

Increasing water productivity in irrigated rice systems in Australia: institutions and policies

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Australian irrigation farmers, and rice growers in particular, are under tremendous pressure to increase water-use efficiency and water productivity. A host of institutions, programs, and policies, often interrelated, affect water availability and price, which drive the need to increase the water productivity of rice-based systems, and irrigated agriculture in general. These are driven by environmental and National Competition Policy agendas at the national, state, and local irrigation area levels. This paper outlines the various institutional and policy drivers that affect water productivity for rice-based cropping systems in Australia, with examples from the Murrumbidgee and Murray valleys. In addition to generic policies, for many years rice cultivation has been subjected to a range of environmental restrictions designed to reduce deep percolation and water-table rise, and increased water productivity has been an implicit outcome of these regulations. However, yield increases from improved varieties and management have been the main causes of increased field-level water productivity of rice.

Australian irrigation farmers, and rice growers in particular, are under tremendous pressure to increase water-use efficiency and water productivity. Irrigated agriculture accounts for about 75% of all water use in Australia, with about 18 million ML of irrigation water used on about 2 million hectares each year (NLWRA 2000). The extraction of water for irrigation has large effects on rivers and associated ecosystems and their ecological sustainability (MDBMC 2001d).

The Australian rice industry uses about 1.5 million ML to produce about 1.2 million t of paddy annually, and virtually all of this is grown in the Murrumbidgee and Murray valleys of the state of New South Wales. Rice culture depends entirely on irrigation, with average rainfall of about 150 mm and evapotranspiration of about 1,150 mm during the growing season. The rice industry is a significant element in

the economic and social prosperity of major regional communities (Dwyer Leslie 1992), with a farm-gate value of AUD296¹ million in 1997 (NSW Irrigators 2002).

The majority of the rice crop is grown in gazetted irrigation areas or irrigation districts, each of which is run by a large nonprofit-making private irrigation company (or cooperative), owned by all the landholders who are shareholders in the company. There are three such entities—Murrumbidgee Irrigation Ltd (MI), Coleambally Irrigation Cooperative Ltd (CICL), and Murray Irrigation Ltd (MIL). Large state government-owned and -operated dams in the upper catchments store water for irrigation. The areas and districts purchase river water from the NSW Department of Land and Water Conservation (DLWC). The areas and districts have well-managed channel systems supplying water directly to each farm; private groundwater pumping is also significant in some areas. Recycling of drainage water is significant at the system scale, and increasing on-farm.

Rice is the dominant broadacre crop in the irrigation areas and districts, occupying from 10% to 25% of the landscape for about 7 months, and accounting for 50–70% of the total irrigation water use. The majority of the rice crop is direct-seeded into fields that remain ponded for about 5 months. Large areas of winter cereals and a wide range of other summer and winter crops and pastures are also grown on “rice farms.” Rice typically provides about two-thirds of farm income, and irrigation water is one of the major rice-growing costs, constituting approximately 22% of total variable costs and around 13% of gross revenue, compared with 0–2.5% of gross revenue at six sites across Asia (Valencia et al 2001).

The productivity of irrigated agriculture in the rice-growing regions is threatened by rising water tables and salinization. Up to half of the rise in water tables has been attributed to rice culture (GHD 1985, Dwyer Leslie 1992). Therefore, rice cultivation has been subjected to a range of environmental water-related regulations like no other crop (Humphreys et al 1994), and increased water productivity is an implicit outcome of these regulations.

A host of institutions, programs, and policies, often interrelated, affect water availability and price, which drive the need to increase the water productivity of irrigated agriculture in general, including rice-based systems. These are driven by environmental and National Competition Policy agendas at a range of levels, principally (1) national, (2) multi state/national, (3) state, and (4) local irrigation scheme. This paper outlines the various institutional and policy drivers that affect water productivity for rice-based cropping systems in Australia, with examples from the Murrumbidgee Irrigation Area (MIA).

Irrigation water productivity of rice

Farm-level irrigation water productivity of rice (g grain kg⁻¹ water) has roughly doubled in the past 20 years, fluctuating from 0.6 to 0.8 g kg⁻¹ in recent years in the MIA (Fig. 1). In comparison, Bouman and Tuong (2000) reported water productivities

¹Australian dollars (AUD); AUD1 equaled approximately US\$0.55 at the time of writing (October 2002).

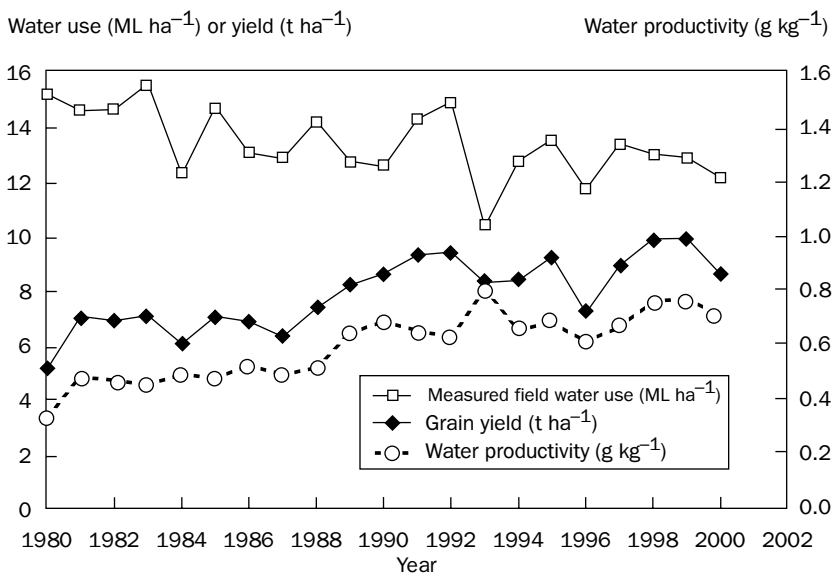


Fig. 1. Trends in rice water productivity, grain yield, and field water use in the MIA.

of 0.2–0.4 g kg⁻¹ in India and 0.3–1.1 g kg⁻¹ in the Philippines for continuously flooded rice. The increase in water productivity in the MIA is largely due to a yield increase, a result of improved varieties and management (Lewin et al 1994, McDonald 1994), and to a smaller degree to declining water use (Fig. 1). The dips in the yield trend in Figure 1 are due to unfavorable seasonal conditions (especially low temperatures during the reproductive period, e.g., 1996 and 2000). The theoretical crop water-use requirement also fluctuates considerably in response to the highly variable seasonal conditions experienced in the rice-growing regions (Fig. 2). The trends in rice-field water use closely match the trends in theoretical crop water use; however, irrigation water-use efficiency (crop water-use requirement/irrigation amount) appears to have increased from about 0.8 in the early to mid-1980s to an average of about 0.9. This change coincided with the introduction of the rice water-use target policy in 1985-86 (Humphreys et al 1994).

Government natural resource management institutions and policies

Integrated catchment management

Australian water policies, programs, and institutions affecting irrigated agriculture and rice systems need to be understood in the context of the overall natural resource management (NRM) agenda at the national, state, catchment, and irrigation area levels. The peak body is the Natural Resource Management Ministerial Council (NRMMC), a coalition of commonwealth, state, and territory ministers formed in

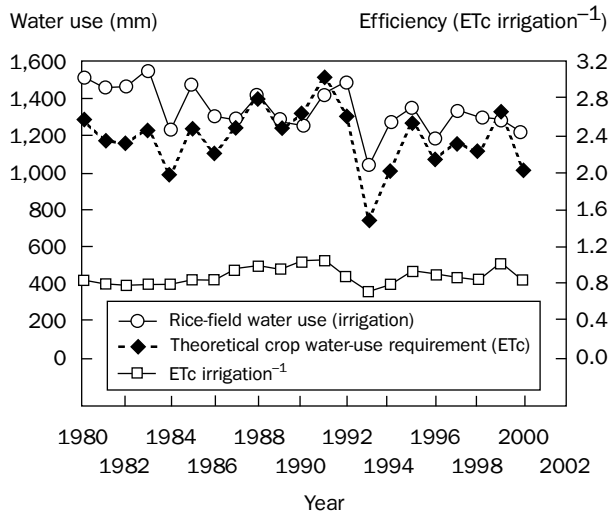


Fig. 2. Trends in rice-field water use, crop water-use requirement, and irrigation efficiency in the MIA (1 ML ha⁻¹ = 100 mm).

2001 to ensure a national approach to NRM. The Council oversees major NRM funding initiatives, including the National Action Plan (NAP) for Salinity and Water Quality. These initiatives are implemented by the states at the catchment and subcatchment levels, but with joint commonwealth/state funding. The NAP is a recent initiative that involves the setting of targets and standards for NRM, including salinity, water quality, and flows, and biodiversity for priority catchments.

Draft catchment “blueprints” have been prepared and made available for public comment for the Murrumbidgee and Murray catchments (MCMB 2001a,b). These draft “blueprints” specify the objectives for each catchment, and detail and prioritize the targets, management actions, and activities required to achieve the objectives. For example, the water management targets with direct implications for irrigation for the Murrumbidgee catchment are to (1) “manage the hydraulic fall and rise rates in the regulated river system to reduce bank slumping” and (2) “ensure the implementation of water-sharing plans.”

An important aspect of the NRM process at all levels has been the involvement of the community in the planning and implementation of NRM plans by establishing catchment and river management committees comprising representatives of all stakeholders. A key component of this process is the community commitment and ownership of the decisions that have considered the socioeconomic and environmental effects of policy change.

The Murray-Darling Basin

Seventy-five percent of Australia’s irrigation, and all rice cultivation, occurs within the Murray-Darling Basin (MDB). This Basin contains Australia’s largest and most

developed river system, covering more than 1 million km² across four states and the Australian Capital Territory. Coordination within the MDB, particularly sharing the water, began with the intergovernmental MDB Agreement under the 1914 Murray-Darling Basin Act. However, since the 1980s, deteriorating water quality, salinization (especially dryland), and acidification of agricultural lands, and loss of biodiversity, have led to the development of the Basin NRM Strategy, the Basin Integrated Catchment Strategy (MDBMC 2001a), the Basin Salinity Management Strategy (MDBMC 2001b), and the cap on water use. Salinity levels in the Basin rivers have been increasing as a result of land-use changes over the past 200 years, which cause rising water tables and mobilization of salt in the subsurface materials. The main cause of increasing salinity in the rivers of NSW is dryland salinity, and the irrigation regions of the NSW Murray and Murrumbidgee catchments are in fact net importers of salt. The MDB Ministerial Council (MDBMC), formed in 1985, has the power to make decisions for the Basin as a whole, while the states in partnership with regions have responsibility for within-valley or catchment outcomes. Water supply and management throughout the Basin have historically been focused on ensuring reliable supplies for irrigation. However, increased priority is now being given to environmental flows to protect water quality for both urban use and river ecosystem health. Furthermore, large-scale revegetation in parts of the catchment to reduce groundwater recharge (the cause of dryland salinization) will significantly affect catchment water yields in the future.

Government institutions, programs, and policies for water management

The Murray-Darling Basin "cap" on diversions

Extraction of water from the river system has increased greatly over the past 100 years, contributing to declining river health. The 1995 audit of water use in the MDB showed that, with 1994 levels of irrigation development, median minimal flows to the sea are only 21% of those that would occur under natural conditions (MDBMC 1995). The audit also showed that the lower Murray River experiences severe drought-like flows in 60% of years compared with 5% of years in natural conditions. Furthermore, in the five years preceding the audit, only 63% of all water entitlements were used, leaving considerable scope for further increases in consumption if inactive entitlements were activated. On average, diversions could have increased by 15% if all existing water entitlements were activated, which would greatly reduce the security of supply for existing irrigators.

In 1995, implementation of a cap on diversions began. Each year, the volume of allowable diversions is set at the volume of water that would have been used with 1993-94 levels of development, assuming climatic conditions similar to those of the year in question. Implementation of the cap is the responsibility of the states and is done on a catchment basis, and performance is reviewed annually. If the cumulative cap is exceeded in any catchment, the state government has to report to the MDBMC on proposed measures to bring diversions within cap limits.

The operation of the cap was reviewed after five years of implementation (MDBMC 2000a). The review found that, without the cap, there would have been a significantly increased risk of environmental degradation, but that the current cap does not necessarily provide for a sustainable ecosystem and should be refined as more knowledge becomes available, and that all forms of water use should be incorporated in cap management arrangements. The review also found that the cap has benefited the security of supply and provided a more certain environment for long-term investment and development, and accelerated water trade. In 2002, the MDBMC agreed to recovery of a further 350, 750, or 1,500 GL for the Murray River to boost environmental flows and management, with the final decision to be announced in October 2003 (MDBMC 2002). An AUD1 billion package will be provided, which includes investment in improved structures and other water-efficiency initiatives, some water purchase for the environment through the market, and a native fish strategy. The Council also reaffirmed the importance of water property rights issues in dealing with the nation's salinity and water quality problems, and noted the need to consider the implications of changes in water property rights for investment and the effects of the changes on water users, particularly farmers.

The Council of Australian Governments (COAG) water reforms

The COAG is a high-level council of heads of state representing the commonwealth, states, and territories, with the power to influence commonwealth funding to the states and territories. The COAG water reforms aim to maximize the economic contribution of water to the Australian community and achieve a better balance between environmental and consumptive uses (Cruse et al 2000, Crean and Young 2001). The main components of the COAG water reform framework are

- pricing reform based on principles of full cost recovery and transparency
- a comprehensive system of water allocations, backed by separation and clarification of water property rights
- formal determination of water allocations, including allocations for the environment
- water trading, including cross-border (state) sales of water allocations or entitlements
- institutional and organizational reforms involving the separation of resource management and regulatory roles of government from roles of providing water services
- improved public participation and community consultation in water management decisions

The COAG policy was strengthened by its inclusion in the Commonwealth Government's 1995 National Competition Policy, which provides payments to individual states and territories for a total of AUD16 billion for staged implementation of the recommendations. Implementation of the COAG water reforms is the responsibility of the states (see below). Significant achievements to date include pricing reform and determination of volumetric water allocations. Downsides have been the failure to adequately define and implement water property rights (particularly

in advance of trading) (Cullen 2002) and insufficient separation of regulatory and water service roles in some states (NCC 2001).

The Snowy River Agreement

The Snowy River Agreement is another example of coordination and cooperation between the states and commonwealth. In October 2000, the Victorian, NSW, and Commonwealth governments announced an AUD375 million agreement to restore the environmental health of the Snowy River by increasing flow to 28% of its natural flow, from the current level of about 10% because of diversion for hydropower and irrigation in the Murrumbidgee and Murray systems. To achieve this, the government will invest in capital water-saving projects such as pipelining, better water accounting, improved maintenance of irrigation distribution systems, and major engineering works. The water agreement will release up to 294 GL into the Snowy River and 70 GL into the Murray River annually.

The NSW Water Management Act 2000

The Water Management Act 2000 prescribes that the first priority of water sharing is to protect the water resource and its dependent ecosystems. An interim State Water Management Outcomes Plan (SWMOP) has been prepared to provide strategic direction and guidance for water management in NSW. The five-year plan outlines the policy context, targets, and strategic outcomes desired from the management and use of water across the state. The SWMOP was supposed to have input from peak irrigator groups, but in fact the interim plan was developed in isolation by government agencies, and, in the case of Murrumbidgee, delivered with little time (3 days) to provide input by irrigator groups to the committee 3 days before submission of the draft plan (M. Linnegar, personal communication). The Plan is currently with the state cabinet, and all ground- and surface-water sharing plans (see below) must be in accord with the SWMOP.

Water supply and allocation

In response to the COAG requirement to separate regulation and resource management from service, NSW State Water (a commercial business entity within DLWC) was created in 1997 to deliver water to users. However, it is questionable whether there is a sufficient degree of separation between State Water and DLWC (NCC 2001). Water administration and licensing are conducted by DLWC, which is responsible for sharing the available regulated and unregulated water resources between competing water uses to achieve optimum economic, environmental, and social benefits.

Licenses are divided into normal and high security entitlements, reflecting the type of water use. High-security entitlements are usually issued for town water supplies, stock and domestic use, industrial use, and permanent plantings (e.g., orchards, vineyards), and are usually a small component of the total valley entitlement. For most license entitlement categories, no new licenses have been issued since 1977.

DLWC's main tool in the sharing process is the announcement of allocation levels as a percentage of each license's annual entitlement. Allocation announcements are

made on a seasonal basis for each river system depending on the amount of water in storage and the minimum expected inflows (in 99% of years) during the season. The 99% reliability ensures that the allocation will not need to be subsequently reduced during the irrigation season (unless conditions more severe than the worst recorded drought occur). The choice of such a conservative reliability was made on the basis that the risk of supply shortfall should be a matter for the individual licensees, and not the result of government decision. Allocations may be updated during the season because of increases in available water.

Water sharing plans (WSP). Under the Water Management Act 2000, WSP are being developed for all river and groundwater sources in the state. Once finalized, the plans will be binding for 10 years. The WSP for the regulated Murrumbidgee River has 11 objectives to protect water access among various uses, including irrigated agriculture, town water supply, and the environment (DLWC 2001). Environmental flow rules were originally developed by river management committees comprising representatives of all stakeholders and first implemented in 1998. The rules were designed to ensure minimum outflow from the dams, minimum end-of-system flows, and some degree of natural flow and variability downstream of the dams, and to maintain an environmental contingency allowance. Hydrological modeling indicates a 3% long-term average reduction in diversions for irrigation as a consequence of the WSP, but in extreme years the reduction would be as high as 17% (DLWC 2001).

Announced allocations in the Murrumbidgee (1980-81–1994-95) averaged 116% (range 100–120%) before the introduction of the cap and environmental flows compared with an average of 81% (range 72–90%) from 1998-99 to 2001-02. Similarly, announced allocations in the NSW Murray have changed from an average of 126% (range 85–140%) to an average of 68% (range 29–87%) over the same periods. Economic modeling suggests a reduction in long-term average farm gross margin of 2% as a result of the WSP (DLWC 2001). However, irrigation industry groups consider that the government has grossly underestimated the social and economic effects of the reductions in water availability because of the WSP. For example, the effect for the major irrigation valleys in NSW was estimated to be a total loss of gross production of AUD0.3 billion per year, or 24% of the total farm-gate value of irrigated production in NSW, and with additional effects on employment on- and off-farm (NSW Irrigators 2002). The annual losses for the Murrumbidgee and Murray valleys were estimated to be AUD73 million and AUD18 million, respectively, with a total loss of AUD14 million (4.7% of farm-gate value) for the rice industry. Almost 400 submissions have been received on the Murrumbidgee WSP, and there is considerable tension between irrigators and the state government, and the threat of a legal challenge from the Australian Conservation Foundation. In her “Reflections on developing a water sharing plan,” Bowmer (2002) outlines the successes and failures of the process, and suggests that the challenge for the future is to demonstrate that local solutions can work inside an overarching set of state and national policies and principles.

Water pricing

The Independent Pricing and Regulatory Tribunal (IPART) regulates pricing in NSW. In the past, price played a small role in the allocation of scarce bulk water resources as the state water authorities allocated water to agricultural use in large volumes and at prices that generally did not cover the operating and maintenance costs, let alone the high capital costs of the infrastructure (IPART 1996). Since 1995, IPART has independently determined the path of water prices back to full recovery of both operational and asset refurbishment costs, using a process that is both transparent and independent.

The infrastructure required to manage the water resource for irrigation also provides benefits to the wider community such as flood mitigation and environmental protection; therefore, IPART also has a role in determining the cost-sharing arrangements between irrigators and the other beneficiaries, which are continually under review. IPART originally aimed for full recovery of allocated costs to be achieved by 2003-04. Current water prices recover varying proportions of the costs allocated to users; however, almost complete cost recovery occurs in the Murrumbidgee (91% in 2000-01) and Murray (82% in 2000-01) valleys.

Water charges are two-tiered, consisting of a fixed charge to the license holder that must be paid regardless of water use to cover asset refurbishment, administration, and other overhead costs, and a volumetric charge to cover delivery costs. Bulk water prices determined by IPART are incorporated in the charges set by irrigation companies, which include their own operating and fixed charges. Wholesale irrigation customers receive discounts on their bulk water charges. These are not justified on cost grounds but because wholesalers provide information that assists DLWC in performing its functions (IPART 2001). The current discounts for MIL, MI, and CICL are 40%, 29%, and 32%, respectively.

Water trading

The introduction of water trading has been instrumental in breaking the nexus between property rights for land and property rights for water, and has provided a mechanism for allowing water to be traded from low-value uses to high-value uses. Marsden Jacob Associates (1999) conservatively estimated that the increase in the gross value of irrigated agriculture in NSW from permanent and temporary trade in 1997-98 was AUD60–100 million. A water market may also increase the financial incentive for irrigators to become more water-use efficient by changing management practices and/or investing in technologies, providing there is potential to sell the achieved water savings.

The level of water trading in the MDB has increased significantly since the introduction of the cap in 1995, from 502 GL in 1996-97 to 820 GL in 1999-2000 (10% of total diversions). Approximately 90% of trades are temporary, and almost all trades are within-valley. Similar statistics apply to trade in NSW, with total trading of 421 to 548 ML over 1996-97 to 1999-2000 (Table 1).

The effectiveness of water trading in increasing the economic value of water will depend on an efficiently functioning water market. There are several impediments to

Table 1. Water trading in New South Wales.

Year	Irrigation diversions (GL)	Permanent transfers (GL)			Temporary transfers (GL)			Total trade (GL)	Intra-valley trade (%)	Inter-valley trade (%)	Inter-state trade (%)	Total trade to diversions (%)
		Intra-valley ^a	Inter-valley	Inter-state	Total	Intra-valley	Inter-valley					
1996-97	7,034				37.5			421				6.0
1997-98	6,476				47.3			548				8.5
1998-99	6,216	56.6	0.0	-3.2	59.8	463.0	0.0	540	96.2	0.0	3.8	8.7
1999-00	4,940	48.1	-2.6	-2.6	53.3	380.5	3.5	441	97.2	1.4	1.4	8.9

^aThe intravalley transfer is a gross value, whereas the intervalley and interstate transfers are a net value. Source: MDBMC (1998, 1999, 2000b, 2001c).

the formation of an efficient water market, in particular for permanent trading (Crase et al 2000, Goesch 2001). These include

1. *Unclear or poorly defined rights to access and use the resource.* The lack of a uniform national system with a clear definition of rights, central registration, and uniform market rules is currently a major impediment. There are now about 20 different water products on the market with a different security of supply (Cullen 2002).
2. *Irrigation authority restrictions.* Currently, irrigation authorities impose a raft of restrictions on permanent and intervalley and interstate transfers of water entitlements. For example, permanent trade out of MI is not permitted, and is subject to restrictions in CICL and MIL (Bell and Blias 2002). The major reasons for trade restrictions are the need to protect against the prospect of stranded assets, to maintain the economic viability of the region, and to prevent environmental problems. Such restrictions may contribute to the fact that most temporary water traded in the Murrumbidgee is surplus to needs and goes from high-security entitlements (high-value, high water-use efficiency—horticulture) to general-security entitlements (lower value, lower water-use efficiency—rice) (MI 2001).
3. *Imperfect market information.* Market information for permanent transfers is not very transparent because they are usually done by private treaty and price is not disclosed. The temporary market is more transparent with transactions through various water exchanges, with the information easily accessible from the Internet. For example, the Southern Riverina Irrigation Districts Council operates a water exchange through MIL (www.murrayirrigation.com.au/watexch/), which posts the historical monthly minimum, maximum, and average prices as well as the quantity traded.
4. *Hoarding behavior and speculation.* Natural supply variability and increased uncertainty surrounding possible changes in environmental allocations have led to the retention of surplus entitlements for greater security and associated speculation that entitlements are increasing in value.
5. *Excessive transaction and transfer costs.* In general, the transaction costs of permanent trade are significantly higher than for temporary trade because of higher search costs to determine the market price for permanent trades, more onerous conveyancing requirements, higher administrative costs, taxation implications, and administrative delays.

The price of temporary traded water is greatly influenced by the availability of water. For example, in 1999-2000, a year of very low allocation (approximately 30%), the mean monthly prices in the Murray Valley reached AUD80 ML⁻¹, whereas, in a year of higher allocation (approximately 80%), the price remained below AUD25 ML⁻¹.

Table 2. Irrigation area, entitlement, and estimated annual farm-gate value of irrigated production in rice-growing areas.

Irrigation company	Total area (ha)	Area developed for irrigation (ha)	Entitlement (GL)			Value of production (AUD million)
			General security	High security	Total	
MI	490,000 ^a	198,000	930	283	1,213	350
CICL	79,000 ^b	77,000	477	8	485	55
MIL	716,000	429,600 ^c	1,445	–	1,445	250
Total	1,285,000	704,600	2,852	291	3,143	655

^aIncludes Wah Wah District, which is 272,000 ha, with only 25,000 ha (10.3%) being irrigated. ^bNot included is the Coleambally Outfall District, which is approximately 320,000 ha, of which 9,000 ha are irrigated. ^cAn estimate of irrigation area is approximately 60% of total area, with less than half of this irrigated in any one year (personal communication, Adrian Smith, MIL, 2002).

Irrigation area institutions, programs, and policies for water management

Privatization of irrigation

The move toward privatization commenced under the NSW Irrigation Corporations Act 1994 and local ownership commenced in the mid- to late 1990s. All three irrigation companies are now privatized and are responsible for managing their businesses as nonprofit companies, and for implementation of Land and Water Management Plans (LWMPs), which are the vehicle for achieving and demonstrating sound environmental management. The area, water entitlement, and approximate farm-gate value of irrigated production for the three irrigation companies are summarized in Table 2.

The irrigation companies purchase water from the state and are responsible for all sales, operations, and assets within the irrigation areas. The price of water charged to irrigators is set to meet all costs and in 2000-01 was approximately AUD15–19 ML⁻¹ for irrigators in the MIA, AUD17 ML⁻¹ in the CIA, and AUD18 ML⁻¹ in the Murray Districts (includes fixed and variable costs at 80% allocation).

The primary goals of the irrigation companies are profitable and environmentally sustainable irrigation regions. Both goals are drivers to maximizing water-use efficiency or minimizing wastage (surface and deep drainage losses) and its effects on water tables and salinization. Therefore, there is considerable investment in automation of flow monitoring and control of flow structures, such as SCADA (supervisory control and data acquisition) technology, to increase water-use efficiency. Targeted investment in sealing leaky sections of channels causing local environmental problems is also important; however, the economics of this is not conducive to large-scale works.

Bulk license conditions for irrigation areas and districts

The right to supply water each year to the three irrigation companies is contingent on meeting the requirements of two licenses issued by the NSW government under the Pollution Control Act 1970 (administered by the NSW Environmental Protection Agency) and the Irrigation Corporations Act 1994 (administered by NSW DLWC). Compliance with the license requirements involves reporting on and meeting up to 50 conditions each year, some of which are rice environmental monitoring, groundwater pressure levels and salinity, and drainage volumes and quality (salinity, chemicals, etc.) (MI 2001, CICL 2001, MIL 2001).

Land and Water Management Plans (LWMPs)

The land and water management planning process began in the early 1990s and was largely driven by concerns about rising water tables and salinization. The development of LWMPs was a community-driven process to identify options for improved management, and with the opportunity to acquire government-funded incentives over a period of 15 years to encourage adoption of the best management practices. The LWMPs have been officially under way for one to six years in the different regions, and include education programs in addition to on-farm and regional actions. The incentives include subsidies for undertaking intensive soil surveys (using electromagnetic inductance—EM31) to detect areas unsuitable for ponded rice, channels, and on-farm storages, for on-farm recycling systems, and for groundwater pumping. These technologies all promote increased water productivity.

Rice environmental policy

Rice environmental policy has had a major influence on increasing the water productivity of rice since the 1940s (Humphreys et al 1994). The policy aims to minimize the rate of development of high water tables and subsequent secondary salinization. Rice growing is restricted to medium and heavy clay soils and to fields where water use does not exceed a seasonal adjusted target based on the theoretical crop water-use requirement. The volume of water supplied to each farm is measured and farmers are required to specify the area of rice (and other crops) they are growing and which crop(s) the water is going to. The area of rice is measured each season from aerial photos or satellite imagery and rice water use for each farm or field is calculated directly by the irrigation companies.

Rice environmental policy was implemented and administered by the state (NSW DLWC) until the late 1990s, when the irrigation companies took over management of the irrigation areas and districts; however, they largely retained the existing policy (DLWC 1995). Since 1984, the development of rice environmental policy has been guided by the Rice Environmental Policy Advisory Group (and its predecessors) comprising representatives of the rice industry, irrigation companies, and government agencies.

Conclusions

A host of institutions, programs, and policies, often interrelated, affect water availability and price, driving the need to increase the water productivity of irrigated agriculture. Rice water productivity (g grain kg⁻¹ water) at the farm level has almost doubled in the past 20 years in the MIA; however, this has largely been due to increased yields. Water-use efficiency (crop water-use requirement per irrigation amount) appears to have increased by about 10%, starting in the mid-1980s, coincident with the introduction of the target rice water-use policy, to assist water table control. There is little scope for further increasing rice water-use efficiency at the farm level while rice is grown under continuous ponding, and research is under way to develop alternative systems and varieties with sufficient cold tolerance to remove the need for ponding during the early reproductive phase.

The main driver for increasing water-use efficiency and water productivity now and in the future is the reduced availability of water because of increased allowances for the environment. Pricing policy will have little influence, as in the rice-growing areas prices are almost at full cost recovery already. To date in the MIA, water trading has shifted surplus water from horticulture to rice, contrary to the theory of water shifting to higher-value, higher-productivity uses, probably because of market restrictions. As the availability of water decreases further, this will further affect prices and the direction of trade. Therefore, irrigation companies and irrigators are strongly focused on improving water-use efficiency at the irrigation area level, in particular through automation of flow structures and monitoring, and through the implementation of Land and Water Management Plans that promote on-farm efficiency measures such as whole-farm planning, recycling, and the identification of suitable soils for rice, channels, and water storage.

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Notes

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