The Drive for Water Use Efficiency

A report for NUFFIELD AUSTRALIA FARMING SCHOLARS

by Jarrod Ryan

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Foreword

When I applied for, and was awarded, my Nuffield Scholarship I was managing a property situated in the Douglas Daly Region of the Northern Territory. Located approximately 200km south west of Darwin the property was chosen as the site to trial the production of export quality hay for the Asian market (predominately Japan). Although the region is considered semi tropical and has an annual rainfall of approximately 1200mm, the project focussed on growing fodder under irrigation during the north's dry season (approximately May to October).

Whilst several species of fodder including sorghum, lucerne and oats were grown, the most successful, and those adopted for commercial production, were Rhodes Grass and Superdan. With the assistance of Balco Limited two export trials were conducted to Japan with positive results.

In November of 2007 the property was sold so that the family's southern business activities could be focussed on.

Tintinara is the site of an intensive dairy operation, employing 20 full time staff with a milking herd of 2000 cows and a replacement herd of approximately 600 heifers. The property has 450ha of centre pivot irrigation which is intensively managed to provide both grazing and cropping options throughout the year as well as 500ha of dry land sown to winter cereals every year. In conjunction to this approximately 75ha of lucerne and 150ha of corn is grown offsite and fed back through the dairy.

Located approximately 200km south east of Adelaide in South Australia the district is considered marginal cropping country with an annual rainfall of approximately 450mm and sand soils. Long dry summers mean that irrigated production is essential for the farms profitability.

Even though the properties were situated at opposite ends of the country and varied drastically in environmental conditions both were facing water supply uncertainties.

In the Northern Territory the government was struggling to put in place a sustainable water use framework. Due to successful lobbying by both the environmental sector and the powerful Amateur Fishing Association potential water use in the Northern Territory is restricted with a ban on drawing from any river or water course and allocation from aquifers not to exceed

20% of recharge. In the main irrigation district, centred on Katherine, this effectively meant that the Tindal Aquifer which services the region was already over allocated and in other districts development was suspended whilst the relevant government department wrestled with the problem.

In South Australia the operation faced a 20% cut in its water allocation due to a bureaucratic decision that if dry weather patterns prevailed and all of the aquifers allocation was drawn it could damage the aquifer.

These two experiences have convinced me that in the current environmental, social and political climate that the irrigation sector will experience further water reductions. Irrigators must ensure that they are utilising their allocations to maximise value whilst ensuring resource sustainability.

Cows at Tintinara

Acknowledgements

The list of people to thank is many and varied and the following is in no particular order of merit.

Firstly I would like to thank Nuffield Australia for selecting me to receive this scholarship and hence the opportunity to travel and study agriculture and its associated activities on a global stage. This opportunity has been an eye opening and life changing experience.

Special mention is to be made of Jim Geltch, Nuffield Australia and all of the various hosts and contacts that contributed to the Global Focus Program.

Thank you also to my sponsor NT Government Department Of Primary Industries, Fisheries, Forestry And Mines (DPIFFM) for without their continuing support this scholarship would not be possible.

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To the numerous contacts and hosts that gave up their own time and expertise I thank you immensely for your information, hospitality and generosity.

Thank you to my father and mother, Peter & Helen, for having the faith in me to get the job done.

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Executive Summary

Today our ability, as a nation and as individuals, to utilise effectively the collective water resources on hand is one of the most important factors in ensuring the survival and ongoing prosperity of our nation. As nationally, and internationally, public concerns escalate over the longevity and sustainability of water resources the debate rages as to the best use of those water resources (be that agriculture, environment, industry or human consumption). As the debate gathers momentum the effects are already being felt across Australia as users of all descriptions find themselves facing life with a reduction in water availability.

Australian Irrigators need to act now to ensure that they are proactive in accepting and dealing with the changes that are inevitable to occur in the industry. In order to survive irrigators must ensure that they are managing their water resources in a manner that not only maximises crop yields, but also justifies the value of water used as well as ensuring the sustainability of the resource.

Due to localised environmental, social, political and economic conditions influencing not only the practical side of water use efficiency but also perceptions of efficiency, a common definition of efficiency is needed. This common definition will allow not only for bench marking of production systems in differing regions but also allow for benchmarking of radically different systems and also of differing users (industrial or agricultural).

As Australia's social conscience grows, increasingly, irrigated agriculture will be scrutinised as to not only its practices but also its relevance. As such, irrigators must ensure that they are operating the most efficient system in relation to their own environmental and economic conditions.

A simple annual examination of current irrigation practices versus the basics tenets of irrigation methodology are the first step to ensuring efficiency. These being:

- Soil Water Holding Capacity
- Crop Selection
- System Capacity

A firm grasp of these basics, and a regular review process, will not only yield immediate efficiency and profitability gains but will also ensure that irrigators are in the right position to take up any new technology as it develops.

Overarching these basic fundamentals the Federal Government needs to ensure a cohesive national approach to water reform is maintained.

Introduction

Irrigated agriculture in Australia is a major contributor to GDP (this figure was approximately $9 billion in 2004-05[1]) as well as providing significant employment in rural communities.

However, even with these positives the irrigation industry will bear increasing scrutiny as the largest single sector user of water in Australia – agriculture as a whole, irrigated or not, accounted for 65% of the nation's water consumption in 2004 – 05[2].

As continuing dry weather patterns prevail and pressure increases to service growing urban water demand (in part being driven by Federal Government population goals of 35 million people by 2050) the scrutiny of the irrigation industry will be intensified as the nation searches for the best way to make use of its limited water resource. The construction of the Goulburn Valley to Melbourne pipeline which will divert water to supply Melbourne's increasing demand is a relevant example of this competition.

Changes to the irrigation industry are underway as many irrigators already face substantial cuts to their allocations and many more will eventually face the same, as the Federal government moves towards its goal of a 20% reduction in irrigation allocations nationally. These allocation reductions coupled with continuing dry weather patterns have served to kick start the drive for efficiency as many operators search for a way of not only maintaining profitability but of also viability and relevance in the face of increasing competition for water resources.

Irrigated agriculture in Australia must find ways to operate that enable it to compete and contend with

- growing urban populations and hence demands
- the increasingly popular movement to allocate more water for the environment
- economic drives that promote that water must flow to the highest bidder
- increasing imports of produce from other countries with lower input costs and better production environments

Irrigators in Australia must improve their efficiency in order to survive in this political, economical and environmental climate. No longer can irrigators believe that common sense will prevail once weather patterns change, as is evident by the recent decision by the NSW government to release floodwaters for the Lower Lakes in South Australia but not to save millions of dollars in vines and fruit trees as well as the associated jobs, businesses and rural communities.

[1] Australian Bureau of Statistics – Characteristic's of Australia's Irrigated Farms 2000-01 to 2003-04.
[2] Australian Bureau of Statistics – Water Account, Australia, 2004-05.

The Basics

Irrigation water in Australia, as elsewhere in the world, is derived from a number of sources based upon regional characteristics. There are two distinct classifications of water sources for irrigation – these being surface or ground water, as well as the increasing use of recycled waste water.

Surface water refers to the following:

- Dams (public or private) and reservoirs
- Rivers and creeks

Ground water refers to:

- Underground aquifers (both confined and unconfined)

Historically Australia's irrigation sources have been predominately derived from surface water from river systems, such as the Murray Darling, and dams. However as this source has diminished there has been an increasing use of our ground water systems to fulfil demand.

In some regions irrigation water is derived from both sources and in others only one source of irrigation water is available, such as the Douglas Daly in the Northern Territory (limited by legislation rather than lack of river systems to draw upon).

In many cases the source of water and the point at which it is irrigated are separated by large distances. Take for example the distance that water flows down the Murray River to South Australia and its source in the catchment area of the Murray Darling Basin.

Water in surface based systems flows through a series of channels, which are either natural or manmade, from its source and is siphoned off along its course to feed irrigation needs. In Australia these systems are antiquated and as such are a massive source of water loss. Government investment into structural upgrades of these systems can lead to huge gains in terms of water available (both for agriculture and other uses).

Methods of Irrigation

There are a number of different irrigation systems in use dependant on crop type and local geology and topography, each with its own advantages and disadvantages.

Irrigation systems can either be unpressurised (such as flood or furrow irrigation) or pressurised (such as centre pivot or drip systems).

Unpressurised systems have the advantage of lower installation and maintenance costs than pressurised systems but suffer from large evaporation losses and lack of flexibility in watering regimes. However, irrigation systems are developed dependant on local conditions and available water sources and as such even in developed nations such as the United States flood irrigation is still a highly preferred irrigation method, due to low delivery and other associated production costs.

Pressurised systems such as centre pivots or sub surface drip have seen great advancements in water use efficiency as they enable irrigators' precise control over the amount and timing of irrigation, as well as the option to add fertilizer and other chemicals for delivery through the same system. Whilst pressurised systems such as centre pivot used to suffer from evaporation losses and drift, advances like drop tubes and sub surface drip lines have overcome many of these problems. However, pressurised systems are relatively expensive to install and maintain and in some locations water quality may negate their use.

Overseas Observations

California

There is approximately 4.5 million hectares of irrigated agricultural land in California producing a wide range of crops including such things as corn, lucerne, wheat, cotton, nuts and a diverse range of vegetables. The predominant form of irrigation used at the time of study was flood, due to existing infrastructure, but in some areas centre pivot and sub surface drip systems were beginning to be used.

The water is sourced predominately from snow melt, in both the north and east of the state, and collected and transported to production areas via an extensive system of well constructed aqueducts and reservoirs built during the 1960's. Water is allocated on the basis of land ownership and history of usage (first in time first in line). Allocations are also supplemented from time to time via extraction from bores. However, due to the depth of the water (the majority of bores seem to range in depth from 200 – 400+ metres) the cost made the exercise prohibitive as well as the water quality being inferior to that obtained through snow melt. At present there was no restriction on ground water extraction.

In some districts, where allocations have been reduced due to external factors, the use of reclaimed waste water is being trialled with good results. South Bay Water Recycling distributes approximately 57,000,000L of treated waste water each summer to customers in San Jose, Milpitas and Santa Clara. The sewage water is initially captured at the San Jose/Santa Clara Water Pollution Control Plant and then undergoes primary and tertiary treatment before being sold back to users. Presently this “black water” is being put to a diverse range of uses such as irrigating crops, playgrounds, parks, cemeteries and golf courses.

Whilst historically snow melt has provided a secure and good quality water source, producers are now facing restrictions to their allocations due to a number of factors not related to snow fall.

Like Australia, California has a fast growing urban population that requires large daily quantities of fresh water and as such some producers were facing allocation reductions in order to service urban demand. However, unlike Australia, due to the historical precedent of first in time first in line these reductions are being challenged legally at a Federal level in an attempt to either restore them or gain appropriate ongoing compensation for loss of production.

Californian Aqueduct San Joaquin Valley

Californian irrigators are also starting to feel the bite of environmental lobbies to such an extent that in 2008 the irrigators in the southern water districts only had access to 35% of their entitled allocations due to the presence of a small fish, the Delta Smelt, spawning in close proximity to a major pumping station. As the Delta Smelt had been listed as a threatened species by the US Fish & Wildlife Service in 1992 the pumping station was unable to operate for large periods of time for fear of disturbing spawning and reducing fish numbers further.

So whilst Californian irrigated producers enjoy large quantities of cheap good quality water, excellent growing conditions, inexpensive labour and extensive domestic markets (California alone has the seventh largest GDP in the world) like their counterparts here in Australia they are feeling the pressure of urbanisation and a growing social conscience which is being driven in part by a rising standard of living.

Oregon – Three Mile Canyon Farms

Located approximately 200km North East of Portland and in close proximity to the Columbia River, Three Mile Canyon Farms operates state of the art technology to maximise production from the approximate 20,000ha (246 individual circles) of centre pivot irrigation on site. Crops grown range from corn and lucerne (which goes to feed the 30,000 head of dairy cows also located on the property at three sites), wheat, potatoes, soy beans, onions, tomatoes as well as a selection of organic vegetables (at time of visit 2000ha of organic vegetables were being planted to test the waters).

Use of a 160 square kilometre wireless network allows for second by second monitoring of the entire system from river extraction to irrigation event. Water pressure monitors detect leaks immediately and water application can be controlled remotely at each individual sprinkler head to allow for changes in soil or other conditions on each individual circle.

Irrigation schedules for all crops are set a week in advance and programmed into the system which then turns on the appropriate pivot and waters as per program. If there is a fault or problem the system sends SMS messages to the relevant person/s depending on the nature of the problem and or the severity. As a failsafe to these measures the system control room is monitored 24hrs a day and a number of irrigation crews are maintained in readiness to correct leaks or blockages. Irrigation events, even though programmed in advance, are reviewed in relation to daily environmental conditions (through the use of soil monitoring equipment, physical monitoring weather information) and adjusted as necessary.

In addition to this all of the waste water from the three dairy sites was captured, treated and had solids removed so that it could be reused for irrigation purposes. For this operation the treated water not only enabled additional cropping but also provided a ready source of “organic” fertilizer for the organic crops. Begun in 1999 the system has to date cost approximately $US185 million with planned upgrades including the addition of GPS to all irrigators as well as some mainline upgrades.

Colorado

Colorado derives its irrigation water from snow melt feeding the Arkansas, Rio Grande and the South Platte as well as from aquifers. Irrigation methods are an equal mix of flood and centre pivot irrigation, although there seemed to be a growing conversion to centre pivot in response to decreasing allocations. Like Australia irrigators in Colorado have been battling with drought conditions, declining aquifer levels and increasing competition from urban and industrial users.

Forecasts have Colorado’s population increasing by 65% (approximately 2 million people) by 2020. Due to Colorado’s water law (which is also based on the precedent of first in time first in line) municipalities in Colorado need to purchase water allocations from existing users. As such it is estimated that as much as 200,000 ha of irrigated land may be lost as water is sold for urban use.

As well as competition between urban and agriculture users the state of Colorado faces competition for the water flowing through it as the neighbouring states on Kansas and Arkansas also rely heavily on the water flowing in the Arkansas, Rio Grande and South Platte Rivers. As such Colorado is involved in several Federal Court actions taken out by neighbouring states in attempts to gain access to more water.

Brazil – Mato Grosso do Sul

Irrigated agriculture in Brazil only accounts for approximately 3 million hectares out of 60 million cropped annually. Mostly irrigation occurs via centre pivot and is predominately used to supplement rainfall, as Brazil’s rainfall ranges from 1500mm up to 5000mm.

Brazil’s major crops include sugar cane, corn, soy, beans, rice and cotton, although a myriad of other crops are grown depending on location. During the Global Focus Tour the region of Mato Grosso do Sul was visited. It is similar to in latitude to Darwin with similar growing conditions except for the fact that rainfall is spread evenly throughout the year. Crops grown in this region included the entire above mentioned plus tomatoes and citrus fruit. Producers enjoyed the ability to triple crop with corn, soy and tomatoes being produced in a single year.

Centre pivot irrigation was used to supplementary water tomato crops during the middle of the year when rainfall was at its lowest. Water was supplied to the pivots from dams built on farm to capture run off. Due to high levels of rainfall and the relatively small scale of irrigation taking place there were no regulations in place to deal with construction of on farm dams.

Irrigated tomatoes seedlings Brazil

South Africa – Western Cape

The Western Cape has a diverse climate and soil types that allow many diverse products to be grown such as wheat, sunflower, soy, wine grapes, sorghum, corn, apples, pears and a variety of stone fruits. The dominant form of irrigation is sub surface drip as the largest crops irrigated are fruits and vegetables which lend themselves well to this method. Most of the water is sourced via aquifer although the construction of on farm dams is common to collect winter rain. Unlike Australia there are little restrictions on the use of either ground water or surface water.

A method of irrigation that is gaining favour in the Cape, especially amongst horticulturalists, is the concept of Martinez Open Hydroponics Technique (MOHT). Raphael Martinez is a Spanish researcher who pioneered the concept in citrus orchards. Basically MOHT seeks to minimize interference from the soil by optimising the utilization of water and nutrients in order to maximise yield and improve fruit quality. Using premixed nutritional solutions applied directly, and frequently, to the crop during daylight hours MOHT systems appear to be very water efficient and allow for a high degree of control over the crop.

MOHT = Drip Irrigation + Electro-chemically balanced nutritional solution + Tree Management + Crop Control + pH & EC control + Low frequent application rates

Most irrigators using MOHT recorded increase yields as well as stating they gained more control over size, colour, juiciness, nutritional value and shelf life. The MOHT technique was being use predominately by horticulturalists where the high start up costs could be offset by the relatively long life span of crops (citrus, grapes etc) or where the produce commanded a high enough seasonal price to warrant the investment (such as strawberries and berries).

MOHT systems have high initial start up costs as they require complex equipment in order to mix and administer nutrient programs, they must be designed to be able to meet peak crop demand during the hottest part of the day (taking into consideration evapotranspiration).

MOHT produced oranges in the Western Cape

MOHT systems require a high level of attention to detail and farm management as daily monitoring is necessary to ensure that changes to climatic and environmental conditions are observed and adjustment to irrigation scheduling are made. Also due to the shallow root systems created by frequent irrigation, crops become highly reliant on irrigation. As such in order to guarantee irrigation it is recommended that MOHT systems be installed with backup generators and pumps.

MOHT is currently being practiced in some regions of Australia. To date it is limited to high value horticultural crops, where the high water efficiency of the system plus the ability to influence fruiting patterns and quality is attracting the attention of producers.

Defining Water Use Efficiency

The first issue I encountered, even before I set off on my travels, was the lack of an ultimate definition of water use efficiency (WUE). Due to the public interest in the area there are a host of definitions being used. However each definition I encountered appears to be influenced entirely by the political, economic, environmental and social situation immediately impacting that locale with little allowance given for the bigger picture.

A common definition of water use efficiency is necessary in order to give a common direction to the process of water reform, whilst also allowing irrigators in different regions the ability to benchmark production systems.

As a result of the competing and often contradictory definitions of water use efficiency there is a wide range of measures being used, so as to encompass all the key factors involved and allow for a measure of efficiency.

Some useful definitions that go some of the way to defining irrigation efficiency are as follows.

<u>Tonnes per hectare</u> – is the most traditional indicator of performance. However, due to all of the factors that must be accounted for in defining efficiency it can often be misleading.

<u>Tonnes per mega litre</u> – or tonnes produced per mega litre of irrigation water used

<u>Cost of Water per tonne of production</u> – must take into account the cost of infrastructure

Return per dollar water input – directly compares the cost of water with the returns from that water

Irrigation Efficiency – measures the percentage of water actually used by the plant for evapotranspiration

Yield per volume of Drainage – takes into account that some drainage is necessary

Cost of Drainage per tonne of Production – measures the cost to purchase and apply water lost to drainage per tonne of produce

In today's environmental, political and social climate increasingly the measure for efficiency will be driven by Government economists and the urban lobby – and the dominant measure will be net value of production and not tonnes of production.

Managing the Basics: The Key to Efficient Irrigation

Before starting this study it was my opinion that the key to increasing efficiency in irrigation lay with new water smart technology. Whilst it cannot be doubted that great inroads have been made via technological advancement it is now my belief (and practice) that efficiency, and profitability, can be improved immediately by renewing ourselves with the basic principles of irrigation and adapting our irrigation practices and management accordingly. In our drive for efficiency it is easy to lose sight of the basic principles and as such no amount of technology will deliver the results that are required.

The key areas to be reviewed include:

Soil Type – essential for understanding water retention capabilities and plant ability to access that water

System Capability – does the system have the ability to meet crop requirements?

Crop Selection & Requirements – What crop and how much water will that crop need as it moves through the growth cycle?

Soil Type

An integral part of being able to plan irrigation adequately and efficiently lies in understanding differing soil type’s potential to absorb and hold water. This potential varies widely depending on what the soil is made of and therefore what the texture of the soil is.

The texture of soil is important as it is the defining factor in water:

- Movement
- Retention
- Availability (water + nutrient available at any time to the plant)

Clay soil has good water holding ability but can be restrictive of uptake of nutrients, whilst sandy soils allow good access to nutrients but has less capacity to hold water.

The type of soil present impacts on the amount of Readily Available Water (RAW) that the crop can draw on. RAW is the moisture present in the soil between saturation and refill points. RAW directly influences growth and crop quality therefore it is invaluable in determining optimum irrigation.

RAW is calculated using the following equation.

RAW = Plant root depth x RAW value for the soil type present

Soil Type	Raw mm/m			
	A -8 to -20kPa	B -8 to -40kPa	C -8 to -60kPa	D -8 to -100kPa
Sand	35	35	35	40
Sandy Loam	45	60	65	70
Loam	50	70	85	90
Clay Loam	30	55	65	80
Light Clay	25	45	55	70
Medium – Heavy Clay	24	45	55	65

Column A – water sensitive crops like vegetables Column C – wine grapes, perennial pasture and irrigated field crops
Column B – most fruit crops and table grapes Column D – lucerne, annual pasture and winter cereals

Table 1 - RAW Values (Source NSW Agriculture)

For example a perennial rye grass pasture on a sandy soil has the following equation

RAW = 40 – 50cm root depth

Times by pasture RAW value of sandy soil (35mm/m)

= 0.45 x 36

=15.75 mm of RAW available to the plant

This RAW value of 15.75mm can then be used in conjunction with evaporation rates to schedule irrigation events that maximise growth (by avoiding saturation) and minimise stress (by under watering). The ability to match crop needs with soil capacity translates to an increase in efficiency and financial savings as over and under watering can be eliminated and hence eliminate the costs associated with these practices.

System Capacity

Coupled with a sound understanding of soil water capacity is the need to ensure that the basic design of irrigation systems meets crop peak water demands whilst avoiding excessive loss to deep drainage (deep drainage refers to water that passes through the crop root zone and is therefore unavailable for use).

Whilst this sounds simple in theory it is often the case that systems are not performing to specification (this can be due to age, changed conditions or a variety of other factors) and as such irrigation events are taking place that either leads to over watering or under watering, both of which have impact on production and cost.

Whether designing a new system or evaluating existing infrastructure the system must meet the following criteria

- Meet evaporation rates
- Optimise water delivery
- Meet production requirements
- Optimise soil water levels at all times

If these four conditions are met then immediate water savings can be achieved and as such result in efficiency gains, not to mention the corresponding savings in reduced pumping costs, fertilizer etc.

Systems should be reviewed annually to ensure that they are delivering to expectation and corrections made to fix problems as they arise.

Crop Selection & Requirements

The final area in which immediate gains can be made is in the arena of crop selection. Whilst this sounds straight forward the reality is often not the case. Changing water quality and declining quantities mean that crops that have been successful and profitable in the past may no longer be profitable under existing conditions.

The ability to irrigate has given us the opportunity to extend cropping seasons and develop areas that were not historically considered suitable for cropping (whether due to low rain fall or some other environmental or economical factor). It has also given us the false impression that if we just add water it cannot fail. As we well know this is not the case. Systems that work in one area are not always directly transplantable into another region that has water. Local geology and climatic conditions also impact on crop viability and profitability as much as the need for water.

Irrigators need to be open to prospect that they may need to identify new crops when they face cut backs in their allocations or as water quality deteriorates. In the end all choice of crop must ultimately be economically viable.

On Farm Learning

Before commencing this study we had already begun to question our own practices in some areas in relation to irrigation. We had fallen into the trap that we believed that if we just added water we could make anything grow and for several seasons we had been trying to grow annual rye grass (rye pasture makes up a large percentage of the conventional dairy cows' diet) with little success. Due to water quality and soil structure (sand) we were not achieving targeted growth rates or stand persistence. This was costing on two fronts as feed that was not grown on site had to be bought in and due to lower quality feed (both bought in and grown) production suffered.

In order to correct this we rethought our feed strategy in terms of what we were able to grow on site and settled on a base of lucerne, which thrives in the free draining sand and is able to tolerate poorer quality water, over sown in winter to perennial rye grass and cereals. To date this rotation has been working well.

On returning from this study we decided to have all of our pivots tested to see if they were operating as we believed they were. An external irrigation firm tested all pivots for uniformity of distribution, pump capacity and depth control. It was found that most pivots (even the newest one installed less than a year prior) were not operating as per builders' specifications. All of the systems were adjusted to reflect specifications which gave us back a greater level of control and efficiency.

Summary

Defining water use efficiency is extremely challenging as environmental, economical, social and political circumstances affecting differing regions prevent a common definition of efficiency and as such the ability to benchmark methods against one another. For example due to reliable snow melt and solid infrastructure (coupled with high cost of ground water extraction) in California flood irrigation is considered the most efficient (based on cost and reliability). Whereas in the Upper South East of South Australia as allocations are being reduced due to environmental and political considerations there is a strong move from flood to centre pivot irrigation.

Water use efficiency is driven by localised geographic and demographic characteristics. As is evident not only in Australia but elsewhere in the world as rising standards of living produce not only more strain on water resources but have also led to the development of an urban social movement that promotes the belief that agriculture (and especially irrigated agriculture) is wasteful, unnecessary and damaging to the environment.

The irrigated agriculture industry in Australia needs to intensify lobbying efforts to ensure that its role in the wealth creation chain in Australia is recognised and as such its share in water allocation is fair and equitable and seen as valuable.

Increasingly there will be a strong move to measure water use efficiency not in terms of net tonnes of production but rather by net value of production. As in the US water will flow to the highest bidder (whether this be urban, industrial or agricultural) and consumers will pay more for food as prices will reflect higher production costs as producers compete in an open market for water resources.

The Federal Government, within the framework of the National Water Initiative, needs to continue the move towards a proactive and cohesive national approach to reform. This is necessary as without a national approach there will not be lasting water reform as each state and territory seeks to ensure its continuation of its own revenue sources as well as maintain popular voting support and hence government.

The lack of a cohesive federal reform will bring about conditions similar to those prevalent in America where a Federal Water Court adjudicates over an ever increasing backlog of water disputes arising between states.

It is also my belief, and practice, that through an annual review of the basic principles of irrigation – soil capacity, system design and performance and crop selection – irrigators can ensure that they are running the most efficient operation under the existing circumstances and ensure that they are well placed to take advantage of any new technologies that may arise.

Recommendations

Via a simple annual review of the operation of irrigation systems irrigators can benchmark the efficiency of their current system. This review and benchmarking will enable irrigators to make informed decisions in relation to the real cost of irrigating as well as ensure that they are in the position to adopt new technologies as it arises.

Australian Irrigators must ensure that they speak with a unified voice to ensure that their contribution to Australian GDP is recognised and as such that their right to water entitlement is seen as valuable. This in turn will guarantee that they receive fair and equitable treatment in the future allocation of Australian water resources.

The Federal Government must continue the move towards national reform in the arena of water resources and allocations. If the current system is not moved quickly towards a unified, centrally administered, model it is highly probable that Australia will follow the path of the US whose states are looked in a seemingly endless legal battle for control of water resources.

Water must be able to be traded freely to allow the market to set the price accordingly. Water allocations will move to those who can afford to pay the most and correspondingly prices paid for the commodities produced with this water should reflect this.

As in America cities should have to purchase water rights not be granted automatic access to water. Presently Australian cities are allocated water in relation to how many votes reside there not by any other means.

Plain English Compendium Summary

Project Title:	The Drive for Water Use Efficiency
Nuffield Australia Project No.:	
Scholar:	Jarrod Ryan
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Objectives	To investigate water use efficiency technology
Background	With continuing drought conditions and increasing competition from other stakeholders the irrigation industry faces inevitable change. Irrigators need to ensure that they are using the most efficient techniques in order to maximise their returns.
Research	Study commenced with the Global Focus Tour where we visited America, Canada, Mexico, Brazil and the UK. I then travelled to the Western Cape Region in South Africa as well as California, Colorado, Oregon, Nebraska, Washington State and Maryland
Outcomes	Australian Irrigators are at the forefront of water use efficiency due to the unique set of environmental, economic, social and political conditions experienced in Australia. Irrigators need to ensure they have the basics covered (soil type, system capacity and crop selection) for their individual situation.
Implications	Irrigated Agriculture in Australia needs to ensure that its role in wealth and job creation in Australia is recognised and rewarded in any future water resource allocations.