Water Use for Agriculture in Priority Rivers Basins

CONTENTS

1 THE MURRAY-DARLING BASIN

The Murray-Darling Basin contains the majority of irrigated agriculture in Australia. The purpose of this chapter is to determine the country's high-priority irrigation commodities in terms of the environmental impact they generate. The chapter commences with an outline of management systems within the basin, setting a context for an analysis of the basin's characteristics, the agriculture within it, and the environmental problems associated with it. There are some significant differences between the northern and southern parts of the basin which are also relevant to a decision about future priorities. Further, there are some significant issues in relation to commodities outside the Murray-Darling Basin and, in determining Australian priorities, these must also be considered.

Past management practices, which have led to unsustainable land and water use, and current practices, which focus on achieving sustainability, provide an essential context for determining priority crops on which to focus this study. The biophysical characteristics of the basin are also presented. These reveal the inherent difficulty of applying European-style water use practices in a very different geological and hydrological setting. The attempt to harness water resources in Australia has led to a particular type of agricultural use and this in turn has led to a huge range of environmental problems.

Located in the south-east of Australia, the Murray-Darling Basin covers 1,061,469km^2, equivalent to 14 per cent of the country's total area. East-west, the basin extends 1,250km, from the most easterly point near Warwick to the most westerly, north-west of Goolwa. From the source of the Warrego River in the north to the headwaters of the Goulburn River in the south – from 24°S to almost 38°S in latitudinal terms – the distance is some 1,365km.

1.1 Management of the Murray-Darling Basin

1.1.1 Conflicts in the basin

Conflicting social, environmental, economic and political issues are at play when discussing water management in the Murray-Darling Basin. One of the most pressing issues in the basin is, and will continue to be, the resolution of conflicts between different users competing for the limited quantities of fresh water. There has been a history of conflict over water resources in Australia since European settlement, arising from the different, competing values which have underpinned water resource management policies. These competing values have manifested themselves in conflicts between stakeholders; for example, the construction of dams in catchment areas used for stock, the downstream needs of agriculture versus the needs of urban and industrial centres, and competition for water between the recreation and tourism sector and those favouring conservation of water resources for regenerative processes.

1.1.2 The management dilemma

Central to the problems of water management in the catchment is the inherent conflict between a national hydrological system and a political/administrative system, the boundaries of which do not coincide. The inter-jurisdictional nature of the Murray-Darling River has long compounded conflicts over water. The basin extends over three-quarters of the state of New South Wales, more than half of Victoria, significant portions of Queensland and South Australia, and includes the whole of the Australian Capital Territory. The tributaries of the Darling form part of the border between Queensland and New South Wales, while Victoria lies on the southern bank of the Murray River. These are critical factors in any examination of the management of the basin.

Although there are no language barriers between the different jurisdictions charged with managing land and water resources, there are significant challenges in generating cooperative approaches. The need for cooperation was recognized early in the development of the Australian federation.

Table 1.1 State shares in the Murray-Darling Basin

State	Total surface area (km^2)	State area in basin (km^2)	% of state area in basin	% of total river basin
New South Wales	802,081	599,873	74.79	56.51
Victoria	229,049	130,474	59.96	12.29
Queensland	1,776,620	260,011	14.63	24.50
South Australia	984,395	68,744	6.98	6.48
Australian Capital Territory	2,367	2,367	100.00	0.22
Total	**3,794,512**	**1,061,469**		**100.00**

1.1.3 The Murray-Darling Basin Agreement

In 1984, a Parliamentary Select Committee was convened to examine the management of the basin. The committee's final report, *Salt of the Earth*, concluded that salinization was worsening rapidly, affecting productivity and the economic viability of irrigation in the basin. Between 1985 and 1987 there were countless meetings of ministers responsible for water, land and environmental resources to negotiate a new agreement. The outcome was the Murray-Darling Basin Agreement, signed by the Commonwealth Government, New South Wales, Victoria and South Australia. Queensland became a signatory in 1996, with the Australian Capital Territory joining in 1998. The preamble to the agreement states that "the Commonwealth, New South Wales, Victoria and South Australian governments wish to promote and coordinate effective planning and management for the equitable, efficient and sustainable use of water, land and environmental resources of the Murray-Darling Basin". The agreement created a three-tiered administrative body, comprising the Murray-Darling Basin Ministerial Council (MDBMC), the Murray-Darling Basin Commission (MDBC), and the Community Advisory Committee.

One major success of the agreement has been the implementation of a comprehensive planning framework for the basin by the MDBC. In 1990, a Natural Resource Management Strategy was adopted by the MDBMC. The strategy established two fundamental 'pillars' for handling natural resource management in the basin. The first was the philosophy of integrated catchment management, recognizing the linkages between various biophysical processes, which affect or are affected by water, its movement and its uses. The second 'pillar' was the community/government partnership, recognizing that neither party working in isolation can protect the basin's natural resources. In 1999, the MDBC commenced the development of a new integrated catchment framework for the period 2001–2010. The framework recognizes the complex interrelationship between the condition of land and water resources and human activities and pursuits, and that land management and use affects the quality and quantity of the catchment's water resources. As a consequence, water resource planning must take full account of the variety of natural factors and features and the human influences on the environment.

Despite some progress in implementing water reforms, there is a realization that the health of the river basin has continued to decline in many areas, with ongoing threats to a number of species.

There has also been national recognition of the need to inject significant additional investment if sustainable land and water management is to be achieved.

1.1.4 National Action Plan for Water Quality and Salinity

As a result of past poor land management practices, a hydrological imbalance in the basin has been created resulting in salinization, increased turbidity, nutrient levels, bacterial pollution and pesticides. This is threatening the biological diversity, environmental health and productivity of many regions. Faced with estimates that it will cost AU$46 billion over ten years to overcome the problem of salinity, the federal government has launched a AU$700 million package entitled 'Our Vital Resources: National Action Plan for Salinity and Water Quality in Australia'. The plan was announced in October 2000, however its arrangements are still being determined, with considerable uncertainties as to how the money will be delivered and targeted towards outcomes.

1.2 Features of the Murray-Darling Basin

1.2.1 Ecoregions in the Murray-Darling Basin

There are three WWF Global 200 ecoregions situated in the Murray-Darling Basin: Eastern Australia Temperate Forests, Southern Australian Mallee and Woodlands, and Eastern Australia Small Rivers and Streams.

<u>Eastern Australia Temperate Forests</u>
The generally more moderate climate and high rainfall of south-eastern Australia give rise to unique eucalyptus forests and open woodland dominated by acacia trees. The region served as a refuge when drier conditions prevailed over most of the continent. Consequently, it has a remarkable diversity of plants and animals with high levels of regional and local endemism. Species include koala (*Phasolarctos cinereus*), golden-headed flying fox (*Pteropus poliocephalus*), squirrel glider (*Peterus norfolcensis*), and wombat (*Vombatus ursinus*). Forests of mountain ash (*Eucalyptus regnans*) provide habitat for the endemic Leadbeater's possum (*Gymnobelideus leadbeateri*). Birds include endemic species such as Albert's lyrebird (*Menura alberti*) and russet-tailed thrush (*Zoothera heinei*), as well as a vast number of wider-ranging species like black-necked stork (*Ephipiorhynchus asiaticus*), Australian king-parrot (*Alisterus scapularis*), and yellow-tailed black-cockatoo (*Calyptorhynchus funereus*).

General threats: Much of the pre-European settlement vegetation in this ecoregion has suffered from historical conversion of forests to any of a number of uses: suburban/urban centres, livestock production, agriculture, and timber production, among others. With the exception of south-western Australia, this is the most heavily altered area on the continent. Invasive plant and animal species are numerous and problematic throughout the ecoregion, while increased growth of suburban and urban areas, alteration of natural disturbance regimes, and grazing are continuing threats.

<u>Southern Australian Mallee and Woodlands</u>
This ecoregion is one of only six Mediterranean shrubland complexes in the world. Although not as rich as the nearby Mediterranean shrublands of south-western Australia, these woodlands are extremely diverse, supporting an array of plant and animal wealth. Native plant communities include those dominated by mallee (*Eucalyptus diversifolia*) which are distributed along coastal dunes and swampy areas dominated by species of *Gahnia*. Other dominant plants include *Melaleuca lanceolata* and *Hakea rugosa,* in addition to numerous herbaceous species such as

morning flag (*Orthrosanthus multiformis*), desert baeckea (*Baeckea crassifolia*), and silvery phebalium (*Pheballium bullatum*). Among numerous birds species with the smallest ranges are the firetail (*Stagonopleura bella*), skylark (*Alauda arvensis*), little raven (*Corvus mellori*), Gilbert's whistler (*Pachycephala inornata*), and the endemic red-lored whistler (*P. rufogularis*).

General threats: Much of the native vegetation in this ecoregion has been cleared for agriculture or for grazing. Today, portions of the ecoregion are managed for commercial forestry, including some public lands.

<u>Eastern Australia Small Rivers and Streams</u>
Both species richness and endemism are high in eastern Australia's streams, in contrast to streams in western regions. South-east Australia has a particularly species-rich and endemic crayfish fauna (family Parastacidae), as well as a large number of endemic freshwater fish. The rivers, lakes and springs of this ecoregion contain numerous relict species, including many species of dragonflies (*Odonata*) and mayflies (*Ephemeroptera*). The most famous resident of eastern Australia's freshwater systems is the platypus (*Ornithorhynchus anatinus*). There is also an unusual group of gastric-brooding frogs of the genus *Rheobatrachus*, and a large number of freshwater snails (family Hydrobiidae) have very localized distributions within portions of the ecoregion. Characteristic fish include one of the world's largest freshwater species, the Murray Cod (*Maccullochella peelii*), which reaches lengths greater than 1.5m, and lungfish (*Neoceratodus fosteri*), which is the only living representative of the Ceratodontidae family. Among many endemic fishes are Murray jollytail (*Galaxias rostratus*), the primitive spotted bonytongue (*Scleropages leichardti*), and the migratory Australian grayling (*Prototroctes maraena*), which may be the only extant member of its genus and is considered vulnerable.

General threats: Threats to freshwater biodiversity are numerous. Rivers and streams have been highly modified by the construction of weirs and dams, channelization, and the removal of riparian vegetation. Agricultural, urban, and industrial pollution are growing problems in some areas. Introduced species, including fish and aquatic plants, often translocated from other Australian regions, are threatening native populations. Aquaculture threatens to further the spread of non-native species, as well as to release wastewater into freshwater systems. Forest clearing for agriculture and timber production, and subsequent increases in sedimentation, may be one of the most serious problems.

1.2.2 Climate and water resources

An important consequence of the extent of the Murray-Darling Basin is the great range of climatic conditions and natural environments, from the rainforests of the cool and humid eastern uplands, the temperate mallee country of the south-east, and the subtropical areas of the north-east, to the hot, dry semi-arid and arid lands of the far western plains.

As well as being Australia's largest river system, the Murray-Darling is also one of the world's major river basins, ranking fifteenth in terms of length and twenty-first in terms of area. When all the rivers, creeks and water courses are plotted on a map, the basin appears to have a mass of waterways. However, many of these only carry water at times of flood; for the rest of the time, they are dry. The nature of the Murray-Darling Basin means that, for most of their lengths, most of the rivers flow over plains. One consequence of this is that their individual courses are far from simple, as they meander across their floodplains. The actual course of the Darling is about three times as long as the direct distance that is involved. Another consequence of the nature of the basin is that the rivers generally have extremely low gradients. As a result, under normal conditions, changes in flow spread down the riverbeds relatively slowly.

While the Darling, Murray and Murrumbidgee are the longest and most important rivers, they are but three of the 20 major rivers in the basin. Between them, these major rivers have hundreds of tributaries.

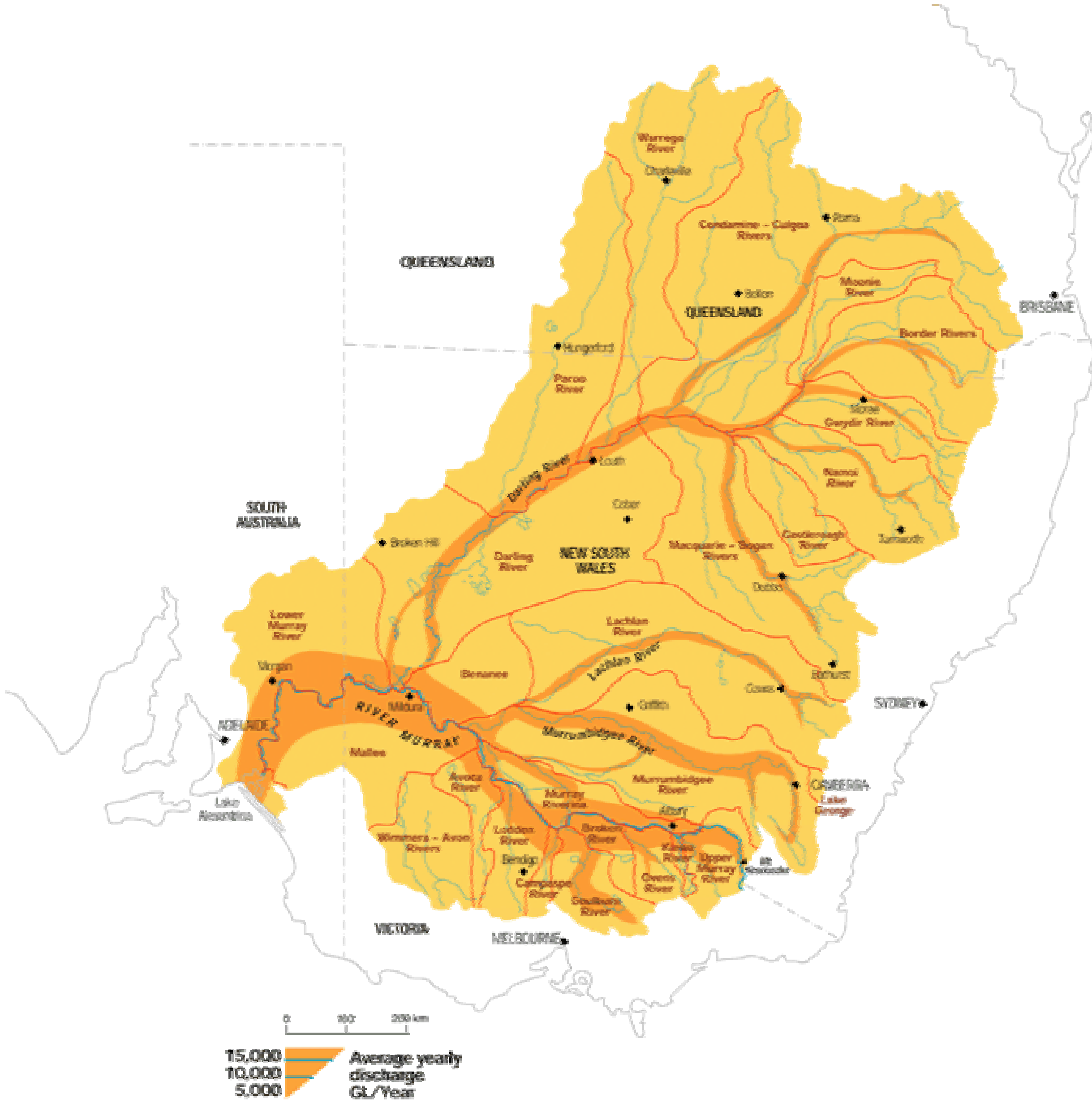
1.2.3 Surface water resources

There is considerable variation in runoff from one part of the basin to another, while runoff also bears little relationship to catchment size. The catchments draining the Great Dividing Range on the south-east and southern margins of the basin make the largest contributions to total runoff. For example, the Upper Murray, Murrumbidgee, and Goulburn River catchments account for 45.4 per cent of the basin's total runoff from 11 per cent of its area. The Upper Murray catchment alone accounts for 17.3 per cent from 1.4 per cent of the basin. By contrast, the Darling group of rivers contributes 31.7 per cent of the basin's mean annual runoff from 60.4 per cent of its area. The Darling catchment itself accounts for 10.9 per cent of the basin's area but only 0.4 per cent of mean annual runoff.

Overall, some 86 per cent of the Murray-Darling Basin contributes virtually no runoff to the river systems, except during floods. Australia's climate, compounded by the variability of its rainfall, means that virtually all of Australia's river systems are subject to considerable variability of flows from one year to the next. In fact, on a global scale, Australia (together with Southern Africa) experiences higher runoff variability than any other continental area. The Murray-Darling Basin is no exception to this, in spite of the fact that much of the river system is now highly regulated. For the Murray and Murrumbidgee, the high and relatively reliable precipitation in their source areas means that stream flow is much more reliable than in other parts of the catchment. But even for some of their tributaries, there are significant exceptions, notably the Broken and Avon Rivers. However, these variations are small in comparison with those of the Darling River and its tributaries. These rivers not only experience massive floods, they can also cease flowing for extended periods. The Darling provides some of the most extreme examples. At Menindee, between 1885 and 1960, the river ceased to flow on 48 occasions. The longest no-flow period was 364 days in 1902/03.

Approximately half the surface water management areas are assessed as being developed beyond 100% of sustainable yield (Australian Catchment, River and Estuary Assessment 2002, p.233).

Figure 1.1 Catchment areas in the Murray-Darling Basin



Source: MDBC 2002a, Surface Water

1.2.4 Water diversions and storage

Given the above potential water resource, it is important to consider the developments associated in seeking to harvest and store the resource. This has been fundamentally important in determining the agricultural activity associated with water use.

Of the water that would have originally reached the sea from the Murray-Darling Basin, over two-thirds is now diverted from its rivers each year. Mean outflow from the Murray to the sea has been reduced from some 13,700 million m^3 per year under natural conditions to 5,750 million m^3, or as low as 35 per cent of natural flows according to some sources.

Table 1.2 Runoff, outflows and diversions in the Murray-Darling Basin

Drainage division	**Mean annual run-off** (million m^3)	**Percent mean Annual run-off** (%)	**Mean annual outflow** (million m^3)	**Volume diverted** (million m^3)
Murray-Darling	23,850	6.2	5,750	12,051

Source: Australian Water Resources Assessment 2000 (p25)

The mean figures, however, are influenced too much by large floods. The median annual flow to the sea (i.e. the flow that is exceeded in 50 per cent of years) is now only 21 per cent of the natural median flow. From a figure of around 3,000 million m^3 in 1930, diversions now total over 12,000 million m^3. On some occasions, as in 1981 and for a number of months in 1995, water has ceased to flow to the sea, though in this case it was due partly to drought conditions. The increase in diversions has been particularly marked since the late 1950s, with over 90 per cent of the diverted water used for irrigation.

The increase in diversions has been primarily due to the expansion of the cotton industry and the use by growers of large on-farm water storage. Australia has 447 large dams with a combined capacity of 79,000 million m^3 of water (equivalent to 158 times the volume of Sydney harbour), developed mainly for urban areas, irrigation schemes and hydropower generation. Australia's several million farm dams account for an estimated 9 per cent of the total water stored (Australian Water Resources Assessment 2000). As a result, there has been much conflict along the Darling, and especially along some of its tributaries, between graziers, conservationists and irrigators.

One very significant result of the reduced flows throughout the basin is that the rivers are now in a state of drought (as defined by river levels) for more than 61 years in every 100, compared with 5 years per 100 under natural conditions (MDBMC 1995). This is a particular issue on the lower reaches of the river system, especially for the Coorong and the mouth of the river Murray. On the other hand, regulation has eliminated most of the extreme low flows, though they are still a feature of the Darling system. Without regulation, the Murray might well have ceased to flow during the drought of 1982/83.

1.3 Agriculture

1.3.1 General agriculture versus commodity approach

With a view to conserving wetlands and biodiversity by focusing on water use, it is important to concentrate on particular commodities, rather than on agriculture and water use and water infrastructure in general. One concern about focusing on particular crops, however, is that water savings for example in one commodity may not necessarily produce an environmental benefit if they are simply transferred to an alternative commodity, and cannot be secured for environmental flows. In addition, such an approach may only address a small part of the environmental problems caused by water infrastructure. That said, a focus on particular commodities of major importance provides enormous potential to influence specific outcomes in specific areas, and provide models for best practice across the entire irrigation sector. However, measuring the success of a focus on commodities may prove very difficult.

The total area devoted to crops in the Murray-Darling Basin is 7,137,303ha, 43.5 per cent of the total Australian crop area of 16,404,332ha and 8.4 per cent of the total farm area in the basin. Crops are grown on 31,164 farms, 60.3 per cent of the farms in the basin. The available indicators suggest that crop production is relatively more important in the basin than for Australian agriculture as a whole.

A large part of Australia's major arable farming area, long known as the wheat-sheep belt, is located within the Murray-Darling Basin. It extends from southern Queensland, through New South Wales and Victoria (to the west and north of the Great Dividing Range) into South Australia. Much of the area has a mean annual rainfall of under 600mm, its unreliable nature being a major determinant of crop yield. A large number of crops are grown in the basin, among them wheat, barley, rice, oilseeds, cotton, and a number of horticultural commodities. Among other crops grown are other cereals and pulses (such as lupins, field peas, chickpeas, lentils, mung beans, faba beans, navy beans, and vetch). Some of these crops are grown mainly for livestock feed, though others supply niche markets for human consumption, especially in the health food sector.

Table 1.3 Irrigated crops in the Murray-Darling Basin

Irrigated crop	**Area** (ha)	**% of national area**	**Application rate** (10^6l/ha)
Pasture	862,155	79.8	6.1
Cotton	231,684	74.2	5.8
Cereals	139,654	2.6	6.5
Rice	109,186	95.8	10.9
Fruit trees	38,856	73.0	10.8
Grapevines	30,492	60.0	9.3
Vegetables	23,511	25.4	7.2

Source: Dunlop 2001, MDBC 2002a, Irrigation

Irrigated agriculture in Australia results in significant costs, not least because the bulk of the irrigation water is used for mixed farming and low-value commodities. The situation is further aggravated by the fact that a number of the commodities are also inefficient users of water (e.g. pasture, rice). In particular, the irrigation needs for grazing need to be carefully examined if the large surface area employed is to be continued, especially since production efficiency is very low (around 1 million litres of irrigation water are required to produce 600–2,000 litres of milk).

Table 1.4 Land use in the Murray-Darling Basin

Land use	**Approximate area** (million ha)	**% of total area**
Unused	8.8	8.3
Conservation purposes	1.9	1.8
Forests	3.3	3.1
Grazing:		
- arid	22.9	21.7
- monsoon	26.4	25.0
- semi-arid	18.8	17.8
- sub-humid	15.3	14.5
- humid	3.4	3.2
- total grazing	86.8	82.1
Crops	7.1	8.4
Urban	0.2	0.2
Total	**105.6**	**100.0**

1.3.2 Geographic perspectives in the Murray-Darling Basin

Given the large climatic differences described above, it is important to consider the differences between the southern part of the basin, which is largely winter rainfall dominated, and the northern part, which experiences predominantly summer rainfall.

Southern region

Rice

Rice is the major irrigated cereal crop and is grown almost entirely in the Murrumbidgee and Murray valleys of southern New South Wales. Commercial rice growing started in the Murrumbidgee Irrigation Area in 1924, but the industry's rapid expansion occurred in the 1970s and 1980s, largely through the increase in the area sown and through improved yields. A record crop of 1,284,000 tonnes was harvested in 1995/96. However, there are resource constraints, not only in terms of the availability of irrigation water, but also because of the environmental consequences of the large quantities of water and flood irrigation methods that are used. Up to half of the water that percolates down to groundwater from irrigated areas in southern New South Wales comes from rice production. This represents some 200km^3 of water every year. Not only is this water wasted, it is an undesirable addition to already high water tables. A reduction of deep percolation from rice cultivation is essential if environmental degradation caused by rising water tables is to be contained. Increased production has to be sought through varieties that give higher yields and require less water.

Fruit trees

The main growing areas are the Riverland (the irrigation areas around Mildura in north-west Victoria and adjoining areas of New South Wales) and the Murrumbidgee Irrigation Area.

Grapes

The major producing areas are in the South Australian Riverland and the Mallee and Murrumbidgee Statistical Divisions.

Vegetables

A large number of different types of vegetables are grown in many parts of the basin. Peas, green beans, cabbages, cauliflowers, pumpkins and carrots in Robinvale and Griffith, onions in Griffith and South Australian Lower Murray, asparagus near Cowra and Jugiong, and Potatoes in the Murray, Murrumbidgee, and Central highlands of Victoria.

Northern region

Cotton

The major growing areas are along the Darling River and especially its tributaries in northern New South Wales and southern Queensland. Limitations on the availability of irrigation water are contributing to an increase in production of dry-land cotton and also to the spread of irrigated cotton production to other parts of the basin, such as along the lower Darling and the Murrumbidgee Rivers.

1.4 Irrigation and drainage development

Agricultural holdings in Australia cover an area of 465,953,718ha, of which 2,069,344ha (0.4%) are under irrigation. Of this area, 1,472,241ha (71%) are located in the Murray-Darling Basin. There are 14,743 farms with irrigated crops and/or pastures – 28.5 per cent of the total number of farms in the basin and 47.2 per cent of all Australian farms with irrigation. As a result, it is estimated that agriculture uses 95 per cent of the basin's available water resources, while for Australia as a whole this is estimated at 70 per cent.

Four main groups of irrigation scheme can be distinguished, according to their form of administration or operation:

- Government established and operated schemes
- Government established and now privatized schemes
- Privately established and operated schemes
- Individually operated schems.

1.4.1 Irrigation methods

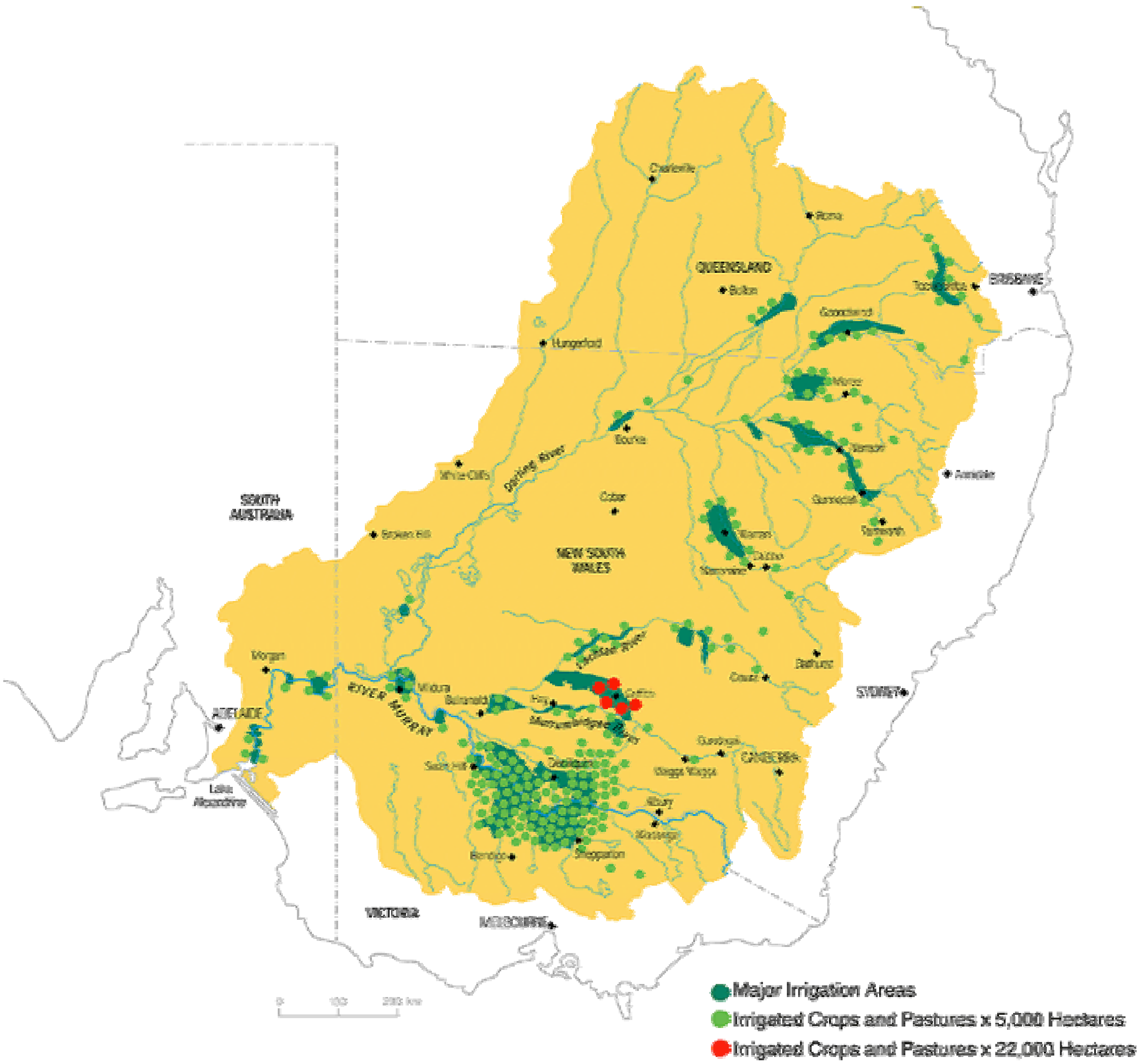
The irrigation of crops and pastures is undertaken in many different ways. Irrigation can be the primary source of water, with the crops more or less totally dependent on irrigation, or it can also be regarded as supplementary, providing moisture at critical periods of plant growth and/or as a means of coping with the vagaries of seasonal rainfall.

A variety of irrigation methods and equipment are employed, and can be summarized as follows:

- *Flood:* In some cases employing laser land forming technology to ensure level fields for increased irrigation efficiency, especially for pastures and rice production
- *Furrows:* The predominant method for horticultural and field crops, and, particularly in the older schemes, for vines and tree crops
- *Sprinklers:* There are various types of overhead sprinkler systems, depending on the crops. Systems can be fixed or portable, though the latter can involve considerable labour input; increasing use of under-tree and micro-sprinklers results in much greater water use efficiencies. Employed particularly for tree crops and vines, with centre pivot systems also used for irrigating fodder crops, lucerne, vegetables, etc.
- *Trickle/drip hoses:* Even more efficient, due to direct application of water
- *Sub-surface drip systems.*

The flood and furrow methods are relatively inefficient, both in terms of application and crop water use. The area irrigated in this way is declining in both real terms and as a proportion of the total area, following the adoption of newer and more efficient methods. Because of the considerable capital investment, irrigation methods and equipment cannot be easily changed, except perhaps in replacing flood or furrow irrigation with more sophisticated systems. The available data on the use of the various irrigation methods are limited and problematic. South Australian data indicate that furrow methods predominate in the older areas, while sprinkler systems are found in the more recently established schemes (Smith and Watkins 1993). It can also be noted that, in South Australia, overhead sprinklers are now showing some decline after their rapid expansion in the 1960s, due at least in part to rising water salinity levels.

Figure 1.2 Location of irrigation schemes in the Murray-Darling Basin



Source: MDBC 2002a, Irrigation

1.4.2 Environmental impacts of water diversions and storages

Impoundments, surface water abstraction and river regulation associated with water resource development are significant drivers of riverine ecosystem condition. These same drivers affect the health and condition of freshwater fish communities, many of which are known to be migratory and rely on hydrological cues for breeding.

To date, WWF has focused on impacts from water storages generally, and has sought unsuccessfully to have various threatening processes notified under environmental protection legislation. These processes are: changes to natural flows, changes to natural quality, changes to natural temperature, barriers to fish passage, introduced species, and removal of large woody debris (for habitat). WWF has, however, managed to ensure the listing under legislation of one aquatic community of the lower Murray, Murrumbidgee and Tumut Rivers which would most likely become extinct if the threats were to continue.

It is difficult to match the particular agricultural commodities to these impacts, and also difficult to identify how changes in the production of particular commodities will address threats to biodiversity. This is because many of the threats relate to the way water is collected and distributed. For example, the changes to natural flows, natural temperatures and barriers to fish habitat are due to dams which make water available for irrigation of a variety of crops, as well as for town water supplies and in some cases hydroelectricity generation. Changes to natural quality can come from irrigation as well as non-irrigation sources, and identifying the particular contribution of each is difficult and specific to a particular valley. The means by which environmental flow increases are to be secured is the subject of much debate. Water efficiency savings in particular industries may not lead to increases in environmental flows unless they are specifically purchased for the environment. Water efficiency gains may be used to increase the total amount of irrigated area. Also, in the particular circumstances of many Australian rivers, where inefficient water users have been operating for a long period, moving to increased water use efficiency can have a significant impact on return flows from farms.

Further, there has been extensive debate about the means by which improvements in particular commodity practices will lead to environmental improvements. In some cases, the benefits can be more clearly linked to practices. Reduction of nutrients and chemicals entering waterways should provide a clear linkage to improvement in particular water quality parameters, however overall river health is dependent also upon riparian zone health, and the quantity, timing and temperature of flows. Again, because of these complexities, determining the extent to which improvements are sought in particular commodity groups and the potential for these to lead to significant health improvement is difficult. Despite this, there have been several attempts to determine the contribution that particular industries can make in particular situations. One example is the complex and important ‘Living Murray’ project developed by the Murray-Darling Basin Commission (MDBC 2002b).

Table 1.5 Inter-basin transfers of water involving the Murray-Darling Basin

From river basin	To river basin	Estimated quantity (million m^3)	Remarks
Transfers into the Murray-Darling Basin			
Brisbane	Condamine	4	Perseverance Ck diversion for Toowoomba water supply (to be augmented by Cressbrook Creek Dam)
Snowy	Upper Murray	580	Snowy Mountains Scheme (additional water made available through regulation)
Snowy	Murrumbidgee	550	Snowy Mountains scheme (additional water made available through regulation)
Glenelg	Wimmera-Avon	76	Rocklands Dam supplies some of the water for the Wimmera Mallee Stock and Domestic Scheme
Transfers out of the Murray-Darling Basin			
Macquarie	Hawkesbury	14	Fish River water supply scheme
Goulburn	Yarra	13	Silver-Wallaby Creek aqueduct for Melbourne water supply
Lower Murray	South Australian Gulf Drainage Division	350	Water pumped from the Murray River for water supply to Adelaide and numerous other parts of South Australia
Estimated Import		833	

Source: AWRC 1987, Volume 1 (pp30–32)

1.5 Land use

For Australia as a whole, recent studies have indicated that over 20 per cent of the native vegetation has been cleared for agricultural and other purposes, compared with previous estimates of 6–8 per cent. The figure rises to 52 per cent in what has been termed the ‘intensive land use zone’ of the continent, which includes much of the basin (Graetz *et al.* 1995).

At least half of the Murray-Darling Basin’s pre-European settlement vegetation cover has been removed, and many new plants and animals have replaced native species. In the arid and semi-arid areas in particular, many native species are not regenerating. Many have been lost, not least those of native grasslands. There is little wilderness of high quality remaining in the Murray-Darling Basin.

Over the period of European settlement, the basin has undergone some of the most extensive and dramatic vegetation changes in Australia. Significant among these has been the clearing of eucalypt woodland and shrubland in the drier areas and their replacement by crops and pastures, notably in what has long been known as the wheat-sheep belt that stretches from south-east Queensland through New South Wales and northern Victoria into South Australia. Over large areas, the native vegetation, both woodland and shrubland, has been thinned rather than cleared, again in the interests of agricultural activities.

Quite apart from the clearing of native vegetation, land use is constantly changing. The introduction of new crops and new farm management practices, for both crops and livestock, means that agricultural land use changes frequently. Crops such as cotton, rice, canola, and sunflowers are evident in terms of land use and their visual impacts. Agricultural and pastoral land is taken for urban development, with Canberra providing perhaps the best illustration within the basin.

Table 1.6 Changes in natural vegetation in the Murray-Darling Basin

	Pre-European area (ha)	Present day area (ha)	Cleared area (ha)	% change
Native vegetation cover	105, 859,000	65,276,960	40,582,040	38
Rainforest and vine thickets	67,944	34,552	33,392	49
Eucalypt tall open forests	859,592	758,312	101,280	12
Eucalypt open forests	7,264,768	4,379,020	2,885,748	40
Eucalypt low open forests	663,416	648,996	14,420	2
Eucalypt woodlands	31,059,512	11,469,272	19,590,240	63
Acacia forests and woodlands	8,954,808	5,208,088	3,746,720	42
Callitris forests and woodlands	2,756,308	2,488,560	267,748	10
Casuarina forests and woodlands	5,811,932	4,751,568	1,060,364	18
Melaleuka forests and woodlands	268	40	228	85
Other forests and woodlands	587,324	289,984	297,340	51
Eucalypt open woodlands	7,475,496	4,390,616	3,084,880	41
Acacia open woodlands	753,328	620,260	133,068	18
Mallee woodlands and shrublands	10,683,964	6,019,656	4,664,308	44
Low closed forests and closed shrublands	378,696	373,960	4,736	1
Acacia shrublands	6,500,416	6,284,280	216,136	3
Other shrublands	1,297,828	1,096,068	201,760	16
Heath	187,884	185,884	2,000	1
Tussock grasslands	6,009,476	2,552,252	3,457,224	58
Hummock grasslands	120,408	110,664	9,744	8
Other grasslands, herblands, sedgelands and rushlands	6,440,560	6,422,280	18,280	1
Chenopod shrubs, Samphire shrubs, and forblands	7,302,204	6,546,504	755,700	10
Mangroves, tidal mudflats, samphires, claypans, salt lakes, bare areas, sand, rock, lagoons, freshwater lakes and reservoirs	673,220	636,496	36,724	5

Source: Australian Catchment, River and Estuary Assessment 2002 (p229)

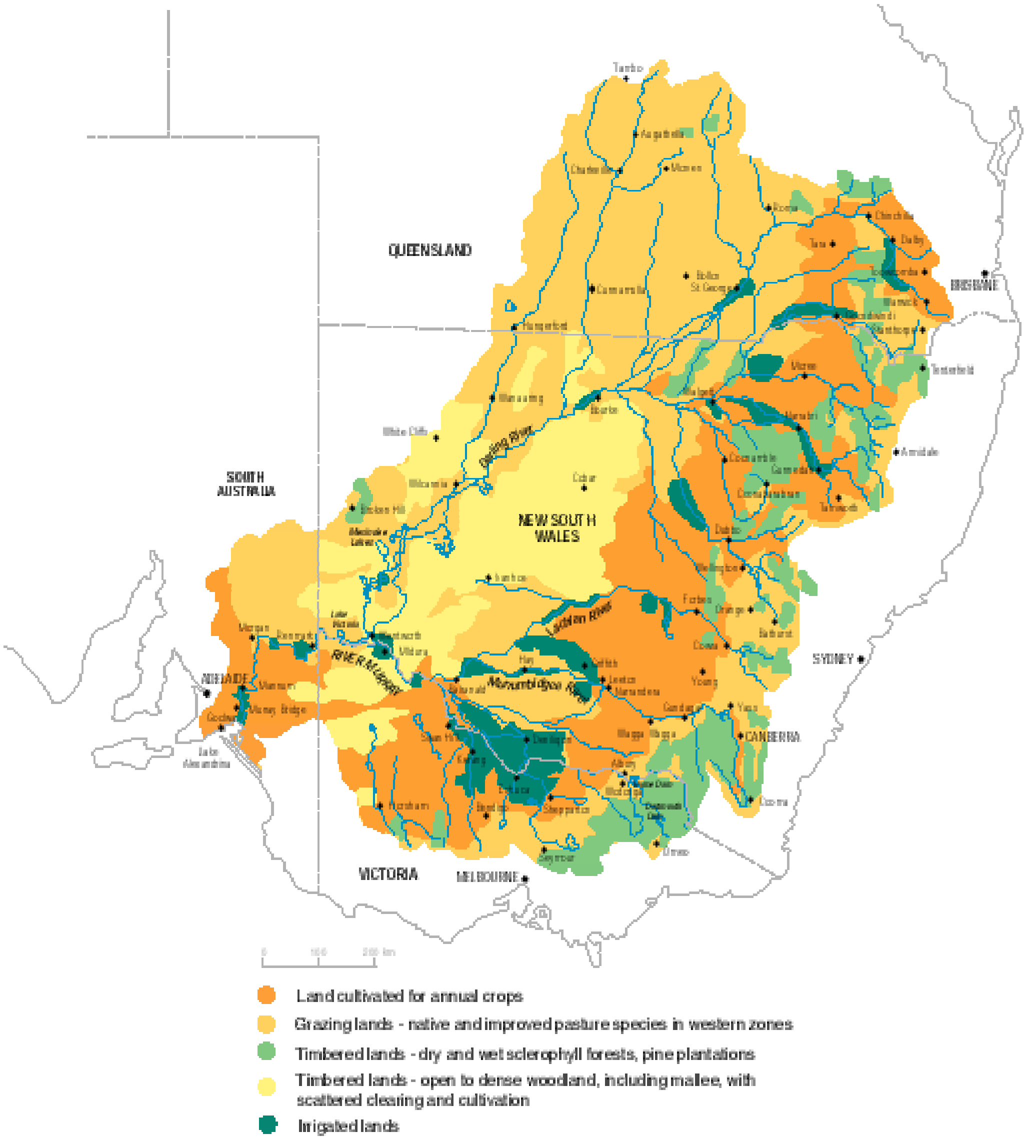
1.5.1 Erosion rate and sediment

Most of the east and south has undergone a two to fivefold increase in rate of hill-slope erosion. Some dry-land agricultural areas in the upper catchments of southern and eastern river basins and on the lowland sandy soils of cleared mallee areas in the south-west are experiencing hill-slope erosion rate increases of between 10 and 30 times natural rates (Australian Catchment, River and Estuary Assessment 2002, p231).

1.5.2 Nutrient loading

River basin nitrogen loads are estimated to have doubled on average compared to pre-European settlement levels. Phosphorus loads are estimated to have tripled on average, due to an increased percentage (77%) of the phosphorus load being transported in association with fine sediment. Approximately half (52%) of the nitrogen load is transported in association with fine sediment, highlighting the role of fine sediment as a key transport mechanism for nutrient loads.

Figure 1.3 Land use in the Murray-Darling Basin



Source: MBDC 2002, Land Use

1.5.3 Salinity

Land salinization occurs naturally in parts of the Murray-Darling Basin in the form of saline seepages and scalds. The concern here, however, is with secondary or induced salinization resulting from European-type land use activities.

In the basin's irrigation areas, the problems that can result from the removal of native vegetation have been compounded by the application of large additional quantities of water, very often without any drainage facilities to remove excess water. Thus, over large parts of most of the basin's irrigated lands, water tables are now less than 2m from the surface, resulting in both salinization and waterlogging. In 1987, it was estimated that 96,000ha were affected by saline soils and 560,000ha had water tables within 2m of the surface, with the latter rising rapidly in many areas. By 2040, 1.3 million ha of irrigated land is expected to be saline or waterlogged as a result of high water tables.

A range of measures is being undertaken to combat rising water tables and salinization in irrigation areas. These include surface and sub-surface drains, groundwater pumping, pumping of saline groundwater into evaporation basins for later collection and disposal, water harvesting (especially of drainage water), in some cases disposal of saline drainage water to the Murray River, tree planting, and adopting a holistic approach to farm planning and management, especially in terms of water use management and coping with saline environments ('living with salt').

<u>Water resources at risk</u>
The most significant off-site impact of dry-land salinity is the salinization of previously fresh rivers. This affects the supply of drinking and irrigation water, with serious economic, social and environmental consequences for rural and urban communities.

A salinity audit by the Murray-Darling Basin Commission suggested that in the absence of remedial action, the median salinity in the Murray River at Morgan was estimated to increase by about 25 per cent over the next five years as a result of increased salt inflows from irrigation and dry-land districts (MDBC 1999). Stream salinity in the Murray exceeds World Health Organisation levels for potable water for about 10 per cent of the year. Salinity levels in the Murrumbidgee River are increasing at between 0.8 and 15 per cent each year, depending on where measurements are made. The audit also suggests that in the upper basin, the Macquarie, Namoi, Bogan, Lachlan and Castlereagh Rivers will exceed the 800EC units threshold for water within the next 50 years. Some will also exceed the 1500EC units threshold for irrigation within 100 years.

Table 1.7 Potential effect of current land use on the spread of dry-land salinity by 2050

Catchment region	**2050** (ha)
Fitzroy	732,421
Murray-Darling	628,393
Gulf	546,412
Burdekin	476,886
North Coastal	206,534
Burnett	180,837
South-east Coastal	179,970
Central Coast	90,101
Curtis	87,399
Western	2,687
Total	**3,131,639**

Source: Australian Dryland Salinity Assessment 2000 (p 27)

Costs of salinity
Estimation of the costs associated with losses in biodiversity is complex and methods are not well developed. Preliminary results from a recent study carried out for the Murray-Darling Basin Commission in eight priority catchments indicate that salinity costs to farmers, local government and government agencies are approximately AU$251 million a year.

Table 1.8 Total equivalent costs in eight priority catchments in the Murray-Darling Basin

	Lower estimate (AU$million/yr)	**Upper estimate** (AU$million/yr)	**Best estimate** (AU$million/yr)
Local government	-	-	14.69
Households	41.03	139.23	90.13
Businesses	8.45	8.96	90.13
Sate government agencies and utilities	-	-	16.31
Environment	?	?	?
Agricultural producers	-	-	121.80
Total	**202.28**	**300.99**	**251.64**

Source: Australian Dryland Salinity Assessment 2000 (p14)

1.5.4 Economic and social impacts

The gradual long-term movement of labour out of agriculture and the declining proportional contribution of agriculture to total economic growth bring with them significant changes in the social structure of rural areas. Significant changes include: a declining number of farms, fewer young people entering agriculture, increased dependence on off-farm income, ageing of the farm population, and continuing decline in the size of Australia's farm population. Demographic modelling of future structural changes in Australian agriculture projects that there will be a continuing decline in the size of Australia's farm population. Two scenarios present themselves:

- A 30 per cent decline in farmer numbers by 2020 and a further increase in median farmer age, peaking in 2001 – based on the behaviour of farmers during the period 1991–1996, with poor prices for farm commodities
- A 55 per cent decline in farmer numbers with little increase in current median age – a faster adjustment scenario based on behaviour during the period 1986–1991, in which commodity prices were generally higher (Australian and Natural Resource Management 2002, p79)

1.5.5 Future of irrigation

The factors that will play a role in the future of irrigation in the Murray-Darling Basin can be divided into two categories: economic and environmental.

The economic issues comprise the price of water, water rights, and the viability of much of irrigated agriculture. Too many low-value commodities are currently being produced by inefficient irrigation methods, while many farms are too small in area and income. These agricultural systems and current water prices cannot support the cost of rehabilitation of water supply schemes and the installation of drainage systems.

The environmental factors involve a complexity of land and water salinization issues, the major problem being the increase in water demands by the domestic and industrial sectors. This will require irrigated land to be taken out of production.

The Australian Bureau of Statistics (ABS) has released estimates based on surveys of water use during 1996/97. These are presented in Table 1.9. ABS estimated that 68,703km^3 of surface and groundwater was extracted from the environment in this period. The net amount of water used was 22,186km^3, allowing for return flows, mainly from hydropower. ABS also estimated that over the four years from 1993/94 to 1996/97 total net water consumption rose by 19 per cent, from 18,575km^3 to 22,186km^3. A large part of the rise was accounted for by the agriculture sector, particularly pastures. It should be noted that there is great variability in annual water use within the Murray-Darling Basin, and the early 1990s were a period of drought, reduced storage, and reduced allocations. Hence, the data for 1993/94 to 1996/97 overstate the long-term trend.

Table 1.9 Australia's mean annual water use by category in 1996/97

State	**Irrigation** (million m^3)	**Urban/industrial** (million m^3)	**Rural** (million m^3)	**Total use** (million m^3)
New South Wales	8,643	1,060	305	10,008
Victoria	4,451	987	339	5,777
Queensland	2,978	1,052	561	4,591
Western Australia	710	1,027	59	1,796
South Australia	819	292	53	1,164
Tasmania	276	186	9	471
Northern Territory	53	87	39	179
Australian Capital Territory	5	63	4	72
Total	**17, 935**	**4, 754**	**1,369**	**24,058**

Source: Australian Water Resources Assessment 2000

Table 1.10 Change in mean annual water use by category between 1983/84 and 1996/97

	1983/84 (million m^3)	**1996/97** (million m^3)	**% change**
Irrigation	10,200	17,935	76
Urban/industrial	3,060	4,754	55
Rural (including rural domestic)	1,340	1,369	2
Total	**14,600**	**24,058**	**65**

Source: Australian Water Resources Assessment 2000

Table 1.11 Supply, use and consumption of water in Australia in 1996/97

Sector	**Self Extracted** (million m^3)	**Mains supply** (million m^3)	**Mains use** (million m^3)	**In stream discharge** (million m^3)	**Net water consumption** (million m^3)
Agriculture	7,156		8,346		15,503
Services to agriculture	13		14	9	19
Mining	545	5	30		570
Manufacturing	217	511			728
Electricity and gas	47,771	13	58	46,509	1,308
Water supply, sewerage & drainage	12,864	11,507	350		1,707
Other	104	0	419		523
Household	33		1,796		1,829
Total	**68,703**	**11,526**	**11,526**	**46,518**	**22,186**

Source: Dunlop 2001

2 CONCLUSIONS FOR THE MURRAY-DARLING BASIN

2.1 Irrigated agriculture

The Murray-Darling Basin is one of the largest river basins in Australia and, containing a number of WWF Global 200 ecoregions, is a major focus of WWF's Living Waters Programme. The basin covers a number of states and the entire Australian Capital Territory. This study has assessed the size of the surface areas of each of these states in the basin. Data were collected on the major irrigated crops, their water requirement per crop, and the area under cultivation. All data are available from the Murray-Darling Basin Commission website.

Since more than 71 per cent of the irrigated area of Australia is located in the Murray-Darling Basin, water consumption per crop in the basin will be considered as representative for Australia as a whole.

One crop, however, that is not grown in the basin is sugarcane, which is grown mainly in Queensland and covers an area of 172,267ha (Dunlop 2001). Total water consumption for this area is estimated at 1.2km^3, which ranks sugarcane among the top four water-consuming crops in Australia.

Table 2.1 Water consumption by four major crops in the Murray-Darling Basin

Crop	**State/river basin**	**Area** (ha)	**Water use** (km^3)
Pasture	Murray-Darling	862,155	5.3
Cotton	Murray-Darling	231,684	1.3
Rice	Murray-Darling	109,186	1.2
Sugarcane	Queensland	172,267	1.2

Table 2.2 Water use and gross value for irrigated agriculture in Australia, 1996/97

	Gross value (AU$million)	**Net water use** (million m^3)	**Irrigated area** (ha)	**Value per ha** (AU$/ha)	**Value per million m^3** (AU$million/ million m^3)
Livestock, pasture, grains and other agriculture	2,540	8,795	1,174,687	2,162	0.3
Vegetables	1,119	635	88,782	12,604	1.8
Sugar	517	1,236	173,224	2,985	0.4
Fruit	1,027	704	82,316	12,476	1.5
Grapes	613	649	70,248	8,726	0.9
Cotton	1,128	1,841	314,957	3,581	0.6
Rice	310	1,643	152,367	2,035	0.2
Total	**7,254**	**15,503**	**2,056,581**		

Modified after ABS Water Account for Australia 2000

From Tables 2.1 and 2.2 it can be concluded that the largest water-consuming crops, pasture and rice, also have the lowest value per unit of water, with sugar and cotton in third and fourth place. Where feasible, conversion to fruit and vegetable cultivation should be pursued, as this will reduce water use and provide higher income per unit of water.

2.2 Future water demand

IWMI Working Paper No.32 *Water for Rural Development* was used to collect information on the future water situation. The general conclusion for Australia is that there will be economic water scarcity – i.e. primary water supply (PWS) less than 60 per cent of the potential utilizable water resources (PUWR) – with a requirement to increase PWS by more than 25 per cent over current levels.

Table 2.3 Water demand forecast for Australia

	Irrigated cereal area (million ha)	**PWS** (km^3)	**Rain-fed cereal area** (million ha)	**PUWR** (km^3)
1995	0.62	24.4	13.43	211
2025	1.11	36.3	12.94	
Increase (%)	79	49	- 3.6	

Source: Molden 2000

An interesting development in Australia is that the total cereal area will not change; thus, the decrease in rain-fed cereal area is compensated by an increase of 490,000ha of irrigated land. A similar development can be observed in Thailand, the major rice producer of South-East Asia.