Can Australia overcome its water scarcity problems?

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Abstract

Australia is a continent of extremes with respect to water resources; relative abundance in the tropical north where few people live and relative scarcity in the more populated, temperate south. In addition, both south and north are affected by wet/dry seasonal climatic conditions and the south, in particular, by increasing climate variability marked generally by declining rainfall. In the south, previous poor governance systems have led to the over allocation of surface and groundwater supplies and there is increasing competition for water from irrigators, urban/domestic, industrial and mining users. As a consequence, there has been a major deleterious impact on the health of many rivers and their associated environments. So, Australia is confronted with a major question; can water productivity and water governance be improved to ensure environmentally sustainable and productive river systems? This paper examines how this may be achieved. It concludes that economic reforms coupled with scientific and management innovation may alleviate many of the water scarcity issues.

Water Resources in Australia

Water scarcity is becoming an increasingly significant problem for many countries. According to an International Water Management Institute definition, a very significant portion of the world is projected to suffer from both physical (<1000 m^3 per person/annum) and economic water scarcity by 2025. Whilst Australia's water resources are well in excess of this per capita definition of scarcity there is growing concern that export of “virtual water” in food may be to the detriment of our environment.

COUNTRY	RIVER	RATIO BETWEEN THE MAXIMUM and the MINIMUM ANNUAL FLOWS
Switzerland	Rhine	1.9
China	Yangtze	2.0
Sudan	White Nile	2.4
USA	Potomac	3.9
South Africa	Orange	16.9
Australia	Murray	15.5
Australia	Hunter	54.3

Table 1. Variability of flow in some of the world’s major rivers compared with two Australian rivers.

Australia’s water resources are highly variable (Table 1), and reflect the range of climatic conditions and terrain nationally. In addition, the level of development in Australia’s water resources ranges from heavily regulated rivers and groundwater resources, through to rivers and aquifers in almost pristine condition. Over 65% of Australia’s runoff (Fig. 1) is in the three drainage divisions located in the sparsely populated tropical north. In contrast, most large urban cities are situated in southern regions with irrigated agriculture principally located in the Murray Darling Basin where only 6.1% of national run-off occurs. Thus Australia has significant water resources, but the populations and agricultural activities are concentrated where water resources are most limited. Australia has around 440,000 gigalitres (GL) of water. The best estimate of how much water can be diverted and turned to human use is approximately 105,000 GL (Table 2).

At present, Australians extract about 70,000 GL and consume about 22,200 GL, of which 15,500 is used in agriculture. But the consumption in irrigated agriculture is increasing (Fig. 2) —by about 15 percent in the past three years—and as agriculture consumes 70 percent of the water resource Australian agriculture must learn how better to turn that scarce water into wealth and wellbeing for our communities.

Total run-off	440,000 GL (divertible 105,000 GL)
Water extracted	70,000 GL
Water consumed	22,178 GL
• agriculture	15,522 GL
• households	1,829 GL
• sewerage and drainage	1,707 GL
• mining and manufacturing	1,289 GL
• Electricity and Gas	1,308 GL
• Other	523 GL

Table 2. Water in Australia 1993–1997 (*Source: ABS website, May 2000*)

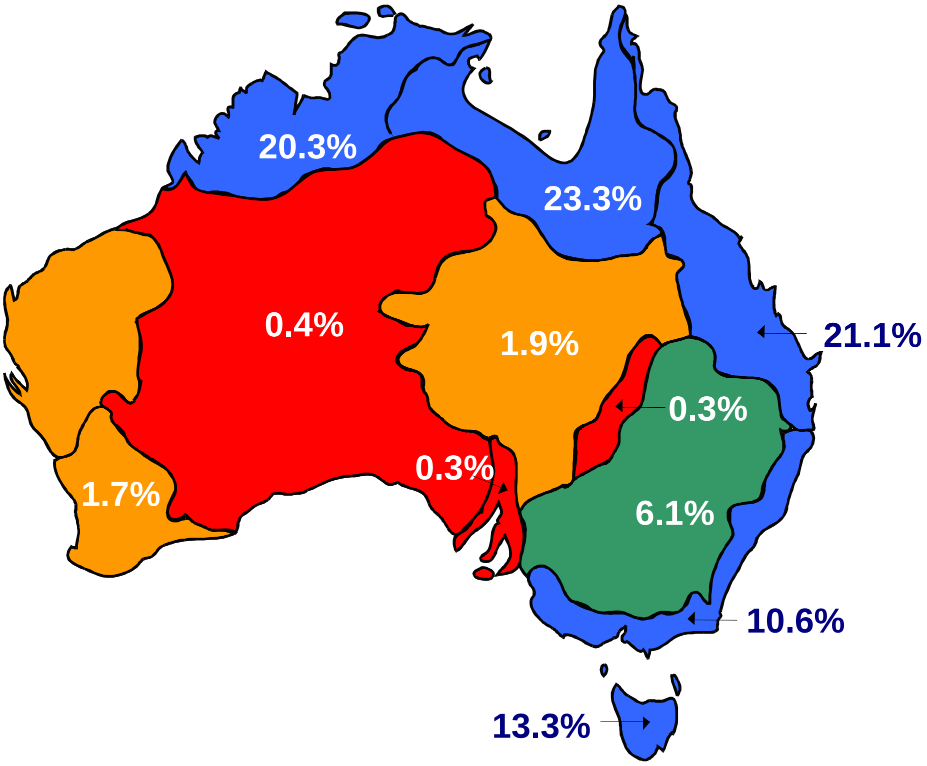

Figure 1. Australia's distribution of run-off (Source: *Water and the Australian Economy,* April 1999)

Two million hectares of Australia (<1% of the land surface) is irrigated and this generates about 50 percent of our profit from agriculture. Nearly 75% of this irrigated agriculture occurs in the

Murray-Darling Basin where water demand and levels of water extraction from rivers and groundwater are now unsustainable. About 75% of the mean annual flow in the basin is diverted with the result that the mouth of the Murray has often closed in recent years of lower rainfall. To cope with climate variability more than twice the average annual flow in the basin is held in storages (Fig.3). Such high level of storage and extraction have very damaging impacts on the heath of the rivers, floodplains, wetlands and estuaries of the Murray –Darling. Recognising this in 1994, Australians ruled a line and agreed to cap extractions at 1995 levels (Fig. 4). This was one of the first and most important policy decisions in the Murray-Darling, which recognised that the limits of sustainability had been overreached.

The major challenge facing Australia is that of balancing water extractions for irrigation and other uses with provision of appropriate environmental flow to maintain healthy rivers and thus service the needs of all users of rivers and groundwaters. Experience demonstrates that if regulators place a cap on surface water, demand is transferred to groundwater. However, in reality surface and groundwater needs to be managed conjunctively. While returning increased flows to rivers in southern Australia is a major challenge, and absolutely critical to river system health, many other land management factors such as, drainage; nutrient and chemical pesticides loading are very important to the health and ecological function of rivers, groundwaters, wetlands, floodplains and estuaries.

Potential Impacts on Water Resources of changes in Climate and Land Use

<u>Climate Change and Variability</u>

Climate change projections (as summarized by Hennessy, 2003) for Australia show increased potential evaporation, a tendency for decreases in winter-spring rainfall (June–November) over the southern half of the continent and a tendency for increased summer/autumn rainfall (December–May) in northern Australia. The possibility of a longer and more intense Australian

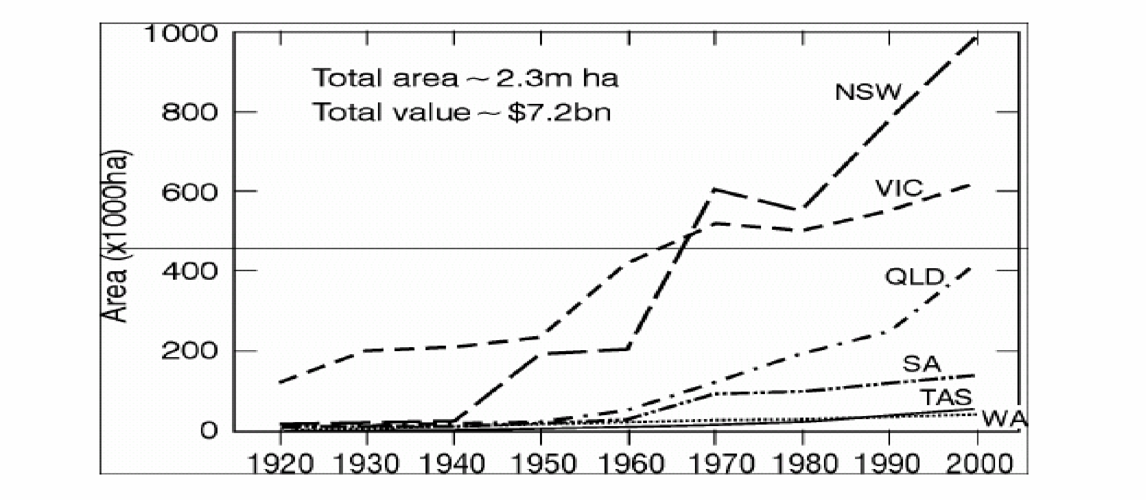

Figure 2. Development of irrigated areas in Australia

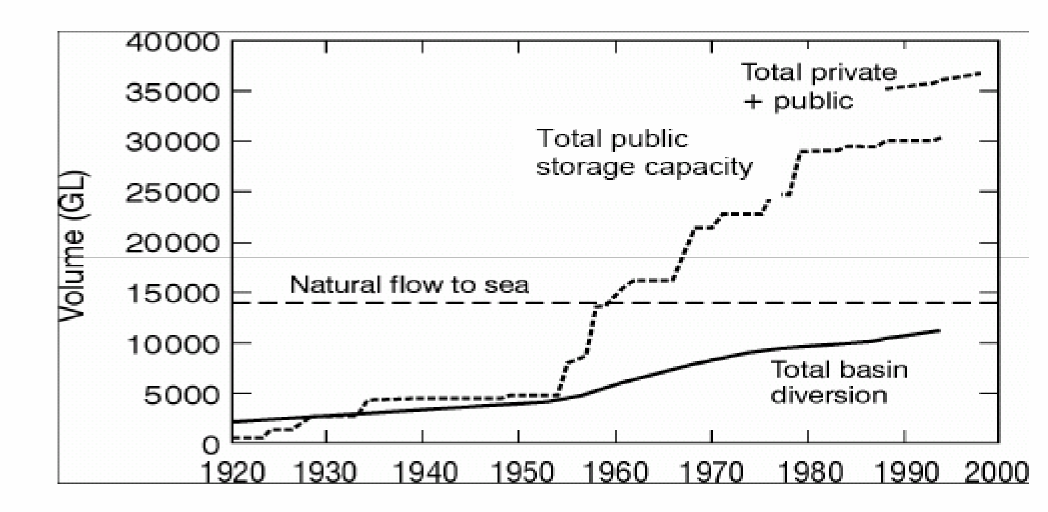

Figure 3. Storage capacity and diversions in the Murray-Darling Basin from 1920 to 2000.

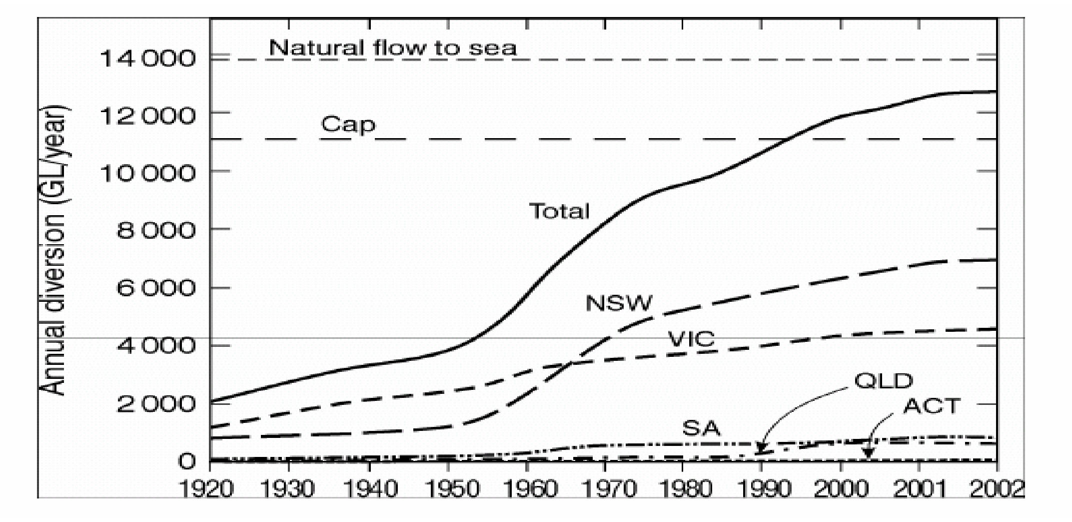

Figure 4. Growth in water use in Murray-Darling Basin 1920 to 2000.

monsoon would lead to greater water surpluses in an area where human use is low, so environmental flows would be enhanced. In southern Australia, where winter and spring rainfall are more important and competition for water between natural and human uses is already high, reductions in water supply appear to be much more likely with the possible exception of Tasmania.

Climate change and Australian natural climate variability are inextricably linked and while the underpinning science of climate change is solid, much remains to be understood (Pearman and Hennessy, 2003). This inextricable link between natural long term variability and drivers of climate change is well illustrated (Fig. 5) by the 100 years data set for the Warragamba Dam, the major water supply to Sydney. Since the construction of the Warragamba Dam between 1948 and 1960 the 7 year moving average rainfall and run off to the dam have been declining to levels that appear to be consistent with pre 1950 moving averages. A return to inflow to the dam similar to this 1900-1950 period will present real difficulties for Sydney’s water supply. It is onto this high variable and cyclic pattern of rainfall that climate change (both magnitude and variability) is to express itself.

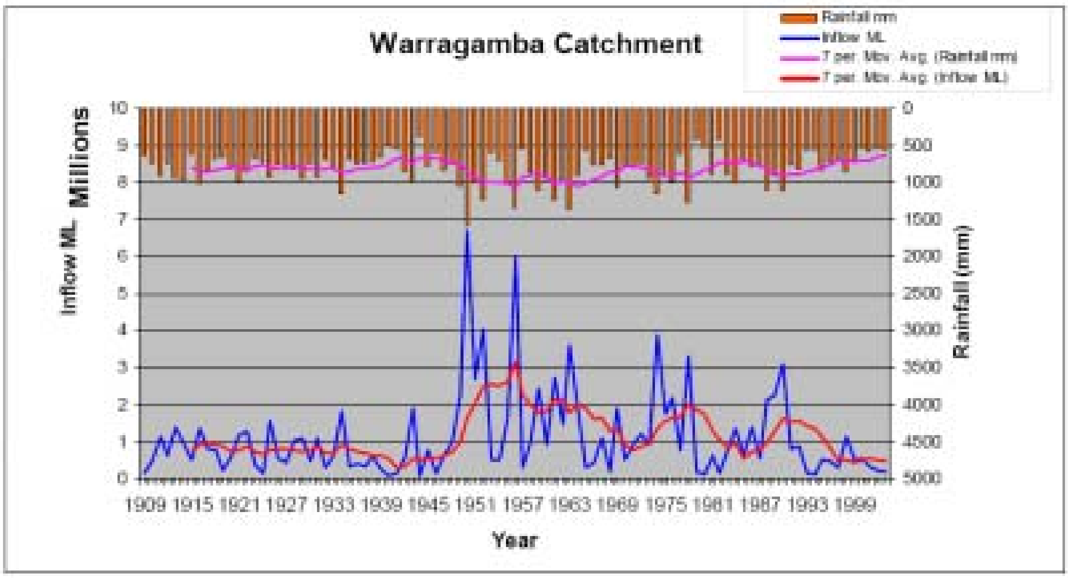

Figure 5. Rainfall and Runoff in Warragamba catchment from 1900 to 2003 (source Cox , 2005)

The evidence is that climate change will increase the difficulty Australia faces in securing adequate water supplied for cities and irrigation

Change in Vegetation Cover and land Use

There has been a surge of investment and activity in plantations, farm forestry and general revegetation in Australia. The essential design criterion of sustainable farming is to ensure that present day flows of water, nutrient, carbon and energy match the magnitude of the flows that evolved to suit the way our landscape functions. This will require some radical change to land use, incorporating both commercial tree production and revegetation with tree-dominant native vegetation. Plantation and farm forestry, agro-forestry, new agricultural production systems and restoring native vegetation present opportunities to create a landscape with a mosaic of vegetation that has a similar water-use pattern to the original native vegetation. This future landscape has the potential to both treat the cause of land and water degradation problems and generate wealth sufficient to sustain viable rural communities. Most importantly, this tree-based mosaic has the potential to maintain and enhance biodiversity and delivers a suite of ecosystem services, including carbon sequestration, habitat diversity, salinity control and clean water. Recent synthesis (CSIRO, 2004) acknowledged that concerns have arisen that, in some situations, expansion of forestry on a large scale could diminish flow to streams and groundwater and threaten water availability or water quality. Competition for water resources between forestry, revegetation with tree-dominant native vegetation and other uses can lead to disruption of industries and resource development, as well as community conflict.

The Water Reform Process in Australia

Water in Australia is vested in the State and Territory governments which allow other parties to access and use water for a variety of purposes, including for irrigation, mining and other industrial uses, and servicing rural and urban communities. As demonstrated previously, by the second half of the last century, it was clear that natural equilibria essential to the healthy functioning of the natural resource base had been upset by over exploitation of our natural resources. In 1994, all State and Territory governments agreed on a package of reforms covering water prices, allocations and trading, environmental and water quality, and public education. In agreeing to the reforms, the governments formally acknowledged, for the first time, that Australian rivers, catchments and aquifers do not stop at state boundaries and that development activity in one state can have impacts in other states.

By the late 1990s the Australian Government was sufficiently concerned by the range, breadth and cost of land and water degredation problems that it commissioned a nationwide National Land and Water Resources Audit (NLWRA 2002) that showed that 26% of Australia's surface water management areas and some groundwater management units were either close to, or overused compared with their sustainable flow regimes.

More recently high levels of water extraction and few, if any, natural flood events have put further stress on the River Murray. In 2003 this was recognised with "The Living Murray" initiative aimed at returning 500 GL of water to the river for environmental flow purposes. The Council of Australian Government's (CoAG) latest response to ongoing water issues has been to develop an intergovernmental agreement called the National Water Initiative (NWI). The NWI was signed in recognition of the continuing national imperative to increase the productivity and efficiency of Australia's water use, the need to service rural and urban communities, and to ensure the health of river and groundwater systems. It is a comprehensive package of reforms related to water entitlements, trading and sustainable use.

Responses and opportunities related to water scarcity

Southern Australia, at least, is faced with dealing with the ramifications of growing population, variable climate and increasing water scarcity. To cope with these the reform process has to include incentives that improve water use efficiency and productivity. Thus the NWI is stimulating and guiding the following developments in water management:

Whole-of-system thinking

Many water scarcities have developed because our management has failed to apply whole-of-system thinking to water supply, re-use, consumption and return of water to natural water bodies. Stream flow and groundwater are often managed as independent entities as are urban storm water and sewage treatment and effluent re use. Progress in Australia has built on taking an integrated approach underpinned by recognition of interactions in the water cycles (Fig. 6). For example, rivers are stressed by being dammed and regulated, and by water extraction, when the pattern of flow is changed. Over-extraction of water can endanger native fish, increase salinity and the incidence of algal blooms, and damage vegetation in wetlands and floodplains. Changes in river flow regimes affect groundwater recharge and discharge patterns to and from wetlands, billabongs and flood plains. The death of Red River gums in the billabongs and floodplains some distance from the Murray River is the result of declining and increasingly saline groundwater and lack of fresh water recharge.

Integrated catchment management is now an operating principle for the implementation of CoAG's water reform initiatives and is central to the establishment of catchment management authorities in Victoria and New South Wales and similar structures in the other states. Regional management of catchments using many of the conceptual frameworks that have evolved from a whole-of-system approach are now established practice.

Technical Innovation

Technical innovation in the water industry encompasses a wide range of possibilities including more effective and cheaper ways of treating waste and saline water for reuse, improved leak detection systems for urban and irrigation water conveyance systems, the use of solar energy to desalinate water, remote sensing technologies that improve our understanding of the distribution

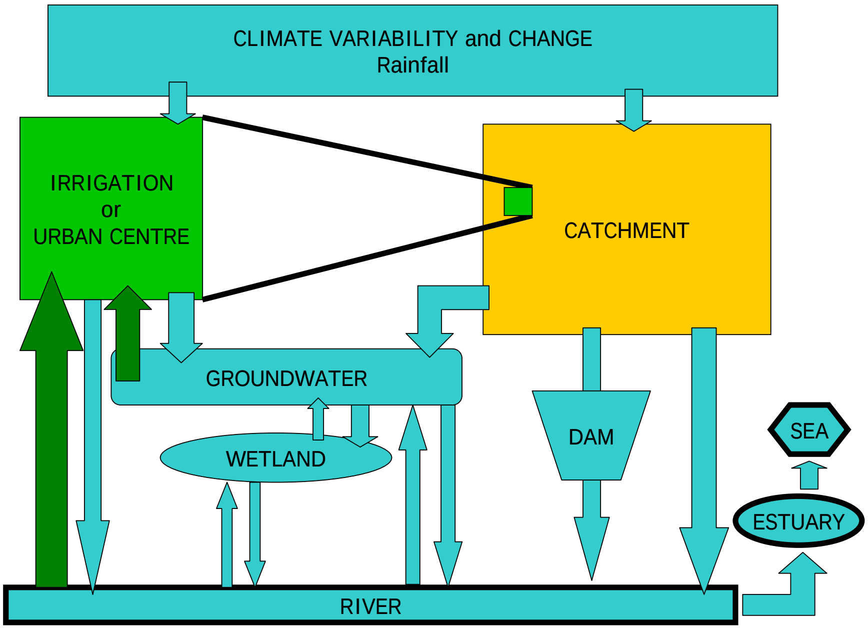

Figure 6. Water flows to be managed in irrigation within a whole of system approach.

vertically and horizontally of fresh and saline water resources, improved modelling of water systems that facilitates adaptive management responses and engineering improvements that reduce the amounts of water required to process materials in mining, agricultural value adding and manufacturing.

<u>Urban systems</u>

Limited sites for new dams and climate variability mean that Australian urban communities need to increasingly look at using water more efficiently and to conserve scarce supplies. In 2003, water usage in Australia's 22 largest cities was 2,065 GL of which 59% was residential and 28% was used for industrial, commercial, local government, parks and fire fighting. Nationwide about 9% of total effluent was reported as being recycled. In 2001/02, over 500 sewage treatment plants nationwide contributed to this recycling of less than 200 GL per year. Demand and pricing management have meant that Sydney, for example, has been able to accommodate population growth. Until 1985 population growth and water consumption paralleled each other (Fig. 7). However, subsequently consumption flattened off enabling the city to accommodate an extra 700,000 people without growth in water demand. Thus we have built major infrastructure and enabled Sydney to grow by 3 million people during what appears to be a rainfall sequence that is much wetter than the first 50 years since federation in 1901.

A number of other initiatives that go under the umbrella headings of "integrated water system management" and "water sensitive urban design" include opportunities to incorporate third pipe "grey" water systems for toilet flushing and garden watering in new housing developments, increased treatment of effluent and its reuse for industry and irrigation, sewer mining and treatment for localised irrigation of parks and sports grounds and stormwater capture and treatment to substitute for potable water in a wide range of non potable uses. However, non potable reuse is still face with considerable regulatory hurdles to overcome. Socially and politically substitution of drinking water by treated effluent and stormwater for non potable uses has a lot of scope to alleviate the demand for new potable supplies. However, indirect potable reuse of treated sewage, will in some instances have to be considered.

<u>Water use efficiency and productivity gains</u>

As elsewhere in the world, Australia's irrigation systems suffer from problems associated with

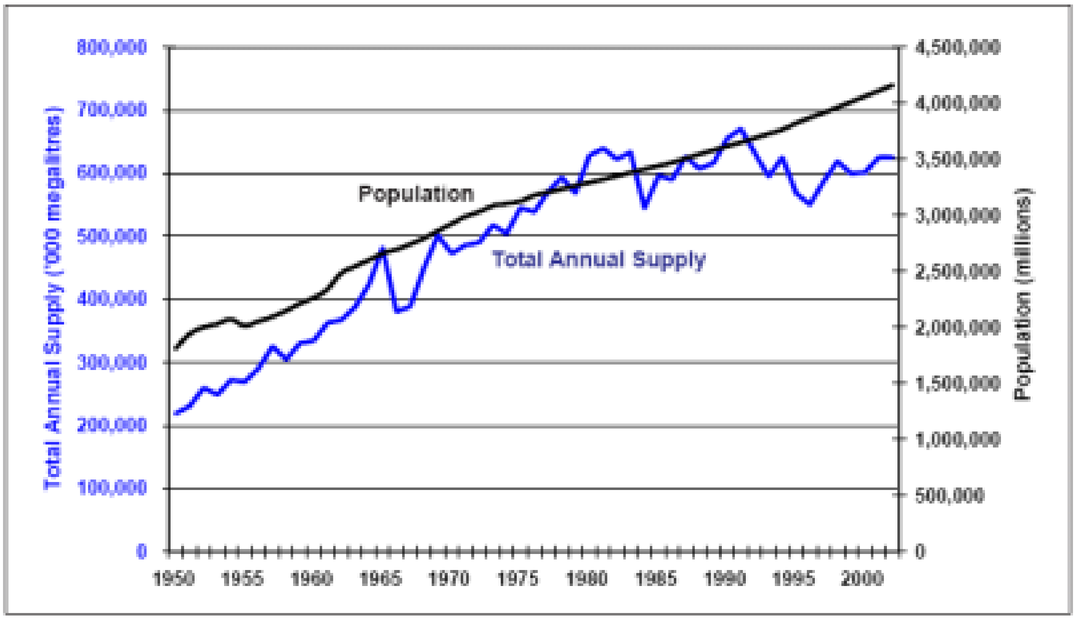

Figure 7. Sydney's water supply in relation to its population growth (after WSAA, 2005).

losses in storage and conveyance, on-farm losses and variable water use efficiency. The Murray Darling Basin Commission has demonstrated that for the basin as a whole, 25% of diversions for irrigation are lost during conveyance in rivers, 15% are lost from canals and 24% lost on farm, meaning that only 36% of irrigation water is actually delivered to plants. Such losses are not atypical across the world. The data for the Murrumbidgee Irrigation Area (MIA) (Table 5) do not include river conveyance losses and indicate on farm losses better than the overall MDB average. Simply increasing water use efficiency (WUE) is not the solution to better use of irrigation water. Technically WUE tells us how much water is consumed by the crop and how much wasted. However, the real wastage comes from not being as productive as possible with the water that is consumed. Efficiency can be high with consequent detrimental environmental consequences, whilst productivity is low. Growing more food with less water alleviates scarcity, contributes to food security and puts less strain on nature. The most effective way to increase water productivity is to shift water use by trading from low value to high value crops. To facilitate this, water entitlements, trading regimes, market factors and other complicated issues such as stranding of assets all have to be taken into account.

Over the last 60 years, Australian agricultural productivity in dryland and irrigated systems has increased on average by 3% per annum (Knopfke et al. 2000). This has kept Australian farmers internationally competitive in the face of declining terms of trade for agricultural products and subsidies on agricultural production offered by some competitors.

Key Indicators	**Liuyuankou China**	**Rechna Doab Pakistan**	**MIA Australia**
Area (ha)	40,724	2,970,000	156,605
Losses from Supply System %	35	41	12
Field Losses %	18	15	11
Net Surface Water available to crop %	**46**	**32**	**77**

Table 5 Surface water irrigation efficiency (personal communication Shahbaz Khan)

Whilst many of these improvements have come from plant breeding, disease and pest management and soil and fertility management, improved use of available water has also been very important. For example, the productivity of Australian rice production has increased from about 0.4 g/Kg of water used to 0.8 g/Kg over the last 20 years with a concomitant reduction in water used from about 1600 to 1250 litres/Kg (Fig. 8). These figures demonstrate that rice production in Australia is one of the most efficient users of water for rice production in the world.

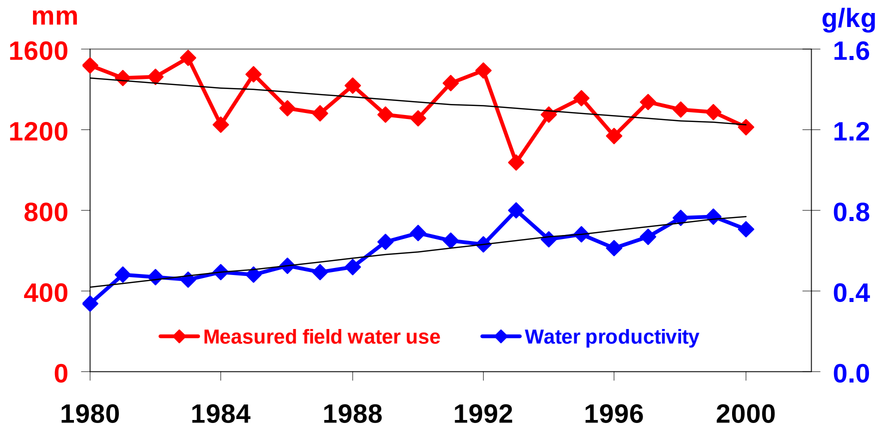

Figure 8. Rice irrigation water use efficiency trend –Murrumbidgee Irrigation Area (MIA) (source:CRC for Rice Production)

Conclusions

Australia is at a crossroads in terms of its ability to cope with increasing water scarcity. A vigorous reform process is underway that is focusing on governance, productivity and environmental issues. This will require a level of commitment by state and federal governments to drive the reforms and oversee a major re-allocation of water between irrigation activities, from irrigation to river and groundwater flow and some movement of water from irrigation to urban use. Within irrigation water will tend to move away from low value production for water use to higher value production. If reforms allow third party access to urban sewage and effluents there will be incentives for innovation in re-cycling and greatly increased water re-use. The capacity to manage periods of adjustment, including through water trading, will be difficult but critical to success. If the reforms are able to establish a framework that allows water to trade and economic incentives develop that encourage and support innovation then we can expect to see a significant increase in water productivity across industries while returning sufficient water to our stressed rivers, floodplains, wetlands and estuaries. They may also enable us to avoid mistakes made in the south as our northern rivers come under increasing development pressure.

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