Improved irrigation through technology and community engagement

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Abstract

While many irrigators are aware that improved technology can increase their control of water, the implementation of these improvements is often limited by external supply and regulatory systems. In a study of a large irrigated area of south eastern Australia, it was evident that significant improvement in water productivity and irrigation efficiency came when irrigated communities were able to combine improved delivery systems and on-farm irrigated practice. The study brought together the bio-physical and socio-economic information that illustrates the use of resources, the water productivity and the differences in performance of different regions. From this analysis it was possible to identify where new opportunities might be available and how irrigation might adapt to an increasingly variable resource and market environment. Further improvement in water productivity will be possible when the introduction of more control technology is combined with improvements in water delivery systems, institutional arrangements and learning support.

The irrigated areas of inland, south eastern Australia are largely associated with two large, connected river systems, the Murray and Murrumbidgee. These rivers arise in the catchments of the eastern and southern highlands and then generally run in a westerly direction through 1000 km of semi arid country. Water from these rivers and their associated storages is used in extensive surface irrigated areas on the flat riverine areas in the east, while in the downstream, westerly regions irrigation occurs in quite narrow ribbon developments along either side of the river. Almost all of these irrigated developments are less than 100 years old, several are less than 50 years old but all areas are actively upgrading and refurbishing the water delivery infrastructure.

Irrigated regions in the Murray and Murrumbidgee Basins

For this study the irrigated areas of the Murray and Murrumbidgee Basins were grouped into ten regions as illustrated in Figure 1.

Within the study regions, the total area irrigated grew by 21% between 1996/97 to 2000/01 to reach 1,243,000 ha. This accounted for 49% of the total irrigated area of Australia.

These regions diverted 8,608 GL[1] of water for irrigation which is about half the total water used for irrigation in Australia. Of the water diverted, 6,656 GL (77%)

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[1] GL = Gigalitre = 10^6 m^3 = 1000 Megalitres (ML) = 10^9 litres

was recorded as being delivered to farms. Recent collation of runoff and inflow to the storages and tributaries of these major rivers indicates that, on average just more than 50% of this inflow is diverted for irrigation.

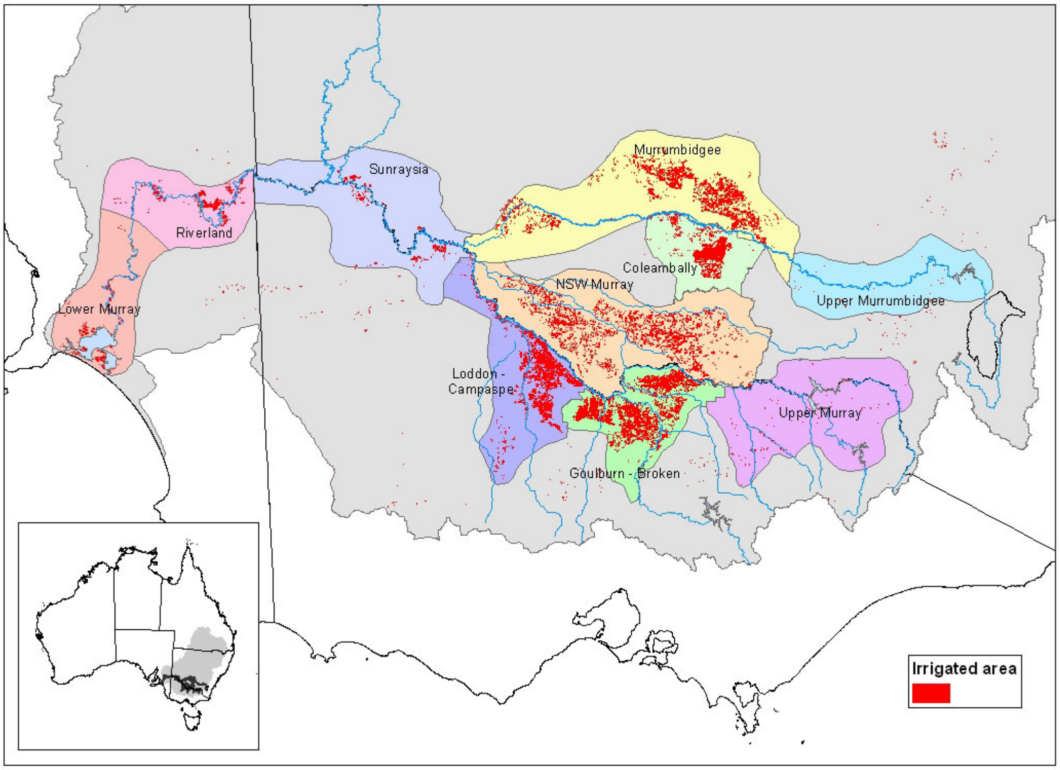

Figure 1 - Location of the nominated regions and distribution of irrigated land area in the Murray and Murrumbidgee Basins.

Water for irrigation is directed through extensive supply and drainage channel infrastructure that has an estimated replacement value of $Aus3.8 billion. This off-farm investment is complemented by an asset value on-farm of $Aus6.3 billion. At the farm level the area irrigated by different application systems is in the ratio of 83:10:7, surface : sprinkler : micro, respectively.

Irrigation – what does it produce and how much is it worth?

With all this infrastructure, water and expertise, what does irrigation in these regions produce? They produce 19% of Australia's vegetables, 50% of all fruit and nuts and 63% of all grapes. The combined estimated revenue for these commodities is $Aus1.7 billion or 40% of all fruit, nut and vegetable production (irrigated and rain-fed) in Australia.

The largest estimated profits for 2000/01, in aggregate, were generated by dairy ($Aus329m), grapes ($Aus289m) and fruit and tree nut crops ($Aus126m). As expected, the largest profits on a per ha and per ML basis were the intensive horticultural activities; vegetables ($Aus941/ML), grapes ($Aus651/ML) and fruit and tree nut crops ($Aus472/ML).

Comparing irrigated and rain-fed districts shows that the total water input from irrigation above rainfall was 2.4 times greater (4.47 ML/ha rain-fed, 10.93 ML/ha rain plus irrigation), with a revenue generation that is 13.1 times greater ($Aus52.45/ML rain-fed, $Aus686.83/ML rain plus irrigation). This increased revenue supports a level of economic activity that is three to five times greater than in the adjacent rain-fed district. The population is greater; there are more businesses, more employment and significantly more services.

The combination of "upstream" and "downstream" dependant activities associated with dairy, fruit, vegetables and wine grapes has an average economic multiplier of 3.5. This means that for every $Aus1000 of farm gate revenue generated, there is an additional $Aus3,500 of dependant economic activity.

There is a substantial difference between those regions in the east (Murrumbidgee, Coleambally, NSW Murray, Goulburn-Broken) on the vast Riverine Plain and those in the west (Sunraysia, Riverland and Lower Murray) within the Murray Basin geological region. The NSW Murray region irrigates 321,000 ha with a diversion volume of more than 2,000 GL to produce irrigated revenue of about $Aus310 million. The Riverland region irrigates 36,000 ha with a diverted volume of 311 GL to produce irrigated revenue of $Aus555 million. The reasons for this difference can be attributed to fundamental differences of geology, soils, and viability of surface irrigation methods. In the "upstream" eastern regions the irrigated areas are flat alluvial plains predominately with deep clay soils while the "downstream" western areas generally adjacent to the incised river have sandy and medium textured soils often overlying calcareous deposits. Eastern regions can divert and distribute water largely without pumping, while in the western regions water needs to be lifted out of the river.

Change in water productivity over time

There are only a few examples of irrigated commodities that have tracked the change in water productivity over time. The rice industry on the Riverine plain in New South Wales (Murrumbidgee, Coleambally and NSW Murray in Figure 1) has documented the improvement in productivity over the last twenty years as illustrated in Figure 2.

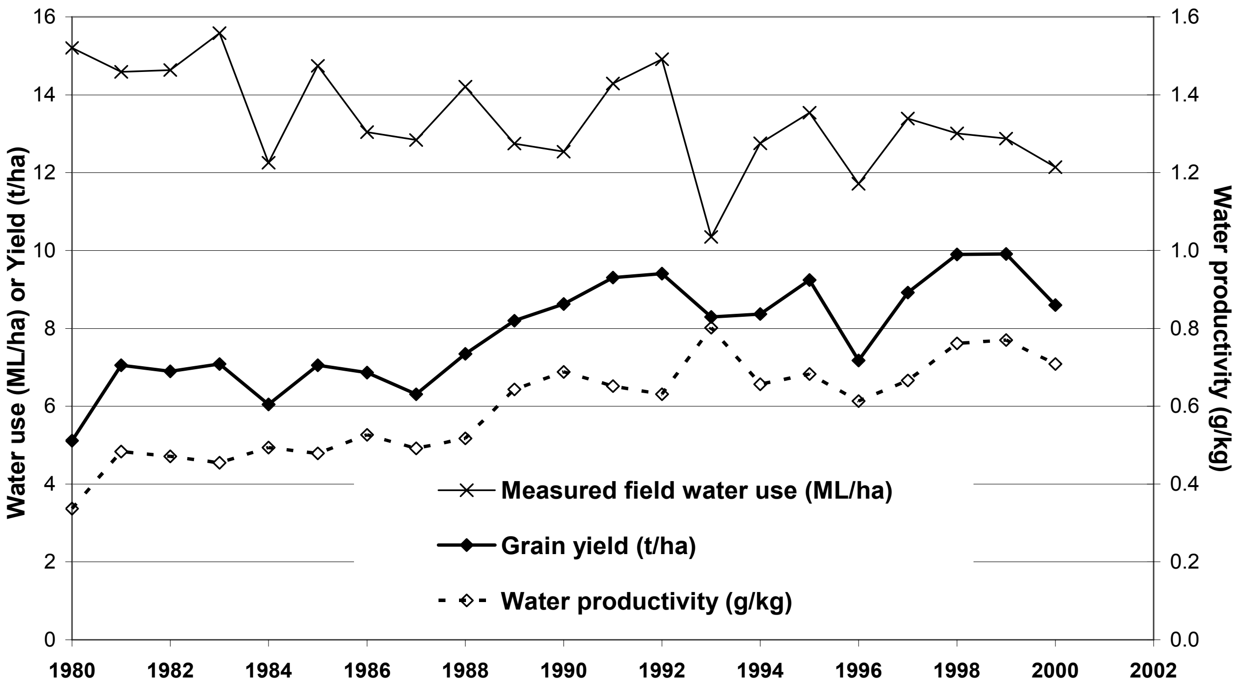

Figure 2 – Change in grain yield and water use in rice over the 20 year period to 2001 with the derived change in water productivity. Data and Figure from Humphreys and Robinson, 2003. Note: units of g/kg x 1000 = kg/ML.

Several recent studies of the irrigated dairy industry in northern Victoria (Armstrong et al 2000, Linehan et al 2004, and Melsen et al 2004) have shown the tremendous variation that exists between dairy farm water productivity – a situation that is consistent with citrus production as shown by Skewes and Meissner (1997). The survey of 170 farms between 1994 and 1996 produced water productivity values with a range from 25 to 115 kg milk fat per ML of irrigation water. A similar, although smaller, survey in 1997 to 1999 indicated that while there had been significantly different water availability conditions between the two survey periods there was no consistent evidence to indicate that limited water had improved water productivity. The Melsen et al (2004) study focused on two case study farms for which long term records had been kept. The indications are that there was a small but gradual improvement in water productivity between 1967 (45 kg milk fat /ML) and 1991 (90 kg milk fat / ML) and that this increased to 150 kg milk fat /ML in 2002. However, as Melsen et al. point out, this later rise is primarily due to the dairy farmer bringing in additional supplementary feed. The amount of irrigation water and productivity from the irrigated pasture is unlikely to have changed significantly. There appears to be some evidence of improved water productivity in dairy but given the complexity of the feed and animal interaction there is need for greater consistency in collecting the data so that we can be sure of the trend.

Other commodities have variable information on change in water productivity but none have collected this in a consistent manner similar to that of rice. A paper by Meyer in 1997 compared water use and energy conversion efficiency from average data 30 years apart(Table 1). This demonstrated that water productivity had improved in all commodities and that the major reason was increased yield rather than a consistent decrease in the water used to produce this yield. Similar anecdotal evidence comes from irrigated almonds in the Riverland and Sunraysia regions (Tony Read, Pers. Comm. 2005). In 1987 yields were about 2.7 tonnes per ha using 13 ML/ha of water. It is expected that in 2005 yields will be closer to 4 t/ha with 15 ML/ha of water use. This means that water productivity has risen from 208 to 267 kg/ML, an improvement of 28% over an eighteen year period.

Crop	Year	Yield (kg/ha)	Water use (ML/ha)	Water productivity (kg/ML)
Grapes (white)	1960	25172	10.7	2353
	1990	30000	8	3750
Oranges (fresh)	1960	30206	12.2	2476
	1990	40000	15	2667
Rice (white)	1960	5096	15.2	335
	1990	5850	12	488
Wheat (flour)	1960	911	4.6	198
	1990	3750	5	750
Tomatoes (fresh red)	1960	50300	9.1	5527
	1990	80000	8	10000

Table 1 – Example of increased water productivity over time for selected commodities. Adapted from Meyer (1994).

While we have been able to gather some data for commodity water productivity, it is clear that most recording systems are inadequate to enable a confident assessment of progress over time. There is certainly enough evidence to show that improvement is occurring; there is also enough evidence to demonstrate that there is still a very wide range of performance at farm enterprise level. Improvement is occurring and further opportunities for additional improvement are certainly indicated.

Theoretical consideration of water productivity suggests that with current genotypes it may only be possible to realise about a 30% improvement above current best practice, mostly by reducing ground surface evaporation and using higher density plantings. We therefore need to look at other parts of the water supply and irrigation system to identify possible areas for significant improvement.

Improved distribution and application

Data from the Sunraysia region for the period from 1998 to 2003 (Giddings 2004) shows that as improved irrigation delivery and application systems come into effect so the annual application of water decreased. For example, in comparable evapotranspiration and rainfall years of 1998/1999 and 2002/2003, the amount of water applied decreased from 4.56 kL/mm of evaporation minus rain down to 3.7 kL/mm, a decrease of 19%.

This decrease was associated with major shifts towards more controlled irrigation systems when there was synergistic investment in delivery system upgrades and on farm application systems. Three irrigation areas (Pomona, Coomealla and Curlwaa) converted from open channel supply systems to semi pressurised pipelines between 1989 and 2000. This resulted in a 58%, 28% and 34% reduction in the annual delivery volumes for the three areas. Immediately following the installation of these piped delivery systems there was a major shift in on farm irrigation application systems. For example, in 1997 35% of the irrigation was furrow delivered with only 13% through drip systems. By 2003, the distribution ratio was reversed, 13% by furrow, 36% by drip (Giddings, 2004). Similar responses have been recorded in other areas following upgrading of distribution systems. As a bonus, improved distribution and more controlled application systems also lead to decreased drainage to underlying groundwater and increased depths to the underlying, unconfined groundwater.

A major study of the water distribution in the Murrumbidgee River system (Pratt Water, 2004) indicated that significant water savings are possible in both the distribution system and the on farm application system. The study highlighted deficiencies in the measurement systems on the river that may account for up to 10 to 15% of the total annual flow. With the irrigation area distribution system, more than 100 GL per year, or about 10% of total delivery, could potentially be saved through greater control, reduced channel seepage and suppression of channel evaporation. Economic assessment indicated that controlling channel seepage to save up to 20 GL/year would cost from $Aus400/ML to $Aus2000/ML, depending on the methods used. To realise further water savings, the costs rise by an order of magnitude. For on farm application, analysis of possible change in the Murrumbidgee Irrigation Area indicates that water savings of 60 GL (6% of annual water diversion) would require a capital outlay of $Aus150 million. This outlay is associated with conversion of some existing horticultural crop irrigation systems to drip and some surface irrigated crops to moveable sprinkler systems. Realising water savings through improved application systems is not a linear response, however, since an additional $Aus173 to $Aus377 million would be needed to achieve a further saving of 25 GL.

Essential elements for improved irrigation practice

Where significant regional improvement in irrigated practice has occurred there has been a combined effort involving policy change, incentives, system delivery improvement, on farm practice change, community education and increased service provision. Almost always there is a common understanding of the need to act most often in the form of a threat to irrigation water supplies, from increasing drainage and salinity problems or from significant changes in commodity markets. Often, the expression of political will and leadership is needed to trigger a more concerted private sector shift. Indeed, public and private sector interaction is critical but first both parties need to be convinced that there is a better way and a more confident future.

The lesson from the Riverland rehabilitation process in which open channels were replaced with pressurised pipe supply is that capital investment in supply delivery acted as a catalyst for considerable on farm investment. The synergistic effect on improved irrigation performance occurred through improved delivery and water control and also through an improved attitude and confidence in the future of irrigation.

Significant government policy change has seen irrigation water supply entities change from government control to corporate structures. There is a range of structures across the regions and in many, governance responsibilities are still being worked out. Water access entitlements have been more clearly defined and have been uncoupled from land ownership thus enabling trade within, as yet reasonably constrained, trading conditions. Temporary and permanent trade in water access entitlement has set a market value for water that varies with storage and allocation availability. Access and allocation has taken on new importance since a limit, (a “cap”) was placed on the amount of water that could be diverted from the rivers.

Our experience is that success in irrigation performance is strongly influenced by the extent of regional community involvement in these change processes. A critical element is the identification of influential community leaders who have enough commitment and persistence to work through the many technical, political, business, and community issues that accompany major change processes. These community leaders have taken a front line position in the consultation and communication needs to bring about successful change.

In many of the irrigated regions in this study there has been the development of regional land and water management plans. These have formed an important focus for government and community input. They have involved documenting the understanding of the current land use, its hydrology, groundwater and vegetation assets which then provides the basis for how these assets can be protected and used. This then triggers an assessment of the consequences of continuing with current practice (the “do-nothing” scenario) and also the assessment of some more desirable intervention scenarios. During this process community consultation is critical and has often found the level of shared understanding is quite low even of the most fundamental processes e.g. water flow patterns and drainage. Several regions have addressed this by developing formal adult education programs which have been delivered to a wide section of the community. Other regions have been well supported through post secondary education providers who have developed regionally specific short courses on irrigation and drainage practice. The deployment of increased technology in delivery and application systems means that information systems and implementation skills need to be upgraded. The education and training provision certainly assists this but there is also need for greater levels of service support in the form of equipment provision and maintenance and advice services. Without these, the uptake and continued use of improved irrigation practice may not continue.

In summary, the elements that are important for sustained regional improvement in irrigation practice and associated water productivity contain the following: shared appreciation of the imperative to act, committed leaders at political and community level, policy and regulatory provision to provide clarity and encouragement to act, combined supply and application improvement, community education and training, and ongoing improvement in equipment and advice services.

This study of the major irrigated areas of inland south eastern Australia showed that there is considerable opportunity for increased production, increased water productivity and a balance between water use for production and that for maintenance of environmental values. Realising the opportunities cannot be achieved through a piecemeal, incremental process, it requires collective action at a regional level so that irrigators, delivery system performance and institutional arrangements work together.

References

Armstrong DP, Knee JE, Doyle PT, Pritchard KE and Gyles OA. (2000). Water-use efficiency on irrigated dairy farms in northern Victoria and southern New South Wales. Australian Journal of Experimental Agriculture. 40: 643 – 653.

Giddings J. (2004). Improving irrigation efficiency in the Lower Murray Darling. Paper at Irrigation 2004. Irrigation Association of Australia Conference, Adelaide.

Humphreys E. and Robinson D. (2003). Improving water productivity in rice cropping systems in Australia: institutions and policy. In: 'Rice science: innovations and impact for livelihood.' Eds T.W. Mew, D.S. Brar, S. Peng, D. Dawe and B. Hardy. Proceedings of the International Rice Research Conference'. 16-19 September 2002, Beijing, China. International Rice Research Institute, Chinese Academy of Engineering and Chinese Academy of Agricultural Sciences.

Linehan CJ, Armstrong DP, Doyle PT and Johnson F (2004). A survey of water use efficiency on irrigated dairy farms in northern Victoria. Australian Journal of Experimental Agriculture, 44: 131 -136.

Melsen M, Armstrong D, Doyle P and Ho C. (2004). A case study of changes in production and resource use over 40 years on an irrigated dairy farm in northern Victoria. Department of Primary Industries. Future Dairy Farming Systems in Irrigation Regions – Phase 2.

Meyer WS. (1997). Smarter Irrigation - An Australian Perspective. Keynote address -Irrigation 97, Smarter Irrigation. Conference Proc. P. 1-1 to 1-7. 20-22 May 1997, Shepparton. Also in Irrigation Australia, IAA Journal **12(1)**, p 20-23.

Meyer Wayne S. (2005). The Irrigation Industry in the Murray and Murrumbidgee Basins. CRC for Irrigation Futures Technical Report No. 03/05. April 2005.

Pratt Water (2004). The Business of Saving Water: The report of the Murrumbidgee Valley Water Efficiency Feasibility Project. Published by Pratt Water, Campbellfield Victoria. 152 p.

Skewes M and Meissner T. (1997). Irrigation benchmarks and best management practices for citrus. Technical Report No. 258, Primary Industries and Resources SA, Adelaide, South Australia.