

WATER TRANSFORMED:

SUSTAINABLE WATER SOLUTIONS FOR CLIMATE CHANGE ADAPTATION

MODULE B: ADAPTING TO CHANGES IN WATER AVAILABILITY - INDUSTRIAL & COMMERCIAL SECTORS

This online textbook provides free access to a comprehensive education and training package that brings together the knowledge of how countries, specifically Australia, can adapt to climate change. This resource has been developed formally as part of the Federal Government's Department of Climate Change's Climate Change Adaptation Professional Skills program.

CHAPTER 2: THE FUNDAMENTALS OF MEASURING WATER USAGE, IDENTIFYING WATER SAVINGS, AND RECYCLING & WATER COLLECTION/STORAGE OPPORTUNITIES

LECTURE 2.3: THE AGRICULTURAL SECTOR – GRAZING AND CROPPING

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Document is available electronically at http://www.naturaledgeproject.net/Sustainable_Water_Solutions_Portfolio.aspx.

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Acknowledgements

The Work was produced by The Natural Edge Project supported by funding from the Australian Government Department of Climate Change under its '*Climate Change Adaptation Skills for Professionals Program*'. The development of this publication has been supported by the contribution of non-salary on-costs and administrative support by the Griffith University Urban Research Program, under the supervision of Professor Brendan Gleeson, and the Australian National University Fenner School of Environment and Society and Engineering Department, under the supervision of Professor Stephen Dovers.

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Adapting to Changes in Water Availability - Industrial & Commercial Sectors

Lecture 2.3: The Agricultural Sector – Grazing and Cropping

Educational Aim

This lecture briefly discusses the vulnerability of the agricultural sector to water related impacts from climate change, in particular with regard to large land-using activities such as grazing and cropping. The lecture then discusses a number of emerging methods available to farmers, to achieve dramatic improvements in water productivity in these two areas.

Learning Points

1. Agriculture uses approximately 70 per cent of Australian fresh water supplies, and a similar proportion internationally. Given this reliance, the agricultural sector is one of the most vulnerable to climate change, requiring immediate and large-scale adaptation to deal with diminishing fresh water resources associated with drought, and increasingly variable temperatures. In many parts of Australia, agricultural regions that are currently classed as 'semi-arid' and 'dry' face increased loss of water through soil and plant evaporation and declining water availability.
2. In the absence of implementing adaptation measures, Australia is threatened with declining food production and reduced economic growth in the agricultural sector and associated food processing industries (see also Lecture 3.2). For example, an investigation commissioned by the Federal Government, the Garnaut Review, forecast that over the next 100 years, unmitigated climate change will result in a gradual reduction in capacity for food production in Australia's Murray Darling Basin, unless farming practices change significantly.¹ Farmers around the country are recognising that they need to innovate and adapt practices to continue to thrive under such climate change scenarios.
3. According to the Intergovernmental Panel on Climate Change, '*of the total land used by agriculture, most is under pasture for livestock grazing [occupying] 3,488 Mha (69 per cent) with cropland occupying 1,405 Mha (28 per cent)*'.² Given the large amounts of water used for grazing and cropping this lecture focuses on innovative methods to reduce the amount of irrigation needed to maintain healthy pastures, and the opportunities to reduce freshwater consumption in cropping.

Reducing water consumption in Grazing

4. Historically, grazing pastures tended to lose productivity over time, and farmers were encouraged to maintain their pastures' productivity by investing in more irrigated water, chemicals, fertilizers and machinery to undertake traditional pasture improvement techniques such as the 'Set Stocking' system, where animals are grazed in large groups for extended

¹ Garnaut, R. (2008) The Garnaut Climate Change Review Final Report, Garnaut Climate Change Review, Cambridge University Press, Chapter 6.

² Bates, B., Kundzewicz, Z., Wu, S. and Palutikof, J. (eds) (2008) *Climate Change and Water*, Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva.

periods in one paddock, before being moved to the next. The problem is that, although this method requires minimal labour, it allows the livestock to graze selectively, preferring some species while leaving others untouched, hence the extent of defoliation is largely determined by which species the livestock find most palatable. Livestock also tend to form 'camps' where they rest and these areas can become bare due to frequent trampling, leading to soil erosion and land degradation issues. In contrast, historically, as the plants and the animals were evolving together, herds of closely packed livestock roamed the landscape, regularly moving to new areas to minimise risk of attack from predators.

5. In the late 1950s, French farmer and scientist André Voisin showed that for wet and cold climates, regularly allowing grazed pasture plants adequate time to recover meant that the biomass produced in a season could be significantly greater than that produced by a constantly grazed pasture.³ Voisin quoted from studies which showed that moisture content of mature older permanent pasture can be 50 per cent higher than that of a four year old temporary pasture.⁴ Voisin's method, which is now referred to as 'Time Control Grazing',⁵ involves moving stock through a number of paddocks at high stock density, based on the growth rate of pasture and its consequent requirement for optimal regrowth.⁶
6. In the 1980s Zimbabwean biologist Allan Savoury, successfully adapted Voisin's ideas to grazing systems in hotter and drier climates of southern Africa.⁷ Subsequent studies in other dry climates, such as Australia, have shown similar positive results, including finding that some farms do not need to irrigate at all.⁸ Through short duration and high density grazing, livestock eat whatever grasses and vegetation is available, rather than just those species the livestock prefer. The combination of these changes leads to more soil biota activity, improved soil structure and hydraulic properties and increased and more active root systems of plants.⁹ This also means plants and grasses are able to grow longer in dry periods because more of the natural rainfall is stored in the soil and need less water from irrigation.
7. Switching to 'Time Controlled Grazing' requires some upfront costs in terms of additional fencing to create smaller paddocks, additional labour to manage livestock movement, and there is also a subsequent need to provide more water troughs. However, this can be soon offset by savings in purchasing feed, fertilisers, pesticides and chemicals, land remediation (for example erosion management), and improved productivity gains in animal weight and quality of product. Further there is a substantial reduction in the requirement for irrigation of grazing land.

³ Voisin, A. (1959) Grass productivity, Island Press, Washington DC.

⁴ Low, A. (1950) 'Rate of build-up of water stable aggregates and soil crumb structure', *International congress of Soil Science III*, vol 9, no 13, Amsterdam, cited in Voisin, A. (1960) *Better Grassland Sward: Ecology, Botany and Management*, Crosby Lockwood and Son Ltd, p111.

⁵ Savory, A. and Butterfield, J. (1988) *Holistic Management: A New Framework for Decision Making*, 2nd edition, Island Press, Washington, D.C.

⁶ Cook, G. (1994) 'A Simple explanation of Time Control Grazing', *Proceedings of the 9th Annual Conference of the Grassland Society*, NSW Department of Agriculture, 13-14 July, pp113-114.

⁷ Savory, A. and Butterfield, J. (1988) *Holistic Management: A New Framework for Decision Making*, 2nd edition, Island Press, Washington, D.C.

⁸ Sanjari, G., Ghadiri, H., Ciesiolka, C. and Yu, B. (2008) 'Comparing the effects of continuous and time-controlled grazing systems on soil characteristics in Southeast Queensland', *Australian Journal of Soil Research*, vol 46, pp348-358

⁹ Savory, A. and Butterfield, J. (1988) *Holistic Management: A New Framework for Decision Making*, 2nd edition, Island Press, Washington, D.C.

Reducing water consumption in Cropping

8. Historically farmers have used flooding and open channels to irrigate crops leading to significant water loss from evaporation, leakage or seepage. For example, in the Murray and Murrumbidgee Basins, water is directed through an extensive channel and drainage system. The Australian Bureau of Statistics shows that water diverted for irrigation from rivers and groundwater resources in Australia is approximately 16,660 GL/year, with water losses during distribution and irrigation of around 5,000 GL/year.¹⁰ Overall, the relative popularity of different application systems is: flood and channel surface irrigation (83 per cent of irrigated land), sprinkler (10 per cent of irrigated land) and micro – or drip – irrigation (7 per cent of irrigated land).¹¹
9. With such a dominance of surface irrigation, there is significant potential to improve the efficiency with which water is being used in agricultural cropping systems. Ensuring that the most robust crops are grown for the climatic conditions, and rotating crops to optimise soil health can reduce the water demand from cropping. Irrigation can also be improved through effective 'irrigation scheduling' and 'advanced deficit irrigation methods'. Rainwater harvesting – into tanks or local underground aquifers – can also supplement irrigation requirements. Combining these cropping strategies can optimise the water used (and associated energy consumed) in agricultural cropping systems, enabling large improvements in water productivity.¹²
10. Changing from surface channel irrigation to sprinkler and sub-surface drip irrigation would have a dramatic improvement on agricultural water efficiency by 50-80 per cent.¹³ However, such a switch requires up front capital expenses, and ongoing energy costs related to pumping and monitoring, so needs to be strategically considered and planned. Currently only a few countries including Cyprus, Israel, and Jordan, rely heavily on drip irrigation.¹⁴ Among the world's three largest agricultural producers (India, China and the US) this more-efficient technology is used on only 1-3 per cent of irrigated land in India and China, and on roughly 4 per cent of the irrigated land in the US.¹⁵

¹⁰ Australian Bureau of Statistics (2004) *Water Account Australia 2000-01 - Implications of water reforms for the national economy*, National Program for Sustainable Irrigation by the Centre for International Economics, Canberra.

¹¹ CSIRO Water for Healthy Country (2005) *Irrigation in Perspective. Irrigation in the Murray and Murrumbidgee Basins. A Bird's Eye View*. CSIRO and CRC for Irrigation Futures, <http://www.csiro.au/files/files/p3we.pdf> accessed 1 October 2009

¹² Weizsacker, E., Hargroves, K., Smith, M., Desha, C. and Stasinopoulos, P. (2009 In Press) *Factor 5: Transforming the Global Economy through 80% Improvements in Resource Productivity*, Earthscan, London.

¹³ Hawken, P., Lovins, A.B. and Lovins, L.H. (1999) *Natural Capitalism*, Earthscan, London, Chapter 11: Aqueous Solutions. vfuoiufi

¹⁴ Brown, L. (2008) *Plan B 3.0: Mobilizing to Save Civilization*, The Earth Policy Institute.

¹⁵ Brown, L. (2008) *Plan B 3.0: Mobilizing to Save Civilization*, The Earth Policy Institute.

Brief Background Information

Agriculture contributes AUD\$39 billion annually to the Australian economy, roughly 3 per cent of the GDP, and employs about 4 per cent of the total workforce directly. The food processing and manufacturing industry, which depends significantly on the Australian agriculture sector, contributes over 6 per cent to Australia's GDP, or AUD\$71 Billion per annum.¹⁶ Hence, significantly changed rainfall patterns and water availability, together with increased soil evaporation are critical factors affecting both ecosystem health and economic productivity, particularly given that the Murray-Darling Basin accounts for 65 per cent of irrigated agriculture in Australia.¹⁷ Further, with rising water prices, future consumer decisions – and hence the market for produce – may be influenced by the water intensity of food production and hence the price of water-intensive foods.

Australia is one of the first countries to experience a long term drought of the type forecast to become more common around the world due to climate change. Many parts of Australia are now entering their tenth year of drought and in the Murray Darling Basin, rainfall and runoff levels have been some of the lowest ever recorded between 2001-2007, with the basin outlined in Figure 2.3.1. The Pacific Institute concludes, *'Initially, the drought was considered simply one of many in a region that is prone to these events. Today, scientists believe that these recent events in Australia are a harbinger of long-term climate change. Indeed, Australia's Bureau of Meteorology predicts that within two to three decades, drought will occur twice as frequently and be twice as severe.'*¹⁸ In the past, Australia was able to survive droughts in the Murray Darling Basin because of the significant water storage systems built in the Snowy Mountain Hydro system,.However this most recent drought in Australia supports a finding of the Pacific Institute, that, *'Simply concentrating primarily on building bigger storage dams for rains that, in the end never come, is not enough to maintain agricultural regions. Rather, given climate change forecasts, farmers and governments are now recognising the need to focus on improving water conservation and efficiency strategies on farms to ensure they are resilient in these dry times that are likely to become more common.'*¹⁹

¹⁶ Australian Department of Foreign Affairs (undated) 'Australia's Food Industry', www.dfat.gov.au/facts/foodindustry.html, accessed 7 March 2008.

¹⁷ Craik, W. and J. Cleaver. (2008). Modern Agriculture Under Stress – Lessons from the Murray- Darling. The Murray-Darling Basin Commission. MDBC Publication Number: 46/08. Canberra: Australia. cit in Cooley, H. Christian-Smith, J., Gleick, P (2009) Sustaining Californian Agriculture in an Uncertain Future. The Pacific Institute.

¹⁸ Circle of Blue. (2009). The Biggest Dry: Australia's Epic Drought is a Global Warming. World Economic Forum Strategic Briefing. Circle of Blue: Traverse City, Michigan.cit in Cooley, H. Christian-Smith, J., Gleick, P (2009) Sustaining Californian Agriculture in an Uncertain Future. The Pacific Institute

¹⁹ Cooley, H. Christian-Smith, J., Gleick, P (2009) Sustaining Californian Agriculture in an Uncertain Future. The Pacific Institute

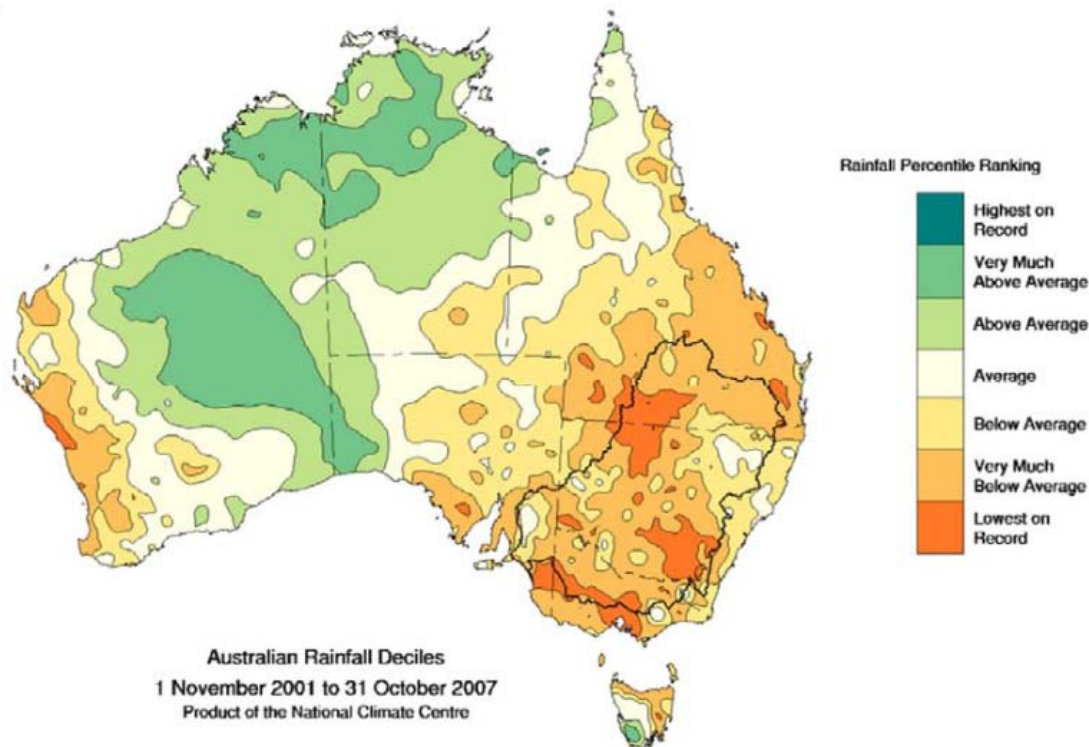


Figure 2.3.1 Australian rainfall deciles from November 2001 to October 2007²⁰.

Source: Craik and Cleaver 2008²¹

The Garnaut Review found that over the next 100 years in an unmitigated case, irrigation might continue in the Basin in the immediate term, but by 2030 economic production will fall by 12 per cent, and by 2050 this loss could increase to 49 per cent.²² By 2100, 92 per cent of agricultural production will be lost due to climate change, translating to at least a 3 per cent reduction in Australia's GDP per year not including the significant social costs of farming families having to leave their farming communities.

Table 2.3.1 Decline in value of irrigated agricultural production in the Murray-Darling Basin to 2100

Year	No-mitigati on case	Strong global mitigation (CO ₂ e stabilisation at 550 ppm by 2100)	Ambitious global mitigation (CO ₂ e stabilisation at 450 ppm by 2100)	Extreme Drought (the worst case 'scenario)
2030	12%	3%	3%	44%
2050	49%	6%	6%	72%
2100	92%	20%	6%	97%

Source: Garnaut Review²³

Given such challenges faced by the agriculture sector, particularly in livestock grazing (occupying 3,488 Mha, or 69 per cent) and cropland (occupying 1,405 Mha, or 28 percent), this lecture focuses on steps that can be taken to improve water productivity for such land-reliant farming. The following

²⁰ The outline of the Murray-Darling Basin is shown in the southeast Australia

²¹ Craik, W. and J. Cleaver. (2008). Modern Agriculture Under Stress – Lessons from the Murray- Darling. The Murray-Darling Basin Commission. MDBC Publication Number: 46/08. Canberra: Australia. cit in Cooley, H. Christian-Smith, J., Gleick, P (2009) Sustaining Californian Agriculture in an Uncertain Future. The Pacific Institute. At http://www.pacinst.org/reports/california_agriculture/final.pdf accessed 16 Sept 2009

²² Garnaut, R. (2008) *The Garnaut Climate Change Review Final Report*, Garnaut Climate Change Review, Cambridge University Press, Chapter 6.

²³ Garnaut, R. (2008) *The Garnaut Climate Change Review Final Report*, Garnaut Climate Change Review, Cambridge University Press, Chapter 6: Impacts of Climate Change on the Australian Economy, www.garnautreview.org.au/chp6.htm, accessed 7 March 2008.

text first discusses reducing freshwater extraction and irrigation to maintain healthy pastures, and then considers how to reduce freshwater extraction for crops.

Grazing - Reducing the Need for Irrigation

As highlighted in the key learning points, grazing pastures have tended to lose productivity over time, with farmers being encouraged to then invest in more irrigated water, chemicals, fertilizers and machinery to undertake traditional pasture improvement techniques. In the late 1950s, Andre Voisin published a number of publications²⁴ that changed the understanding of the underlying causes of grazing land productivity loss, and showed a new way to restore pasture health and productivity while reducing artificial inputs and irrigation levels. Further developed in the 1980s by Zimbabwean biologist Allan Savoury, the concept of 'Time Controlled Grazing', involves stock being moved through a number of paddocks at high stock density, based on the growth rate of the pasture and its consequent time required for regeneration.²⁵ Large groups of stock graze from 1-14 days in a comparatively small paddock, before the paddock is then left to rest and recover for 30-100 days.²⁶ The short duration and high density grazing forces livestock to eat whatever grasses and vegetation that is available, and not just those species the livestock prefer, leading to more soil biota activity, improved soil structure and hydraulic properties and increased and more active root systems of plants. Key principles in time-controlled grazing include: (1) adjustment of rest/graze periods in relation to plant growth rates, (2) matching stocking rate to carrying capacity, (3) planning, monitoring, managing livestock movement, (4) short grazing periods, (5) high stock density for minimum time, and (6) use of biodiversity to improve ecological health.

The work of Voisin and Savory was developed at a time when 'Set Stocking', also known as continuous grazing, was the norm. This method involved livestock browsing on a paddock for an extended period of time, typically months. Set Stocking allowed the animals to graze selectively on preferred species.²⁷ Over many months in the same paddock livestock's continuous grazing tends to reduce vegetation and grass height of their preferred species to lower and lower levels because their grazing does not give the plants time to regrow and recover. As grasses and plants lose their height they also have less surface area to undertake photosynthesis and thus less capacity to grow large root systems or rapidly regrow. This is not the only problem. In nature, grasses and plants have co-evolved with livestock grazing them. Thus, when grazed, plants and grasses are naturally stimulated to re-grow fresh stems and leaves. If plants or grasses are not grazed every few months, they are said to become 'rank' and 'tired'.²⁸ The combination of these negative processes tends to reduce the resilience of plant and grass cover, never giving them time to re-grow to maximise leaf or grass surface area. Without a maximum surface area of leaves to maximise photosynthesis the plant or grasses growing capacity is reduced, thus reducing the rate at which it can regrow when grazed by cattle and livestock. Finally, another problem with the 'Set Stocking' system is that livestock tend to form 'camps' where they rest and these areas become bare, due to frequent trampling, leading to

²⁴ Voisin, A. (1959) *Grass productivity*. Island Press: Washington DC. Reprinted 1988 Voisin, A. (1960) *Better Grassland Sward: Ecology, Botany and Management*. Crosby Lockwood&Son Ltd.

²⁵ Cook, G. (1994) 'A Simple explanation of Time Control Grazing', Proceedings of the 9th Annual Conference of the Grassland Society, NSW Department of Agriculture, 13-14th July, pp113-114.

²⁶ Hacker, R. (1993) 'A brief evaluation of time control grazing', Proceedings 8th Annual Conference for Grassland Society NSW, pp82-89.

²⁷ Allan, C. (1994) 'Grazing Management – The Animal Factor', in Garden D. & Michalk D. (eds) Proceedings 9th Annual Conference of Grassland Society NSW, July 13-14th, pp77-82.

²⁸ Ticehurst, J. (1996) 'Over Grazed but Under Stocked: A Comparison of Grazing Systems in the Southern Tablelands, New South Wales, Australia', Honours Thesis, Australian National University.

soil erosion and land degradation issues,²⁹ as once land degradation occurs on one part of the landscape over time it tends to spread.

Voisin and Alan Savory realised that the 'Set Stocking' system was the opposite of what has been happening in nature for millions of years, where plants, grasses and landscape have co-evolved with roaming herds of livestock. In nature herds of closely packed livestock roamed the landscape to minimise risk of attack from predators. The herd ate, trampled, urinated and left their dung and moved on rapidly to avoid being easy targets of attack.³⁰ Hence, Time Controlled Grazing returns the grazing period and rest period back to something that more closely mimics what has occurred in nature for millions of years. The short duration and high density grazing forces livestock to eat whatever grasses and vegetation that is available, and not just those species the livestock prefers. This stops overgrazing of preferred species and non-preferred species going 'rank' and unpalatable. The short duration that stock spend in each paddock prevents them from forming habitual camps and wearing out the plants as occurs in 'Set Stocking', stopping bare areas forming which can be easily erodible. The regular movement of the herd densely together also ensures parts of plants and grasses are 'mulched' – pushed back into the soil – by the action of the hooves of cattle, and the livestock's manure is more evenly spread out across the landscape reducing the need for artificial fertiliser. Voisin and Allan Savory also recommend a return to natural native grasses and perennial plants as these tend to have greater resilience and co-evolved to thrive with only natural levels of rainfall.

Such methods have now been applied to 30 million hectares of grazing land globally with remarkable results, including an increased capacity to capture carbon in the soil. The IPCC 4th assessment wrote that 89 per cent of the mitigation potential for the agriculture sector arises because of the potential to increase soil carbon storage. As grazing pastures comprise 69 per cent of agricultural land globally,³¹ there is significant potential to enable greater levels of carbon to be stored in the plants and soil.

Case Study: Gundry Farm, Southern NSW

Many farms now in Australia apply time controlled grazing methods, demonstrating how the shift to native perennial grasses and plants enables grazing livestock farmers to survive without irrigating. For example, George Gundry's family and his ancestors had been running a merino sheep farm for more than a century, but were about to get out of the industry in 1995. The incurable Ovine Johnes Disease (OJD) was killing their sheep, and their soil and pastures had not recovered productivity since the 1980-1983 drought despite their best efforts with fertilisers and other inputs. However, just over a decade after implementing 'Time Controlled Grazing' they are now running one of the most successful farms grazing cattle and sheep in the southern tablelands of New South Wales, Australia. The farm uses no water for irrigation or any chemical fertilisers on its grazing land, yet the property is covered in a tapestry of native grasses and plants that often come up to waist-height as shown in Figure 2.3.2, while neighbouring farm's pastures are brown and relatively bare. The rich tapestry of native plants and grasses holds the water in the soil when it rains and there is no surface erosion. The minimal amount of bore water pumped is for drinking water troughs for the cattle. Reducing inputs and their associated costs (i.e. for fertilisers, water and fodder) as well as maintenance costs

²⁹ Ticehurst, J. (1996) 'Over Grazed but Under Stocked: A Comparison of Grazing Systems in the Southern Tablelands, New South Wales, Australia', Honours Thesis, Australian National University.

³⁰ Hacker, R. (1993) 'A brief evaluation of time control grazing', Proceedings 8th Annual Conference for Grassland Society, NSW, pp82-89.

³¹ FAO and IFAD (2006) 'Water for Food, Agriculture and Sustainable Livelihoods' in United Nations (2006) *The 2nd UN World Water Development Report*, United Nations World Water Assessment Programme.

(e.g. repair to fences) the farm has lifted productivity by 30 per cent, now supplying fodder to neighbours.³²



Figure 2.3.2 Time Controlled Grazing on the Grundy Farm, showing a diverse and healthy ground cover

Source: Courtesy of Michael Smith, taken on a site visit to the Grundy farm, 24 August 2008.

Time Control Grazing does include initial capital costs including additional fencing, labour and water trough or micro-dam provision. For example, the Gundry's farm transitioned from 14 large paddocks to 142 smaller paddocks to enable better control of what, when and where livestock were grazed. On the Gundry farm, this capital was raised by selling off all the machinery being used for traditional intensive pasture improvement.

Crops - Reducing Waste of Freshwater while Increasing Yields

In the area of improved agricultural methods there are still significant gains to be made in increasing the efficiency of delivering and applying water to crops, and in increasing crop yields per litre of water consumed. The 2009 book, '*Factor Five*', developed by The Natural Edge Project working with Ernst von Weizsäcker, showed how taking a whole system approach can potentially result in five-fold reductions, 80 per cent, in freshwater extraction while also improving crop yields, using a combination of the following five strategies:³³

1. *Appropriate Selection of Crop Species*: Selecting crops and variants of crops that are well suited to the intended bio-physical and climatic conditions can deliver in the order of 50 per cent water saving. We also consider the appropriate selection of livestock species as an extension of this strategy.
2. *Efficient Irrigation Technologies*: As *Factor Four* showed in 1997, water efficiency savings through sub-surface drip irrigation can be significant. It can also be made more affordable, especially for poorer agricultural regions in the under-developed and developing world.
3. *Irrigation Scheduling*: Using irrigation scheduling information that helps farmers more precisely meet crop water needs has been shown to reduce water usage by 17 per cent, and increase crop yields by as much as 8 per cent.

³² David Dumaresq, ANU Senior Lecturer – Sustainable Agriculture (2009) private communication.

³³ von Weizsäcker, E., Hargroves, K., Smith, M., Desha, C. and Stasinopoulos, P. (2009) *Factor 5: Transforming the Global Economy through 80% Increase in Resource Productivity*, Earthscan, London. , p185.

4. *Advanced Irrigation Management:* Applying a range of emerging advanced irrigation management methods, such as regulated deficit irrigation, can deliver in the order of 30-50 per cent water savings.
5. *Rainwater Harvesting:* Using a range of techniques including micro dams, channels, and stream diversion, to divert rainfall over the flood plain ensures rainfall flows through the floodplain before it flows into rivers or out to sea, facilitating infiltration into the water tables and crop irrigation on the plains.
6. *Treating and Re-using Urban Wastewater for Peri-Urban Agriculture:* Using treated and recycled water from cities as a source of irrigation water can deliver over a 50 per cent reductions in water extraction levels from natural sources.”

The following paragraphs provide case studies of water savings in practice for the first two strategies. The first is an example of highly efficient flood irrigation, while the second case study considers sub-surface efficient irrigation technologies and irrigation scheduling.

Case Study: Rice Farming and Efficient Flood Irrigation

Selecting crops and variants of crops that are well suited to the intended bio-physical and climatic conditions can deliver in the order of 50 per cent water savings. A common perception is that rice is a tropical crop, but Japonica rice for example is perfectly suited to the dry temperate climate of Australia, California, Egypt, China and Japan, and can be grown using relatively little water. Australian rice growers use rice varieties evolved to grow in temperate climates that use over 50 per cent less water to grow one kilo of rice than the world average and are recognised worldwide for growing high quality ‘temperate climate’ rice. Farmers are also using crop rotation to enable them to achieve large annual savings in the amount of water needed overall to farm over the year. Located in the in the dry flat land of the Murrumbidgee flood plain in New South Wales, farmer Ian Bight has shown that it is possible to grow up to 20 tons per hectare of both rice and wheat (12 tons of rice and 8 tons of wheat) with 20 ML of water per year (including rainwater). Compared with the average requirement of 10 ML per hectare to produce 4.5 tons per year, this achievement means that the Murrumbidgee farm not only grows approximately the same amount of wheat per ML of water, it also produces a further 12 tons of rice..

The Bight farm grows wheat as a winter crop in rotation with a summer ‘temperate Japonica’ rice crop, where the wheat uses the existing soil moisture from the harvested rice crops.³⁴ In October, 500 hectares are prepared for rice planting by first flushing with water, with the farming land oriented to use the natural slope to ensure that the water flows evenly down to wet the soil. A series of bays are arranged so that as the water level goes up within a bay, it provides enough pressure to open the gate and allow water to flow into the next bay, avoiding over-irrigation and minimising water overflow at the tailgate (the lowest part of the farm). Excess water is also pumped from the lowest part of the farm up to the headwater races where it can again be pumped into the upper bays. Once the rice crop is harvested, a wheat crop is then planted, or corn if it is likely to give better returns in a particular year. The farm sources water for the flood irrigation from a groundwater bore, helping to lower the water table and avoid potential rising salinity issues. However, this does require energy and the farm is investing in biogas renewable energy production with the intent to invest in a large solar thermal system in future to power the pumping and also return electricity to the grid.

³⁴ Australian Rice Growers Association (undated) ‘FactSheet: Rice and Water’, www.abourice.com/downloads/rice_water.pdf, accessed 2 August 2009.

Case Study: Sub-Surface Irrigation Technologies and Irrigation Scheduling

Significant potential exists to improve water productivity in agricultural cropping systems because in many countries more than 80 per cent of irrigated land surface receives water by flooding or through open channels. At the present time, most farming irrigation still occurs without the channels being sealed, leading to significant water loss from evaporation or leakage or seepage into the soils. Thus changing to sprinkler and sub-surface drip irrigation would have a dramatic improvement on agricultural water demand.³⁵ The Australian Bureau of Statistics shows that water diverted for irrigation from rivers and groundwater resources is approximately 16,660 GL per year, and significant water losses occur throughout the system of distribution and farm usage equalling roughly 5,000 GL/yr. In Australia, water for irrigation goes through a channel and drainage system that varies from region to region. The different irrigation systems currently used are: surface irrigation (83 per cent of irrigated land); sprinkler systems (10 per cent of irrigated land); and micro (7 per cent of irrigated land).

Sub-surface drip irrigation can greatly improve agricultural water productivity by as much as 50-80 per cent, as drip lines are buried underground and release small amounts of water into the plant root zone.³⁶ In addition, effective scheduling of such systems, has been shown to further reduce water usage by 17 per cent, and increase crop yields by as much as 8 per cent.³⁷ Sub-surface drip irrigation also possesses the following advantages:³⁸

- It is adaptable to fields with uneven topography or shape, and not prone to subsequent effects of excessive infiltration, water puddling and runoff.
- It is extremely efficient, with precise water application without plant saturation (preventing over-watering) and subsequent runoff. Surface evaporation is also reduced due to drip lines feeding water underground.
- It allows deprivation irrigation to be undertaken through installing a second watering line per line of crop, this allows alternate sides to be watered and effectively managed can reduce the plants water consumption without effecting yield.
- It facilitates the precise application of nutrients, leading to a reduced requirement and hence costs associated with fertiliser use.
- It assists tractor operations and movement flexibility on the farm.
- It facilitates automation and centralised monitoring of the farm's irrigation system.

Hence there is significant potential to achieve substantial reductions in water demand through the uptake of such methods and technologies. This not only reduces the burden on water supplies but also allows greater environmental flows in river systems. The Australian and New South Wales governments, with Visy Industries Chairman Richard Pratt AC, jointly funded a study of the potential for improved water efficiency study of the Murrumbidgee through investing in closed pipes and drip irrigation. Led by CSIRO, the report '*The Business of Saving Water - the Report of the Murrumbidgee Valley Water Efficiency Project*' showed that 295 GL could be saved from the Murrumbidgee and Coleambally Irrigation Areas while maintaining the current area of crops through

³⁵ Hawken, P., Lovins, A.B. and Lovins, L.H. (1999) *Natural Capitalism*, Earthscan, London, Chapter 11: Aqueous Solutions.

³⁶ Brown, L. (2008) *Plan B 3.0: Mobilizing to Save Civilization*, The Earth Policy Institute

³⁷ Cooley, H. et al (2008) More with Less: Agricultural Water Conservation and Efficiency in California - A Special Focus on the Delta, The Pacific Institute, www.pacinst.org/reports/more_with_less_delta/more_with_less.pdf, accessed 21 February 2009

³⁸ Shock, C.C. (2006) 'Drip Irrigation: An Introduction', Malheur Experiment Station, Oregon State University, www.cropinfo.net/drip.htm, accessed 21 June 2009.

investing in water efficient irrigation.³⁹ This report suggests that a significant proportion of the water can be saved and could be returned to rivers to help restore environmental flows. This is important as it now opens a way for the restoration of environmental flows, river habitat and ecology, to help natural ecosystems adapt and cope with climate change. The Australian government is now supporting a range of associated initiatives in the Australian agricultural sector as well as river restoration programs like the Living Murray program, which is a significant example of what is possible.⁴⁰ The following case studies highlight the potential to improve the effectiveness of irrigation and prevent excessive water loss from evaporation in channels.

Table 2.3.2 *Examples of Water Savings through Water Efficient Irrigation*

Case Study	Water Savings Achieved Through Innovations In Irrigation
MJ Hall and Son's Stone Fruit Company, Shepparton, Victoria	MJ Hall and Son's Stone Fruit Company in Shepparton Victoria has reduced water usage and costs by 30 per cent by installing new mini-jet irrigation systems on all their six farms. Peter Hall, the owner says, <i>'Large orchards require complex control systems. We couldn't find one we wanted, so worked with a supplier to develop the mini-jet sprinkler system and computer controls that produce accurate applications of water.'</i>
Peter and Jacque Schulz, Salmon Gum Estates, Loxton, South Australia	Peter and Jacque Schulz have halved their water use and doubled their tonnage. They achieved this by using a number of innovations such as changing from overhead sprinklers to a drip irrigation system, and using moisture probes and computer monitoring to refine and optimise the system. Peter now orders his water on an as-needed basis. <i>'One of the most water efficient things about this system is that it has eliminated the use of channels and overflows'</i> Peter said. <i>'Using the drip system and the moisture probes... we have almost halved our water use.'</i>
Dean Morris & Wayne Protheroe, Citrus Farm, Leeton, NSW	Developed by Spanish plant physiologist Professor Rafael Martinez Valeor PhD, the Martinez Open Hydroponics Technology (MOHT) system has enabled an Australian orchard in Leeton, NSW to halve water usage while increasing yield and productivity for neighbours. Before installing MOHT, they were using between 9.5 and 10 ML of water per hectare of orchard every year with the flood irrigation system, and producing between 25 and 30 tons of fruit per hectare. Now, the same trees are using 4.5 mega-litres of water per hectare, and producing between 38 and 55 tons of fruit per hectare depending on tree age.

Source: Department of Agriculture, Fisheries and Forestry (2004 and 2005)⁴¹

In summary, combining appropriate crop selection, with advanced forms of irrigation can achieve large reductions in the amount of freshwater extraction from rivers and groundwater needed for irrigation in the agricultural sector. Rainwater harvesting and reusing grey and treated blackwater from cities in peri-urban agriculture are yet other ways to achieve further improvements, as discussed in lectures in Module 3.

³⁹ Pratt Water Murrumbidgee Project (2004) *The Business of Saving Water - the Report of the Murrumbidgee Valley Water Efficiency Project*, Pratt Water, Victoria, Australia.

⁴⁰ The Living Murray (undated) website, www.thelivingmurray.mdbc.gov.au/implementing/water_recovery, accessed 5 August 2009.

⁴¹ Department of Agriculture, Fisheries and Forestry (2005) *Innovation in Irrigation 6 case studies from across Australia*, Department of Agriculture, Fisheries and Forestry; Department of Agriculture, Fisheries and Forestry (2004) *Innovation in Irrigation 12 case studies from across Australia*, Department of Agriculture, Fisheries and Forestry.

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