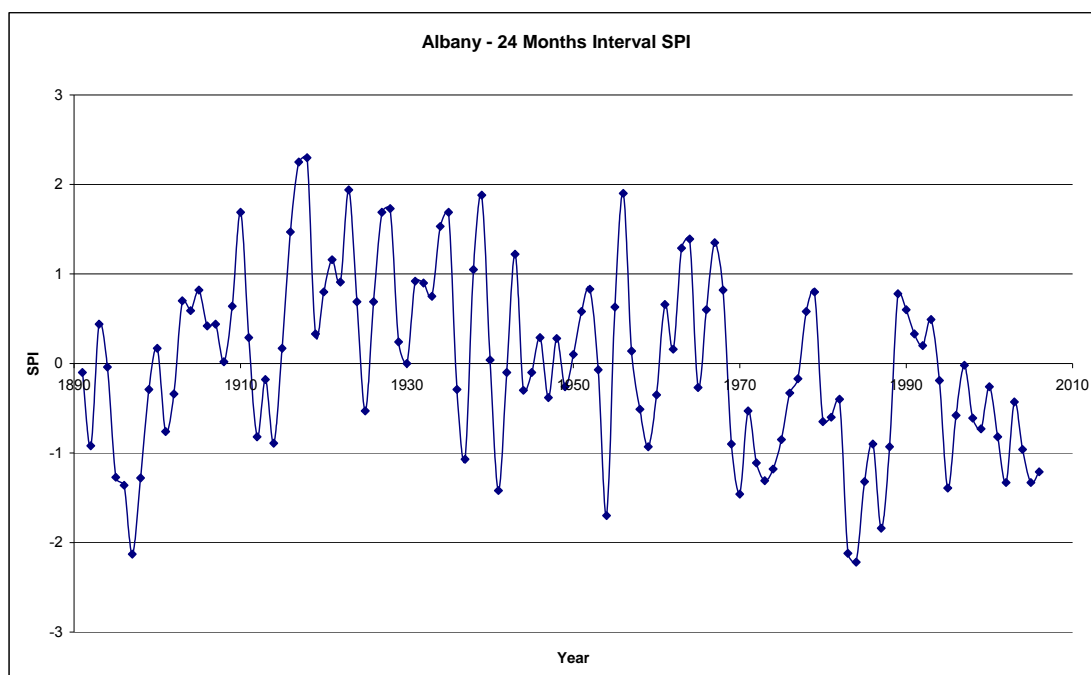
**Table 29: Net crop water requirement for the Western Australia dairy region.**

Year	CWR (mm)	Eff rain (mm)	Net CWR (mm)
1995/96	752	625	325
1996/97	734	738	303
1997/98	769	680	313
1998/99	738	678	355
1999/00	773	709	272
2000/01	791	602	424
2001/02	739	622	306
2002/03	761	629	348
2003/04	740	727	317
2004/05	758	646	331

#### 4.8.4. Climate change and impact of drought

The 24-month SPI (Appendix B) for the city of Albany were applied to compare precipitation totals for 1880–2006 with similar periods in history. Large positive SPIs of 24-month intervals across the region were recorded in 1917 and 1918 indicating the extremely wet conditions to severely wet conditions in 1923, 1939 and 1956 (Figure 74). The large negative SPIs of 24

months indicating extremely dry conditions in 1897, 1983, 1984 to severely dry in 1954 and 1987 were recorded for Albany (Figure 74).



**Figure 74. Twenty-four-month SPI index of Albany in the Western Australia dairy region.**

#### 4.8.5. Key water issues

In 2006, RMCG consultants carried out extensive workshops to determine the major water issues related to dairy farming with the local stakeholders and dairy industry people (RMCG, 2006). The overall objective of the workshops was to consult with the industry across Australia and to develop an irrigation blueprint. The key issues for this region are divided into two zones: Harvey Irrigation Area and the area outside of Harvey Irrigation Area.

##### *Harvey Irrigation Area*

- Pressure on water entitlements with increasing urban water needs – deregulation and pressure on smaller-scale operations has seen dairy drop from 65% to 40%
- Capital cost of on-farm infrastructure restricting the capacity to fully benefit from a pressurised delivery system
- Increased competition from other users – more intensive agriculture and lifestyle/hobby blocks
- Need of significant infrastructure change in delivery system from border check to sprinkler systems
- Small titles and physical restrictions make it difficult to install larger, more efficient centre pivots on-farm
- Limited trading even though water entitlements are well defined
- Water quality of major storages is an area of concern – some work in progress to reduce high saline flows and improve water quality
- Dealing with community concerns about reduction in river flows when system is piped
- Limited on-farm recycling and pressure on nutrient run-off

##### *Outside of Harvey Irrigation Area*



- Some urban pressure with Perth accessing 40 GL from Yarragadee aquifer – need to study impact of withdrawal on farmers entitlements
- Concern about increasing legislation associated with farm dams
- Licence period is too short – impact on confidence to invest
- Rising power costs and power infrastructure limited in some areas, impacting on the cost effectiveness of irrigation.
- Limited trading between users and trade only based on history of use on licensed volume
- A lot of unlicensed, unregulated and unmetered groundwater in Western Australia
- Changes in catchments causing an impact on stream flows (e.g. increasing tree plantations)
- Habitat losses restricting new developments

## 5. KEY MESSAGES

- Dairy is a major water user in the agriculture industry.
- Most water use is for growing pastures through irrigation.
- Less water is available for maintaining sustainable irrigation supplies due to impacts of drought and climate change.
- Significant infrastructure change is needed to convert delivery systems from border check to sprinkler systems. On-farm infrastructure costs restrict the capacity to fully benefit from a pressurised delivery system.
- Water quality of dairy waste systems (effluents in case of no recycling or treatment systems) leaving farms varies significantly across catchments. There is a need for effective integration of dairy effluent with irrigation systems, along with appropriate guidelines.
- Deregulation and pressure on smaller-scale operations have seen a significant drop in smaller dairy enterprises.
- Uncertainty surrounds security of water entitlements due to new policies impacting on confidence in future investments.

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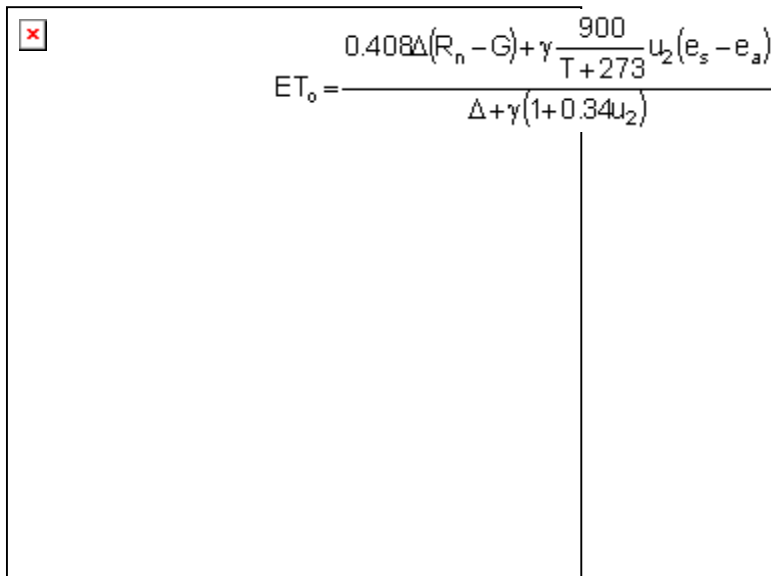
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## APPENDIX: A

### Crop water requirements

In field crops, evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. At sowing, nearly 100% of evapotranspiration (ET) comes from evaporation, while at full crop cover more than 90% of ET comes from transpiration. The evapotranspiration rate is normally expressed in mm/day. The Food and Agriculture Organization (FAO) Penman-Monteith model (Allen et al., 1998) is the most common method used for estimating the evapotranspiration of a reference crop ( $ET_o$ ) – the potential evapotranspiration. A reference crop is an extensive area of short, green, relatively flat vegetation adequately supplied with water.

The Penman-Monteith model includes all parameters that govern energy exchange and corresponding latent heat flux from uniform expanses of vegetation. Most of the equation parameters are directly measured or can be readily calculated from weather data. The Penman-Monteith model to estimate  $ET_o$  is:



The image shows a screenshot of a software interface with a red 'X' icon in the top left corner. The equation for  $ET_o$  is displayed as follows:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where

- $ET_o$  = reference evapotranspiration [mm/day],
- $R_n$  = net radiation at the crop surface [ $MJ/m^2/day$ ]
- $G$  = soil heat flux density [ $MJ/m^2/day$ ]
- $T$  = mean daily air temperature at 2 m height [ $^{\circ}C$ ]
- $u_2$  = wind speed at 2 m height [m/s]
- $e_s$  = saturation vapour pressure [kPa]
- $e_a$  = actual vapour pressure [kPa]
- $e_s - e_a$  = saturation vapour pressure deficit [kPa]
- $\Delta$  = slope vapour pressure curve [kPa/C]
- $\gamma$  = psychrometric constant [kPa/C].

The equation uses standard climatological records of solar radiation (sunshine), air temperature, humidity and wind speed. To ensure consistency among all irrigation areas,  $ET_o$  data is taken from Silo Patched Point Dataset (PPD) website

(<http://www.longpaddock.qld.gov.au/silo/>) that is joint effort of Bureau of Meteorology and Department of Natural Resources, QLD.

The crop coefficient approach is adopted for calculating the crop evapotranspiration ( $ET_c$ ). The crop evapotranspiration ( $ET_c$ ) differs distinctly from the potential evapotranspiration ( $ET_o$ ), as the ground cover, canopy properties and aerodynamic resistance of the crop are different from a reference crop. The effects of characteristics that distinguish field crops from grass are integrated into the crop coefficient ( $K_c$ ). In the crop coefficient approach the crop evapotranspiration,  $ET_c$ , is calculated by multiplying the reference crop evapotranspiration,  $ET_o$ , by a crop coefficient,  $K_c$ :

$$ET_c = K_c \times ET_o$$

Where:

$ET_c$  = crop evapotranspiration [mm/d]

$K_c$  = crop coefficient [dimensionless]

$ET_o$  = reference crop evapotranspiration [mm/d]

**Table A.1: Crop coefficients ( $K_c$ ) for pastures for NSW–Victorian regions.**

Crop Type	Sowing	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Maturity
Summer Pasture	1 Sep	0.08	0.80	0.80	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.80	0.80	Perennial
Winter Pasture	25 Mar	0.08	0.80	0.80	0.60	0.40	0.20	0.20	0.20	0.20	0.40	0.60	0.70	Perennial
Lucerne	1 Oct	0.65	0.65	0.90	1.20	1.30	1.30	1.30	1.30	1.20	1.20	1.00	0.65	Perennial

Source: Wayne Meyer (1996) and David Smith (2004) pers. comm.

The crop water requirements were determined using ten-year weather record (climatic data from SILO). Effective rainfall on a monthly basis is calculated using the US Department of Agriculture, Soil Conservation method. This method is universally accepted for determination of effective rainfall particularly for crop water requirement purposes as it is adopted by FAO experts in CROPWAT model (Kassam and Smith, 2001). This method is limited to monthly rainfall data.

$$Pe = (P_{mon} \times (125 - 0.2P_{mon})) / 125 \quad P \leq 250 \text{ mm}$$

$$Pe = 125 + 0.1P_{mon} \quad P > 250 \text{ mm}$$

Where:

$Pe$  = effective rainfall

$P_{mon}$  = monthly rainfall

The crop water requirements and net crop water requirements for each dairy region are presented in *Chapter 4 – Regional Dairy Profiles*.



## APPENDIX: B

### Standard precipitation index (SPI)

Standard precipitation index (SPI), a normalised continuous rainfall variability function, is a powerful tool to track droughts and for assessing climatic variability (McKee et al., 1993, 1995). Khan and Short (2001) computed SPI for a number of rainfall stations in Australia. SPI is the number of standard deviations that the observed value would deviate from the long-term mean, for a normally distributed random variable. Since precipitation is not normally distributed, a transformation is first applied so that the transformed precipitation values follow a normal distribution. McKee et al., (1993, 1995) used the incomplete beta distribution (see <[www.wrcc.dri.edu/spi/explanation.html](http://www.wrcc.dri.edu/spi/explanation.html)>)

SPI can quantify the degree of wetness by comparing three-, six-, 12- or 24-monthly rainfall totals with the historical rainfall data for the same periods. For example, a six-monthly SPI for August 1999 will compare the March to August 1999 rainfall totals with historic totals for the March to August period over the entire record. A 24-monthly SPI is useful for tracking the severity and persistence of droughts. SPI is computed for each dairy region (see *Chapter 4 – Regional Dairy Profiles*).



### Contact Us

Phone: 1300 363 400

+61 3 9545 2176

Email: [enquiries@csiro.au](mailto:enquiries@csiro.au)

Web: [www.csiro.au](http://www.csiro.au)

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