Water Use Efficiency at the Farm and Regional Level[1]: The Economics of Response and the Furphy[1] of Excellence.

Oliver Gyles[2]

An allowance for water use is part of the agronomic analysis implicit in the foundation of any sensible economic evaluation of crop response or change of farming system. Diminishing returns to investment in water use efficiency imply that the optimum level of investment is determined by the price of the commodity and the cost of increasing efficiency. Given a market for water, the relevant price will be that of the least valuable commodity produced at the margin of regional resources. Until water becomes liquid gold, the farm optimum will be well short of the experimental maximum. Some farm and regional possibilities for investing in increased WUE are discussed.

Key words:- Water use efficiency, investment

1. INTRODUCTION

In the driest state in the driest continent it seems appropriate to consider water use efficiency[2] (WUE). Considering the perceived scarcity of water, it is perhaps surprising that recent problems with land degradation are often attributed to water driven processes. Natural resource managers are concerned by agricultural, environmental and urban impacts of rising salinity and nutrient runoff levels in the Murray-Darling Basin. Governments and local communities have developed and implemented land and water management plans (LWMPs) in response. The volume of irrigation diversions has been capped to ensure base flows for the riverine environment. Further flows for the environment are expected from investment in reducing irrigation supply system losses. The farm program in LWMPs aims to save water through increased irrigation efficiency and further increase agricultural productivity through reduced water logging and salinity. The joint private and public good aspect of LWMPs program outcomes is the basis of the private and public cost share of research extension and implementation.

In this paper the physiological and agronomic aspects of WUE are briefly outlined before the usefulness of the concept of water use efficiency in monitoring technical performance and or land and water quality is examined. The economics of tactical and strategic responses to short and long term reduction in irrigation water allocations is then considered. Opportunities for investment in increasing WUE are discussed in the light of their potential to contribute to private and public good. This perspective is important when considering research and extension policy for agricultural productivity and natural resource management programs (Marsh and Pannell, 2000).

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2. AGRONOMY

Large volumes of water are required for the field production of crops and forage. There is a high physiological demand because the water relations of plants are entwined with the gas exchange processes of photosynthesis. Since crops must transpire water while accumulating dry matter (DM) the relative rates of transpiration and dry matter accumulation govern the WUE of the production system. The rate of water loss from well watered crops is similar to that from evaporation on a free water surface. Typical measurements of average WUE for annual pasture, lucerne and perennial pasture are 1.6, 1.5 and 1.3 tonnes DM/ ML of total water use[3] respectively (Or approximately 700 tonnes of water per tonne of dry matter production). The water response of crops was studied in detail early last century at Werribee using weighing lysimeters (Richardson, 1923) and in the field (LC Bartels, 1924). More recent studies include those by LF Bartels (1966), French and Schultz (1984a, 1984b) and Whitfield et al (1986, 1989).

There are diminishing returns to increasing water use intensity (irrigation or rainfall) as other factors become limiting. Figure 1 shows this relationship between the average yield of wheat and April-October rainfall in three seasons (French and Schultz, 1984b). The curved solid line shows mean yield derived by regression while the straight slope indicates the potential response (French and Shultz, 1984a).

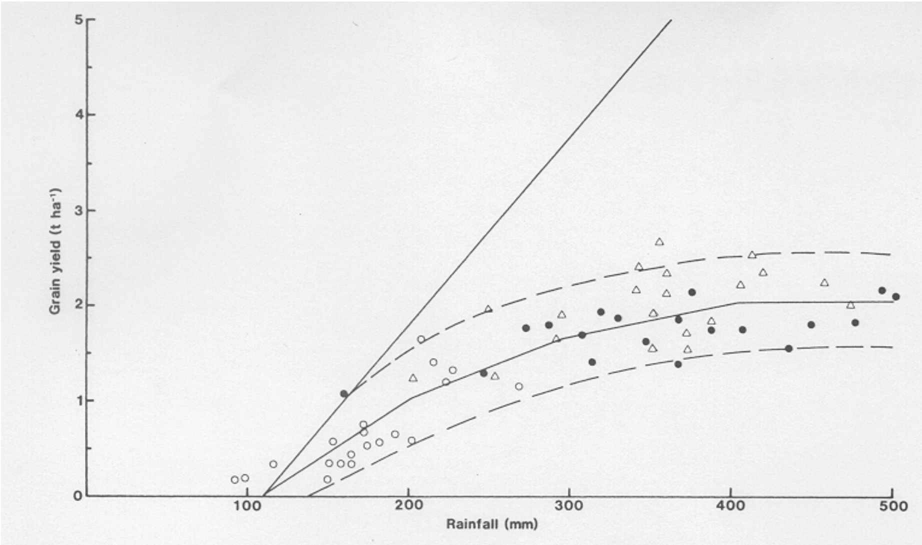

Figure 1: Relation between the yield of wheat and seasonal rainfall.
(After French and Shultz 1984b)

Similar response functions shown in Figure 2 were derived by Bethune (2000) from the relationship developed by Prendergast (1993) for irrigated pasture using a range of irrigation salinities.

Alternative ways to increase yield are:

- higher water use (rainfall or irrigation),
- improved land and water quality (salinity management, land forming, fallowing?)
- intensifying variable inputs for a given water use and land and water quality.

The response to different levels of variable inputs (French and Shultz, 1984b) is shown in Figure 3.

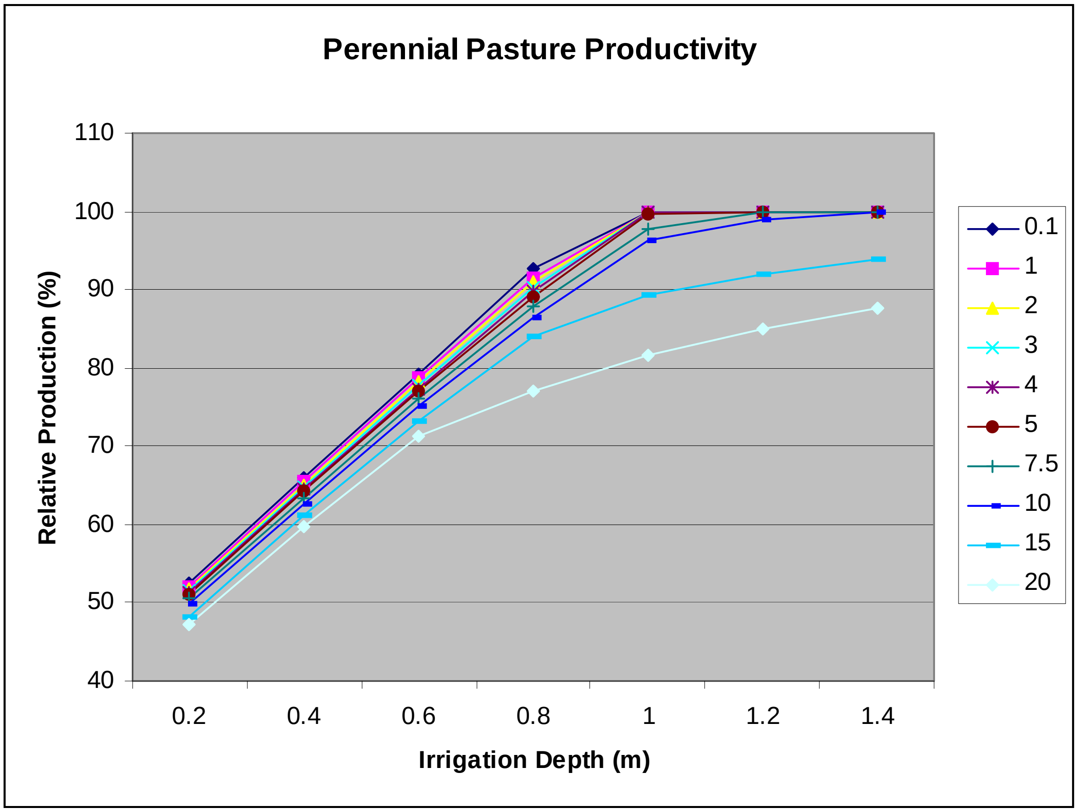

Figure 2: Relationship between relative yield of perennial pasture and irrigation intensity for a range of groundwater salinities. (Gyles 2001)

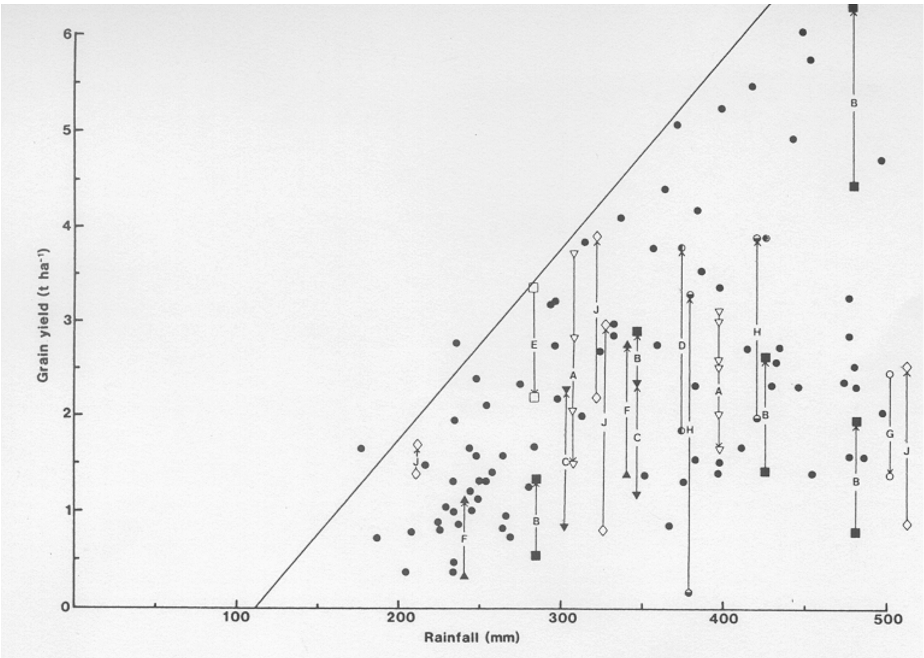

Figure 3: Wheat yield response to various treatments. (A) time of sowing, (B) nitrogen, (C) phosphorus, (F) eelworm control. (After French and Schultz 1984b)

2.1 Water Use Efficiency and Estimating Returns to Research

Clearly climate and weather influence water availability, water use and thus yield. Given the variability of seasonal conditions experienced in Australia in different years and between locations in the same year, it seems obvious that any comparison of technical efficiency should account for water use. Observed differences in yield may be wholly or partly explained by changes in water use rather than improved technology or management. Thus a WUE based analysis of trends of rising yields in the 1950s for southern Australia indicated that a substantial proportion of the claimed increase in productivity due to advances from agricultural research and extension could be attributed to a run of moist seasons[4]. Conversely, productivity analysis for regions or periods of lower than average rainfall may underestimate the returns to research if the water use aspects of production are neglected.

2.2 Water Use Efficiency and Deficiencies in Dairy Farm Performance Analysis

The pitfalls outlined above are partly avoided in Dairy Farm Performance Analysis where an attempt to standardise total water use per hectare is made. This is outlined for irrigated areas for a survey and analysis reported by Moran *et al* (2000). However for rainfed production areas no standardisation is attempted. This means no sensible comparison of agronomic performance is possible save for the unlikely concurrence of uniformly high rainfall over all dairy farms in all regions! (In fact some regions in the survey were experiencing one of their worst droughts on record) Ranking farm businesses on the basis of comparative performance against questionable “economic” indicators seems nonsense enough[5] without further clouding the important issues through faulty agronomic perspectives. “It is as easy to get it [roughly] right as [wildly] wrong - so more sense and less nonsense is the call.”[6]

2.3 Monitoring and Evaluating Investment in Land and Water Quality

Where allowance can be made for trends in technical efficiency of the production process, it can be assumed that other changes in WUE are due to changes in land and water quality. Thus comparison of predicted and observed trends in productivity may be used to monitor and evaluate the effectiveness of investment in natural resource protection programs such as salinity management (Gyles and Young 1993).
Collection of suitable base data for monitoring productivity of approximately half the land and water resources in the Northern Irrigation Region of Victoria was a major objective of a recent survey of WUE on dairy farms (Armstrong et al, 1998a). The relationship between total water use and estimated pasture based production is shown in Figure 4. A four fold range in water use efficiency was found.

3. INVESTING IN WUE

Armstrong *et al* (1998b) identified three main management areas contributing to high WUE. These are:-

1. Irrigation efficiency,
2. Good pasture growth in response to land quality (slope) fertilisers and sufficient irrigation intensity and frequency and
3. Good pasture utilisation through an adequate stocking rate of efficient cows and limited use of supplements.

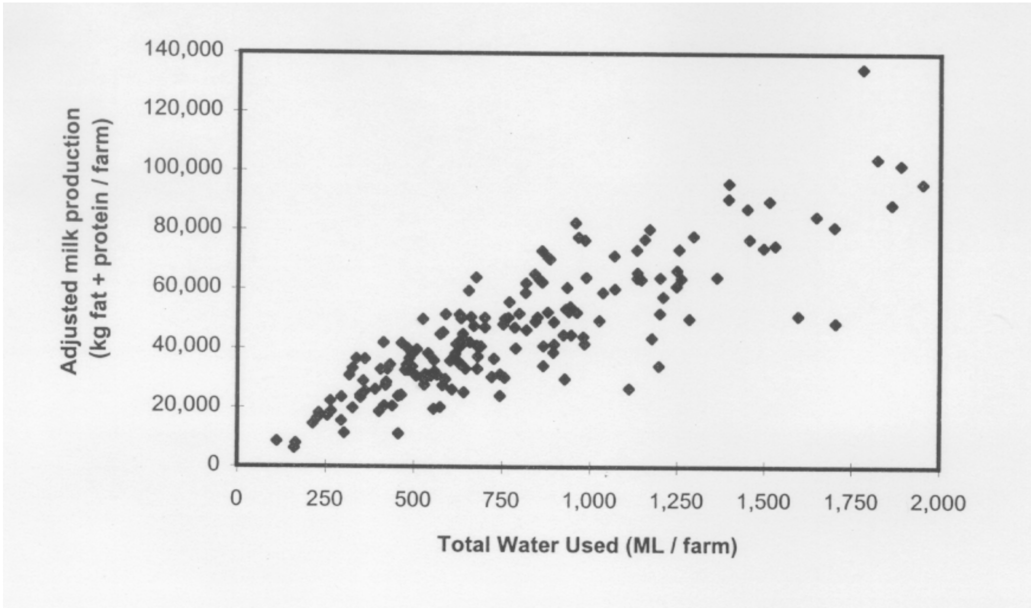

Figure 4: Milk solids from pasture based production and water use on dairy farms in northern Victoria and southern New South Wales (After Armstrong *et al* 1998a)

The main factor affecting irrigation efficiency of pasture bays in northern Victoria is the amount of tail water runoff. This can be reduced by increased surveillance of irrigation at a higher labour cost, use of irrigation sensors and timers or by recycling irrigation tail water. Improvements in irrigation layout can change bay slope and significantly reduce the labour requirement for irrigation. However potential drainage losses from the farm can be as high as 20% (Austin, pers. comm.). Depending on the proportion of run off and the size of the operation, recycling tail water may be profitable but there still may be other cheaper sources of water.

Increased pasture utilisation requires increased investment in cows and increased reliance on supplements or tactical fertiliser use to secure production increases. King and Stockdale (1980) found diminishing returns to increased stocking rates[7]. Also capital investment in milking facilities may be required.

Armstrong (pers. comm.) has compared investment in increased WUE with farm expansion in business case studies and found the latter option more profitable. At some stages of farm development, given the lumpy nature of expansion opportunities and capital constraints, the more profitable alternative may result in lower water use efficiency until intensification of inputs is rational or financially feasible.

Ferris and Malcolm (1999) contend that, given a market for water, individual farm WUE is “the economically efficient technical efficiency ratio for that farm operation”. What constitutes the characteristics of “that farm” will depend on previous sunk capital. This capital investment will not necessarily have been made solely to increase WUE and, in terms of allocation of annual inputs, whether or not the investment was profitable is irrelevant. Appraisal of new investment affecting WUE should consider all benefits and costs arising from the change in farming system. Not all improvements in technical efficiency will be profitable. For example, while Shaw (1990) found that investment in new irrigation technology for horticulture was not justified on the basis of water savings alone, Downs (2000, in press) reported profitable opportunities for increasing WUE where increased quality is marketable.

4. STRATEGIC AND TACTICAL RESPONSE TO LOW IRRIGATION WATER ALLOCATIONS

4.1 Strategic Adjustment

Strategic response is mainly about minimising the costs of maintaining the security of feedbase production. Gyles et al (1999) examined options for adjustment to expected long term decline in irrigation water allocations. Purchase of water right was a cheaper alternative than temporary transfer of entitlement or increasing feed supplements.

Investment in new farming systems will also occur over time. Changes in farm WUE will be governed by the relative profitability of different systems.

4.2 Tactical Adjustment

An extensive survey of production inputs by Lineham (pers. comm., 2001) found no change in water use efficiency by the dairy industry in response to low irrigation water seasonal allocations. Rather, water inputs were maintained by trading water entitlement. This loss minimising behaviour is rational. It also underlines the sense in Ferris and Malcolm's assertion about individual farm WUE being "the economically efficient technical efficiency ratio for that farm operation". Given the expectation that next year's allocation will be closer to average, capital investment in increased WUE would be appraised using a very short time horizon and be unlikely to be profitable. Also since operating margins are reduced by increased costs, the financial feasibility of investment would be reduced.

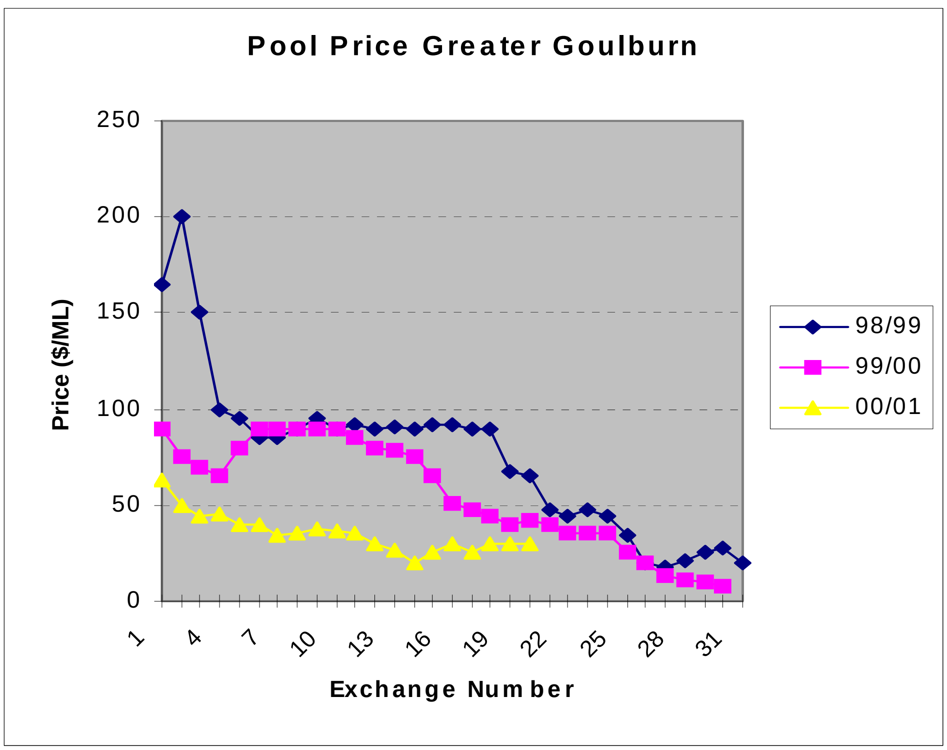

Figure 5: Market clearing prices for the northern Victorian water exchange in seasons 1998/99, 1999/00 and 2000/01

The market clearing prices for temporary transfer of Goulburn system water right at the northern Victorian water exchange over the last three seasons is shown in Figure 5. The transferred right entitles the purchaser to delivery of one megalitre at no charge. Annual water right charges are paid by the owner of the entitlement. The allocation for these seasons was 100% of water right. In an average allocation year volume additional to water right could be purchased as sales priced around $25/ML. The market price of water generally declined through each season to levels around or below the Goulburn-Murray Water charge for supply. The data also indicate a learned response by purchasers over the three seasons to the announcement of allocations. As experience about likely volumes offered and prices for trade has accumulated, purchasers have reduced the price of their bids.

5. REGIONAL PERSPECTIVES

There is currently enthusiasm in policy concerning water use efficiency (WUE). The reaction by those current and prospective irrigators adversely affected by the M-DB Cap and the need for increasing environmental allocations including the return of flows to the Snowy river has generated interest in the potential for regional water savings. However the nature of the water delivery system generally offers little opportunity for real reductions of losses. For example, outfall losses from one jurisdiction are resources (including environmental flows) for those downstream. The appropriate solution here would seem to be a job for the accounting profession rather than engineers. In other cases the operation of existing infrastructure is already providing savings at lower cost. Groundwater pumps picking up channel seepage losses as well as leaching losses from irrigation is one example.

The water exchange prices indicate low to negative returns from irrigation at the margin of regional resources. This would suggest that the water economy is pubescent rather than mature and has implications for assessing the benefits of trade. It also suggests that the estimates of benefits of changing water release policies for the Goulburn system (Eigenraam, 1998) are premature and high.

6. CONCLUSION

Until the much vaunted "high value" industries are able to profitably expand sufficiently, the production function governing the level of investment in WUE will be the response of mixed farming enterprises to irrigation. Where public goods arise from joint investment in WUE such as that for salinity management, cost sharing arrangements should (and have) relied on a scientific basis as recommended by Mullen *et al* (2000).

Watson (1996) has drawn attention to the economic unsuitability of water pricing as an efficient policy mechanism for controlling external impacts of irrigation. The choice between policy mechanisms such as regulation, incentives or emission trading markets will be influenced by their cost effectiveness and other important aspects such as fairness and equity. Whatever the chosen approach a sensible evaluation of the regional and state socio-economic impact of alternatives will depend on a thoughtful and thorough examination and comparison of opportunities at the farm management level.

With an integrated approach to productivity and natural resource protection policy, increased WUE would be seen as one outcome of joint investment rather than an end in itself.

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[1] **Furphy**. A rumour; a false story. [from John *Furphy*, manufacturer in Victoria of water carts, which during World War I were centres of gossip] The Macquarie Concise Dictionary

Above the tap on the Furphy water cart is the motto:

“Good Better Best
Never Let It Rest
Till Your Good is Better
And Your Better Best”

Inspirational words indeed for a young lad watering pumpkins with a kerosene tin bucket, but hardly a recipe for determining best operating conditions!

[2] Water use efficiency defined here as product per unit of total water use by the production system.

[3] Total water use comprises effective rainfall plus irrigation increments and net reduction in available soil moisture. Where there are high water tables, some contribution to the water budget may also be obtained from the phreatic zone.

[4] French (1987) CM Donald Medal address, 4th Australian Agronomy Conference, La Trobe University.

[5] Ferris and Malcolm (1999) discuss the slanted nature of comparative analysis of dairy farm businesses.

[6] Op cit p 29

[7] Not only in milk production. Over wintering mortality rates rose to over 30% at stacking rates of 8 cows/ha!