Irrigation

Mac Kirby

Key messages

- Irrigated agriculture is productive and profitable, generating 50% of all agricultural profit from just 0.5% of agricultural land.
- Australia exports 60% of its agricultural produce and demand should grow with increased standards of living and growing global populations.
- Two-thirds of irrigation in Australia occurs in the Murray–Darling Basin where it faces major challenges from climate change, return of water to the environment, and an increasingly open water market.
- New irrigation development is occurring in Tasmania and there are prospects for new developments in northern Australia, and along the east coast.
- Increasing demand for irrigated agriculture and declining water availability will drive increases in the efficiency of irrigated agriculture.
- Efficiency can be improved through more water-efficient crop varieties, improved farm management, precision applications of water, and more efficient irrigation supply canals, and river management.

Introduction

Irrigation is the largest use of water in Australia and the rest of the world, comprising about 70% of total water use. In countries with dry and variable climate, irrigation from rivers or groundwater provides more productive agriculture than is possible from rainfall alone; thus irrigated agriculture in Australia is generally more intensive and profitable than dryland agriculture. It is supported by sophisticated water management arrangements that have undergone substantial reform in recent years to make water a valued and tradeable commodity. With growing global and domestic demand for food and fibre, the future prospects for irrigation in Australia should be strong, yet it faces several challenges.

Irrigation in Australia is concentrated in the Murray–Darling Basin, where, in future, less water could be available for use because of a return of some water to restore environmental values, and because of lower river flows as a result of climate change, bushfires, and changing land use. Irrigated agriculture will need to respond to these challenges by increasing production efficiency (as was evidenced by some industries during the millennium drought), and through opportunities to improve water-use efficiency. Alternatively, there will be calls to expand irrigation elsewhere, such as in northern Australia, but these developments will involve far broader considerations than the availability of water. This chapter describes these large drivers for changes in irrigation in Australia.

Irrigation today

Irrigation in Australia is dominated by the Murray–Darling Basin where over two-thirds of Australia's irrigation water use occurs,[1] even though the Basin produces only 6% of Australia's runoff. Most of the use occurs in the three large southern valleys of the Murray, Murrumbidgee, and Goulburn-Broken Rivers.[2] This scale of use is made possible by many large dams, including the Snowy Mountains Hydro-electric Scheme, which facilitate regulated releases of water downstream to be diverted into large canals that distribute water across extensive irrigation districts through thousands of kilometres of gravity-fed channels. In some districts, water is piped to farms to provide spray and drip irrigation for horticulture and viticulture. The Ord River scheme in Western Australia and the Burdekin irrigation scheme in Queensland are other examples of large-scale highly engineered irrigation.

Irrigation also occurs in the rivers of the northern Murray–Darling Basin and elsewhere, but not at the same scale. There are fewer large dams and some different types of systems, including pumped groundwater, river water pumped into farm dams, or the capture and storage of floodwaters behind levees. These systems are often self-supplied – where the irrigators are responsible for their own supply. The smaller-scale river systems tend to have less reliable year-to-year supply of water than the major schemes and therefore tend to be used for annual crops rather than horticulture or other permanent plants. Many Australian commodities are grown using irrigation, with dairy, cotton, and sugar being the largest water users (Figure 8.1).

The high production value of irrigated agriculture is shown by its disproportionate contribution to total production. Although just 0.5% of agricultural land was irrigated in 2003–04,[3] it produced 23% of the total gross value of agricultural production[4] and 50% of the profit at full equity.[5] Despite this, irrigation contributes somewhat less than 1% of gross domestic product.[4] It is of course more important to regional economies, making up 9% of the gross regional product in the Murray–Darling Basin in 2005–06,[6] but both national and regional economies are less dependent on agriculture than in the past. Some towns, particularly in annual rice and cotton cropping areas, rely on irrigated agriculture[6] and related processing and service industries. Thus the impacts of any large changes to irrigation due to droughts, climate change, or reduced diversion limits would be minimal at the national level, small at the regional level, but large for those towns and communities that rely upon irrigated agriculture.

There are quite sophisticated water management arrangements, especially in the Murray–Darling Basin, which are used to provide a reliable and equitable supply of water for irrigation

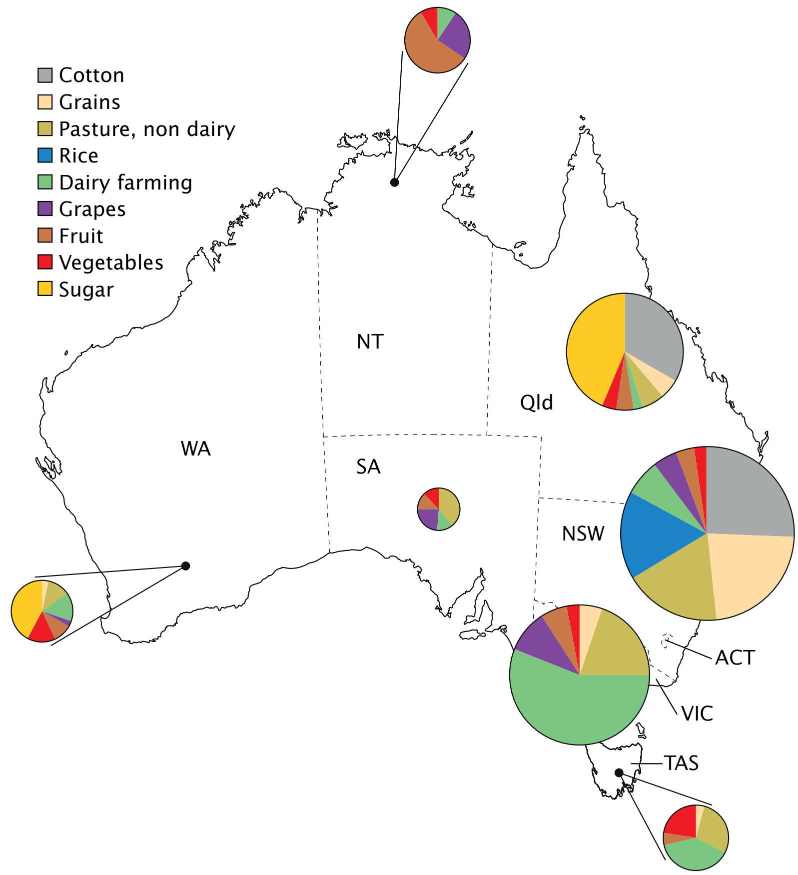


Figure 8.1: *Water use (GL) in 2004–05 by state and major irrigation commodity. The size of pie chart represents the volume used in each state. The charts for Western Australia, Tasmania, and the Northern Territory are too small to see at the correct scale, so magnified versions are also plotted, to show the commodity breakdown.*[4]

and other users. Recent reforms have strengthened the legal, market, and price aspects of these arrangements. Irrigators own entitlements to use water (water licences), which have a nominal historical volume of use attached to them. To allow for large year-to-year variability in the amount of water available, annual allocations are made against the entitlements, which in years of drought can be much less than the nominal volume of the entitlement. For example, most entitlement holders in the Murrumbidgee River received annual allocations close to 100% of the entitlement in the 1990s but during the millennium drought annual allocations fell to as low as 10% of the entitlement. There is a plethora of entitlement types, which vary from region to region. High security entitlements provide the most reliable supplies of water, typically at the full volume and are well suited to permanent crops, such as horticulture, and to town water supplies and industry. General security allocations are much more variable from year to year, making them better suited to annual crops, where farmers can decide whether to plant irrigated crops or not, based upon the seasonal allocation. Although the annual allocations vary, farmers build up a long-term expectation from previous allocations and are sensitive to any erosion in the reliability of their entitlements.

In the Murray–Darling Basin, both entitlements and seasonal allocations of water can be traded, giving additional flexibility to adapt to the changing availability of water. In dry years, trade can be strong and the price of water can be quite high. In 2008–09, 1739 GL of allocations were traded in the southern Murray–Darling Basin and 1080 GL of entitlements were traded.[7] High security entitlements traded at around $2000/ML and general security entitlements traded at about $200–$400/ML in Victoria and about $1000 in southern New South Wales. In 2007–08, allocation trades peaked at about $1000/ML.[7] In the southern Murray–Darling Basin, trade has tended to move water use from upstream areas to downstream irrigation areas, shifting use from dairy pastures, rice, and other annual crops to horticulture and grape vines. Water is now a valuable commodity and its trade is changing the nature of irrigated farming across the Basin. While the trade is economically beneficial, there are some concerns over impacts on the local communities and irrigation districts from which water is lost.

These recent developments underscore much of the tension in the current debate over water for irrigation. Irrigators and other users own entitlements to use water that have a commercial value and can be traded. Individual farmers, communities, governments, and others have invested in infrastructure to store, convey and use that water. Plans and policies to change arrangements, entitlements, or the allocation of water to different uses are bound to disadvantage some users, and raise claims for compensation.

Irrigation canal near Hay, New South Wales. Photo: Greg Heath, CSIRO.

Future prospects

There are strong economic prospects for irrigation. Growing global populations and a growing standard of living will increase demand for food and fibre over the coming decades. Demand for the expansion of irrigation is likely to strengthen given the appeal of its high productivity and profitability. Australia produces enough food and fibre to support more than its own population, exporting 60% of its agricultural production.[8] Australia's population is forecast to grow to about

35 million people by 2056[9] and food demanded by this population can be supplied at current production levels.

World prices of major commodities (grains, meat, and dairy) are projected to rise in coming years, with a continued growth in demand[10] and will, all other things being equal, lead to the continued profitability of Australian irrigated farming. Although the growth in demand and increasing prices are generally favourable for irrigated agriculture, the dairy industry expects that price volatility will be a greater challenge than climate change or access to irrigation water.[11] The wine industry has experienced low prices for some years, and a shift from premium to bulk wines. The outlook is for continuing low wine prices.[12] Thus, although sustained water access is important to irrigators, price and other terms of trade are crucial to profitability. The irrigation industry has adapted to these pressures and so remains competitive in the global market.

Future of irrigation in the Murray–Darling Basin

Despite the strong prospects for irrigation produce, there are some risks to future water availability for irrigation in the Murray–Darling Basin. River flows in the Basin are projected to decline by 11% (2500 GL/year)[13] under a mid-range projection of climate change to 2030, with further reductions in later decades or under conditions of more severe climate change. Other risks to future water availability (see Chapter 2) include reductions to river flows from vigorous regrowth of forests following very large bushfires in north-east Victoria and southern NSW, new forest plantations, farm dams, and the increased use of groundwater. These could collectively reduce river flows in the Murray–Darling Basin by a further 1500 GL/year by 2030.[13]

Water access for irrigators will also continue to reduce as a result of increasing return of water to the environment in the Murray–Darling Basin. The Living Murray Initiative aimed to return 500 GL/year (averaged over 5 years) to the environment, although the actual recovery was less and difficult to determine (as at 2009) because of the millennium drought.[14] The Australian Government is buying back water entitlements to recover water for the environment and, up to early 2011, had recovered nearly 1000 GL. It is expected that the Murray–Darling Basin Plan (yet to be released at the time of writing) will require further water to be returned to the environment. While the precise amount is being strongly contested and will be reviewed every 10 years, claims on the amount required to achieve sustainable rivers, lakes, and wetlands generally vary from 2000 to 5000 GL/year.

Rural communities are concerned that the needs of urban water supplies or industrial users may compete against those of irrigation. Located outside of the Murray–Darling Basin, Adelaide and associated areas and towns obtain some 180 GL/year from the Murray River, and Melbourne has recently obtained entitlements for 75 GL per year from the Basin, facilitated by a new pipeline.[15]

Future growth in demand for urban water could be partly met by purchasing entitlements from irrigators, and the higher price of urban water to consumers makes this quite cost-effective. Compared with irrigation, however, the volumes involved in urban water are modest, but they may be locally significant.

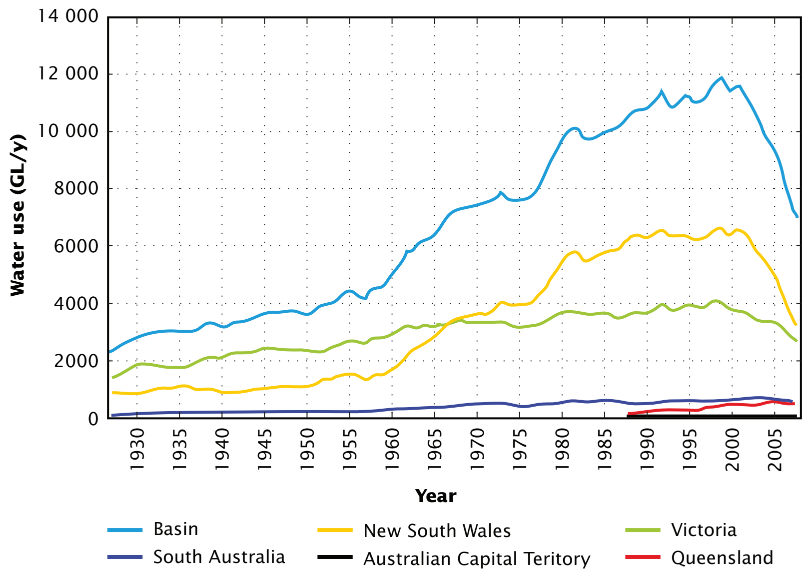
Also of localised concern are the impacts of trade in entitlements, which will move water out of some irrigation districts and into others. Lower overall availability of water for irrigation will increase competition for the resource, and trade improves overall efficiency of water use, but there are concerns about local community impacts and the problem of 'stranded assets' – where a reduced number of water users are scattered across a whole irrigation district and are left paying to run the whole supply infrastructure. With fewer users in a scheme, irrigation would ideally withdraw to the most profitable areas, closing the most distant and least efficient parts of the canal network, which often incur large losses of water. Irrigators are concerned that a 'Swiss cheese' pattern is emerging with a random loss of entitlements in a district requiring the whole irrigation network to be maintained.

Exit fees placed on the sale of entitlements, or regulations to limit trade in entitlements, are used to deal with the problem of sold entitlements. They have the disadvantages of restricting trade and not really tackling the problem of improving efficiency of the system. For example, no more than 4% of a district's water entitlement can be traded-out in a single year in New South Wales and Victoria. At the same time, governments are making large investments to improve irrigation infrastructure and make it more efficient, but without knowing if long-term use in those areas will be maintained. These problems can be solved by charging prices that more completely represent the fixed and variable costs of maintaining irrigation, but they could also be mitigated by improved projections of the future of irrigation in each district and identification of the opportunities to make irrigation districts more efficient (see below).

Irrigation during the millennium drought

The types of changes and adaptations that irrigation may face in the Murray–Darling Basin are well illustrated by the experience of the millennium drought.

Water use in the Basin fell 70% from 2000–01 to 2008–09 (Figure 8.2; Table 8.1), by far the biggest recorded drop in use. Earlier droughts had less impact on irrigation because the level of water use was less and earlier droughts were less severe. Some water plans were suspended in the drought and emergency measures were put in place. Because future droughts of the same intensity can be expected, this means that historical expectations of water users cannot be met in the long term. Lower overall use of water would result in more reliable allocations during intense drought, so there is a trade-off between levels of use and its reliability.



▸ ***Figure 8.2**: The historical growth of water use in the Murray–Darling Basin, more than 90% of which is for irrigation. Water use fell sharply during the millennium drought.*[16]

Despite the 70% drop in water use in the millennium drought, the gross value of irrigated agricultural production fell by only 14% (Table 8.1), leading some to suggest that irrigation productivity is quite adaptable to drought, and thus to other reductions in water supply. However, there are several factors influencing gross value of production and each irrigation commodity experienced and responded to the drought quite differently.[17]

Table 8.1: Irrigation water use and gross value of irrigated agricultural produce (GVIAP) in the Murray–Darling Basin.[1,17]

	2000–01	2005–06	2006–07	2007–08	2008–09
GVIAP ($m)	5085	5522	4922	5079	4349
Water use (GL)	10 516	7370	4458	3142	3492

Some major commodities, particularly dairy and cereals, experienced major price increases in 2008, which offset lower production. The price spikes masked a potentially worse impact of the drought for some commodities and cannot be relied upon in future droughts. By contrast, cotton, experienced a decline of 80% in water use, 80% in production and a 75% decline in gross value from 2005–06 to 2007–08 as prices changed little. Cotton is an annual crop and farmers are used to large variations in production between years, but several years of low production can increase debt, reducing the viability of farms and having consequences for regional communities.

Dairy is a major commodity in the Victorian part of the Basin. It experienced a decline of about 78% in water use from 2000–01 to 2007–08, but raw gross value rose. This was due partly to the price of milk almost doubling, but also because water trade allowed dairy farmers to adapt to lower allocations either by buying the additional water they required or selling water and using the proceeds to buy feed instead of growing it. This enabled dairy production to continue, but at higher cost than before the drought.

The rice industry suffered the most in the drought. Rice production and water use in 2007–08 fell to about 1% of their 2000–01 values, leading to the closure of several rice mills.[18] This points to the impact of the drought on communities and processing industries, not just the farmers. Some rice farmers switched to winter cereals, which maintained production throughout the drought. The water use of high value commodities such as fruit, nuts, and vegetables was maintained by purchasing water allocations, but at a high price.

Water trading gave individual irrigators flexibility and was estimated to increase production by $370 million in the southern Basin at the height of the drought.[19] These benefits transfer into benefits for communities, regions, and the Basin as a whole.

The drought is only a partial analogy for future adaptations, though, because it was treated as a temporary change and farm debt was allowed to increase. Some of the future changes to irrigation will be more permanent and thus require more fundamental economic, as well as social, adaptations.

New irrigation developments

With good prospects for irrigated agriculture but declining water use in the Murray–Darling Basin, there will be strong interest in developing other irrigation areas. Irrigation is increasing in Tasmania, where there are plans to develop an additional 120 GL/year from the current 636 GL/year,[20] which is modest in scale compared with the Murray–Darling Basin. It is often speculated that there could be dramatic increases in irrigation, both in northern Australia and basins of the east coast of Australia, but a comprehensive assessment of opportunities and costs is yet to be undertaken. Possibilities include large schemes to dam coastal rivers and transfer water over the divide into the Murray–Darling Basin or other western-flowing rivers. Such schemes may be technically feasible, but are not economic at present[21] (see Chapter 1).

Any new developments will be driven by several factors other than water availability. Often there are other limits such as the availability of flat land with suitable soils for cultivation that will not be subject to salinity, and to which water can be easily supplied. Agriculture requires associated processing industries, transport infrastructure, and markets, all of which need to be economically viable. In the wet–dry tropics, the extremes of the dry and wet seasons suit few crops and encourage many pests and diseases, which have resulted in pioneering schemes failing in the past. Other water users must be considered and a duty-of-care exercised to minimise environmental impacts. Opportunities for new irrigation will be found but, as noted in Chapter 1, they will not be as easy to realise as the maps of abundant runoff (Figures 1.2 and 1.3) might suggest.

Improving irrigation system efficiency

Much attention is being devoted to increasing water use efficiency: producing more product and greater profits from the use of less water. There are two main areas of focus: efficiency in water management and infrastructure; and on-farm efficiency in irrigated agriculture.

Increasing the efficiency of a water supply can be achieved in part by reducing water losses. Australia's largest irrigation areas have extensive canal systems (Murrumbidgee Irrigation Area about 3500 km,[22] Murray Irrigation area about 3000 km,[23] Goulburn Murray Water area in northern Victoria about 7000 km[24]). Significant volumes of water can be lost from these canals. On-farm and off-farm losses in the Murrumbidgee valley total 300 GL annually.[25] True losses (water that can be captured and better used) need to be distinguished from apparent losses (water, such as groundwater recharge, that is not really lost but is available for use elsewhere). Canal seepage is a true loss if it recharges saline groundwater and becomes unsuitable for use, or is an apparent loss if it recharges a fresh aquifer or drains back to the river and is available for further use. Off-farm losses include leakage, seepage, and evaporation from delivery canals and storages – estimated true losses are 130 GL/year in the Murrumbidgee valley. On-farm losses include evaporation from the soil surface and recharge to saline groundwater – estimated true losses are 100 GL/year. The remaining 70 GL/year of the total 300 GL/year of losses in the Murrumbidgee valley are apparent losses of water draining back to the river and aquifers and are used elsewhere.

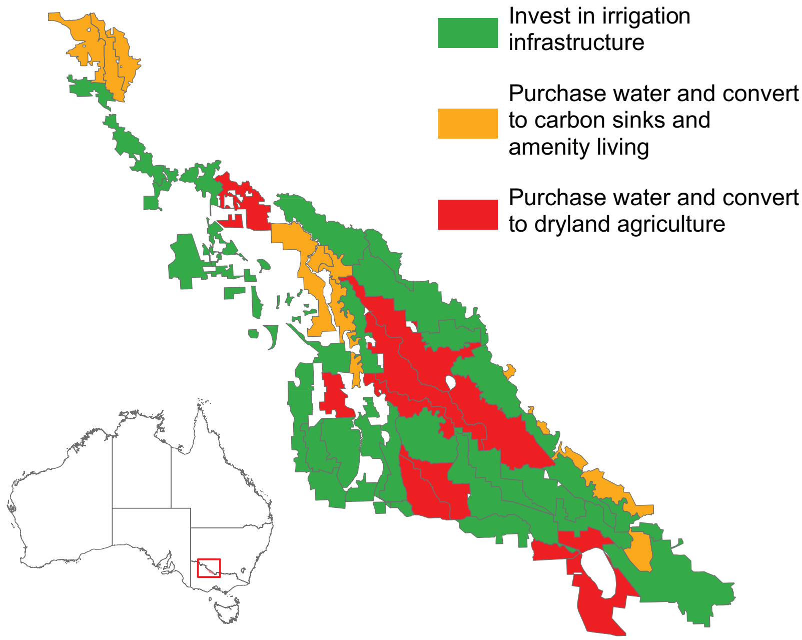
Sprinklers irrigating a field of Lucerne near Wagga Wagga, New South Wales. Photo: Bill van Aken, CSIRO.

Problems emerge if the gross application of water is accounted for without considering what is normally returned for others to use. For example, installing better irrigation technology to halve the water application rate and double the area of crop may, through the more efficient use of the same volume of water on twice the area, reduce the volume of water that once seeped back to the river or an aquifer. Thus, the returned water, which was once used elsewhere (by the environment or another irrigator) is now no longer available. The same occurs if the gross amount of water applied is traded out of a valley: the removal of the gross amount ignores the return flow. Around 10% of diverted water may return to the river, but this estimate is highly uncertain.[26] The issue of reduced irrigation return flows may become significant as water becomes more tightly managed.

Investment in savings measures require a full cost–benefit analysis. Savings in off-farm losses could be made by piping or lining canals, though piping is unlikely to be economic in many circumstances.[25] Savings of on-farm losses could be made by conversion to pressurised irrigation systems (from furrow or other 'inefficient' systems), treating on-farm channel seepage losses, and reducing evaporation from on-farm channels and storages.

Modernisation of measurement and control structures also improves the efficiency of water infrastructure. Traditionally, Dethridge wheels (simple wheels turned by the flow from a channel) were used to measure water flowing onto farms, but were known to systematically under-measure the amount of water supplied.[26] They are being replaced with more accurate

Dethridge wheel measuring irrigation water consumption, Griffith, New South Wales. Photo: Bill van Aken, CSIRO.



▸ ***Figure 8.3**: Torrumbarry Irrigation Area showing a classification of zones for investment in the context of declining water used for irrigation. Green locations are a priority to maintain irrigation because they are the most productive land and most efficient for water supply. Amber locations have environmental value, so could be priority areas for ecological restoration. Red areas are priority for conversion to dryland agriculture because they are the least effective for irrigated agriculture and the most expensive for water supply.*

remote-controlled channel management systems. Sophisticated control systems are also being used to better manage flows in the main supply canals and reduce rejection flows caused by the conveyance of more water than is taken by farmers. The excess water, 'rejected' through channel ends, often discharges into wetlands, but at a normally dry time of year.

Restructuring canal layouts can lead to water savings from reduced evaporation. A smaller and more effective canal layout can also keep an irrigation scheme viable under lower allocations or when water is lost in trade. For example, farms in the Torrumbarry Irrigation Area of Victoria were assessed for their relative prospects for irrigation productivity based upon soils and salinity.[27] Water is likely to trade out of Torrumbarry, and it would be beneficial to retire those areas with both low productivity and high cost of water supply to leave the most viable district (Figure 8.3). If the canal infrastructure were to be modernised to the new configuration shown in Figure 8.3, total agricultural production of the area would increase by 9%, even though water use would decline. Water from other areas could be purchased and allocated for environmental flows (62 GL, or 20% of 2004–05 water use). Of the areas identified for retirement, some have value for ecological restoration (amber) and the others could be returned to dryland production (red). Thus, water savings may benefit both irrigation and the environment.

Improving on-farm efficiency

A number of improvements to on-farm efficiency have been beneficial in recent years and could be further developed and adopted to meet future reductions in water availability. They focus on producing more crop from less water, or more profit from the water used, by considering the whole farm enterprise and measures that improve crop quality, not just crop production.

The measures include new crop varieties, the use of deficit irrigation, irrigation flow monitoring, more even watering by laser levelling of fields, better irrigation scheduling, lining of farm channels to reduce seepage losses, and converting irrigation systems from gravity systems to sprinkler or drip irrigation. Savings may be significant, but costly, and are not always profitable.[25,28] Water is typically a small input cost on a farm and some of the measures increase other costs such as energy and capital.

As an example, improvements from new cotton varieties that are more drought tolerant have in some cases doubled water use efficiency from one to two bales of cotton per megalitre. Better soil management, irrigation scheduling, and on-farm design further enable more of the applied water to be used by the crop.

For grapes, the development of new rootstocks, and research around partial root-zone drying and deficit irrigation (applying less water than the crop demands), have lowered water applications by 30–50%. These have reduced yields but improved the quality (colour, tannins, etc.) and raised the price.

For annual crops such as rice, maize and wheat, irrigators can integrate dryland farming techniques into new farming systems to optimise planting and better choose when to irrigate with limited water. Strategies such as retaining crop residues in the Riverina (previously uncommon) and spreading available water further by irrigating winter cereal crops, which require less water than rice, have shown potential to increase whole-of-farm water use efficiency.

The IrriSATSMS system is an example of how new technology and services can improve irrigation water use efficiency. IrriSATSMS combines satellite data on crop development with local weather data and delivers daily information to farmers on crop water requirement via their mobile phones. This approach aims to provide growers with a user-friendly daily irrigation water management service and a benchmarking and auditing mechanism for growers and water providers through the reporting back of the amount of water applied and crop produced.[29]

Climate change may influence crop water use efficiency, as well as threatening water availability in southern Australia. Increases in the atmospheric concentration of CO_2 may promote crop growth and water use efficiency, but this effect is strongly variety dependent. For example, under a projected 2050 climate (higher CO_2, higher temperature and lower rainfall), yield increases of 1–10% could be achieved by changing varieties. Decreases in grain yields of 2.2% were predicted in early maturing varieties. Supplemental irrigation at key times through the growing season may mitigate the impact of climate change, although this requires further investigation.

Monitoring soil moisture in an irrigation district, Griffith, New South Wales. Photo: Greg Heath, CSIRO.

Conclusions

There are thus many prospects for continuing to improve the productivity and profitability of irrigated agriculture, along with prospects for new irrigation developments. These prospects may outweigh some of the threats to irrigation from a drying climate, return of water to the environment, and growing urban water demand, but that will depend on the local circumstances and adaptability of each region. In some areas, irrigated agricultural will grow while it will reduce in others. The challenge is in making those transitions in a way that is cost effective, socially acceptable, and without further negative impacts on the environment. Improved productivity is also needed to meet the increasing demand for food and fibre from growing domestic and global populations.

Further reading

Cooperative Research Centre for Irrigation Futures Website. Irrigation toolkit. CRCIF, Darling Heights, <http://www.irrigationfutures.org.au/news.asp?catID=14>.

Davidson B (1966) *The Northern Myth*. Melbourne University Press, Melbourne.

Fairweather H, Austin N and Hope M (2003) 'Irrigation insights 5 – water use efficiency: an information package'. Land and Water Australia, Canberra, <http://lwa.gov.au/products/pr030566>.

Khan S, Rana T, Abbas A, Hafeez M, Hanjra M, Asghar N, Pillow R and Narayan K (2008) *Technical Manual for Assessing Hotspots in Channel and Piped Irrigation Systems*. CSIRO, Canberra, <http://www.environment.gov.au/water/publications/action/pubs/project-report.pdf>.

Meyer WS (2005) 'The irrigation industry in the Murray and Murrumbidgee basins'. Cooperative Research Centre for Irrigation Futures Technical Report No. 03/05, April, pp. 26–40. CRCIF, Darling Heights, <http://www.clw.csiro.au/publications/waterforahealthycountry/2005/IrrigationIndustryMurrayCRCIF.pdf>.

National Program for Sustainable Irrigation, <http://www.npsi.gov.au/national-program-sustainable-irrigation/publication-and-tools>.

National Water Commission (2010) 'The impacts of water trading in the southern Murray–Darling Basin: an economic, social and environmental assessment'. NWC, Canberra.