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# PROFITABILITY OF GROWING SUGARCANE UNDER ALTERNATIVE IRRIGATION SYSTEMS IN THE BURDEKIN DELTA

By

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## Abstract

The Burdekin canegrowing area is a major irrigation area in North Queensland with more than 35 000 ha of irrigated sugarcane. The major proportion (some 95%) of the cane is furrow irrigated. Effective water and irrigation management is vital to maximise producer's net returns, and for sustainable utilisation of the soil and water resources. Water management in the delta is currently the focus of a cooperative research effort involved in obtaining robust scientific data to help underpin decisions affecting the long-term economic viability of the region. Potential future economic impacts of recent and current changes to water management and environmental policies need to be considered. Also, the costs of agricultural inputs, particularly water and labour, are likely to continue to increase. In combination these factors may therefore increase the attractiveness of alternative irrigation systems, which need to be continually reviewed as conditions change. In this paper we use agronomic and economic data from Burdekin delta farms to estimate the relative profitability of changing from current furrow irrigation to an alternative irrigation system. We estimate the net profitability of these systems on a multi-period investment basis, and provide a ranking of the current and alternative systems according to economic criterion of net present value (NPV). Furrow A has the highest NPV followed by the Centre Pivot, then Furrow B and the Trickle irrigation system. When the volumetric water charges are used instead of area-based groundwater and differential surface water charges, the ranking of the irrigation systems changes and the Centre Pivot has the highest NPV followed by Furrow A, Furrow B, and Trickle. Under the volumetric water charging option, the overall NPVs for each irrigation system are lower than the NPVs for area-based water charges.

## Introduction

Water is becoming an increasingly scarce resource and therefore limiting agricultural development in many regions and countries of the world. In the past, building new physical systems to harness additional water resources has been the standard approach. However, with increasing demand for water by non-agricultural users, greater emphasis is now being placed on the need to improve the effectiveness of existing irrigation systems. Globally, efficient and sustainable management of water resources is increasingly becoming a policy objective. There are several factors to be considered in irrigation management to improve productivity and reduce costs. One of the key decisions is how much water should be allocated to a particular crop relative to other crops. This decision needs to be based on the quality and availability of water resources, reliability of water supply, physiological requirements of the crop, and expected value of crop output. In the case of sugarcane, there are choices to be made about how much water to apply to different classes of cane rather than different crops. The most frequently recommended irrigation strategy is to apply water at a level that gives maximum net income to the grower, and adoption of modern water-saving irrigation technology is often cited as a key to increasing water use efficiency while maintaining current levels of production (Green *et al*., 1996). However, most new technology typically requires greater capital investment, so irrigators are often reluctant to adopt new systems unless they can be convinced of the likely benefits. In this paper we assess the relative economic performance of traditional and new irrigation technologies at the farm level over a number of years. We describe the analytical framework used and discuss some of the likely implications of our findings.

## Alternative irrigation systems

The ability of an irrigation system to provide water uniformly and efficiently is a major factor influencing the agronomic and economic viability of the farm production system. In general, irrigation systems may be grouped as gravity flow (such as flood or furrow irrigation) and pressurised systems (such as centre pivot and drip or trickle systems). A brief description of the three most commonly used irrigation systems in sugarcane growing areas in Queensland follows.

Furrow irrigation is the most widely used system and it is favoured where topography and soil type permit. It has low capital costs, is simple to operate and is suitable for land with slopes less than 3% (Holden, 1998). While efficiency can vary from 10% to 90% (Tilley and Chapman, 1999), the more accepted range is 30% to 90% and efficiency can be improved by better management practice (Holden, 1998). If inappropriately managed, furrow irrigation, like any other irrigation system, can lead to deep drainage losses. This can, in turn, lead to a rise in watertable and increased salinity as experienced in parts of the Burdekin River Irrigation Area and on the Atherton Tableland (Tilley and Chapman, 1999). Estimated equipment costs for furrow irrigation are about $1500 per hectare which include costs of land levelling and earthworks for tail-water return (Holden, 1998). Land development cost for furrow irrigation is about $800/ha while this cost for pressurised systems is about $500/ha.

Centre pivot irrigators are the most extensively used, fully automatic overhead irrigation system. The irrigator rotates in a circle up to 1.6 km in diameter covering about 200 ha (Holden, 1998). This system has the potential to deliver more than 90% application efficiency depending on slope of the land and wind conditions (Tilley and Chapman, 1999). This technology is attracting increasing interest, particularly in areas of water scarcity. Advantages over furrow irrigation include easily varied application rates and a uniform distribution pattern, even under relatively windy conditions. Large areas can be irrigated at relatively low cost for electricity and labour. Nutrients can also be applied with the irrigation water which is another attractive feature. This system does not require land (laser) levelling which is a common practice for furrow irrigation systems. A disadvantage is the relatively high initial capital cost (currently around $2500/ha).

Trickle or drip irrigation systems, if well managed, have the potential to achieve more than 95% application efficiency (Tilley and Chapman, 1999). In these systems, water is delivered to the plant root zone via thin-walled tubing laid either on top of or below the soil surface. The system operates at low pressure, allows small amounts of water to be applied to large areas, lends itself to automation, and can be used for fertigation (application of liquid fertiliser). According to Thorburn *et al.* (1998), studies published since the mid 1980s have shown that cane yield can be increased by 5% to 20% with evidence from a small number of studies indicating irrigation efficiency of 50% to 80%. Fertiliser input rates can also be reduced with trickle irrigation due to more directed and efficient application of the fertiliser. A recent study found that increased crop yield and sugar content were possible, with a 25% reduction in nitrogen input relative to the industry standard (Dart *et al.*, 2000). Part of this gain arises from in-crop adjustments to nitrogen management to overcome problems such as loss of nitrogen in wet periods, compared to other systems where potential over-fertilisation may be a problem for the environment (Dart *et al.*, 2000). High installation costs (currently in excess of $4000/ha) and potential problems with rodents and low water quality causing iron deposits in the tubes are major barriers to adoption. In addition, a high level of management expertise is required.

## The Burdekin delta study area

The Burdekin delta is located on the northeast coast of Queensland, approximately 90 km southeast of Townsville, close to wetlands, waterways, estuaries, and the Great Barrier Reef. It covers an area of about 850 $km^2$, and together with the Haughton River – Barratta Creek system, is one of the largest alluvial aquifer systems in Australia. The area has a tropical climate and seasonal rainfall (two thirds falling during January to March), ranging between 250 mm and 2500 mm a year, with an average of about 1000 mm a year. Evaporation varies from 10 mm/day in November to 2.8 mm/day in June (Arunakumaren *et al.*, 2000). The Burdekin area is predominantly used for sugarcane production, with some smaller areas under tropical fruits and vegetables, and a small area where groundwater or soil quality are not suitable for sugarcane is used for cattle grazing. The delta is one of the few areas in Queensland where cane is grown under full irrigation. Reports indicate that irrigation applications can vary from 10 to 40 ML/ha/y (Arunakumaren *et al.*, 2000).

## Analytical framework and data collection

The biophysical information used in this study, including crop yield and irrigation water use was derived from four experimental sites in the Burdekin delta for 2000/1 season. These sites are classified as:

Furrow A – furrow irrigation on a sandy loam soil (high permeability)
Furrow B – furrow irrigation on a heavy clay soil (low permeability)
Drip – drip irrigation on a sandy loam soil (high permeability)
Centre Pivot – centre pivot irrigation on sandy clay soil (medium permeability)

Irrigation water applied at these sites was measured by flow meters placed either at the pump or in the fluming. Yield and CCS information were obtained from mill records for each farm (Table 1). For the current study, it was assumed that the farm has a crop cycle of one plant and three ratoons, with the average yield of the three ratoon crops being about 5% less than plant cane. The measured yield and estimated average yield of the three ratoon crops is given in Table 1 for each irrigation system. These values (actual data from the 2000/1 season) have been used in the analysis. The average effective rainfall in the region was about 400 mm per annum (equivalent to 4 ML/ha irrigation water), and assumed the same for each irrigation system. The last column in Table 1 shows total yield per unit of water including rainfall.

**Table 1**-Yield, CCS, irrigation water applied and total yield per ML for different irrigation systems.

| Farm | Trial yield (one crop) (t/ha) | Average yield (one plant and three ratoon crops) (t/ha/y) | CCS (units) | Irrigation Applied (ML/ha) | Total yield per ML (t/ha/y/ML) |
|---|---|---|---|---|---|
| Furrow A* | 144 | 138 | 15.9 | 24 | 5.1 |
| Furrow B* | 130 | 125 | 14.8 | 10 | 9.3 |
| Centre Pivot | 150 | 144 | 15.0 | 6 | 15.0 |
| Drip/Trickle | 148 | 142 | 15.1 | 12 | 9.3 |

*A and B refer to farms with different soil permeabilities as described in the text

Data about sugar production costs including irrigation related charges, capital cost of each irrigation system, other production costs and farm fixed costs obtained by Qureshi *et al.* (2001) have been used in the analysis. The appropriate savings in each irrigation system due to reductions in fertiliser, herbicide and labour, and the average pool price of sugar in Queensland as well as the price paid to the grower as estimated Qureshi *et al.* (2001) were also used in the analysis. In addition to cane yield, CCS and irrigation water applied, the parameters used in the analysis are set out in Table 2.

**Table 2 -** Parameter values used in the analysis

| **PARAMETER** | **VALUE** | **PARAMETER** | **VALUE** |
|---|---|---|---|
| **Farm/Labour Characteristics** | | **Irrigation Costs** | |
| Farm size | 60 ha | NBWB ground water charge | $68.50/ha |
| Sugar pool price | $325/t | SBWB ground water charge | $48.50/ha |
| Fixed costs | $20,000 per farm | NBWB threshold for low priced surf water | 8 ML/ha |
| Permanent labour cost | $20/hour | NBWB surf water low price | $4.80/ML |
| Harvesting contract cost | $5.60/t | NBWB surf water high price | $22.20/ML |
| Tractor cost | $28/hour | SBWB threshold for low priced surf water | 4 ML/ha |
| Planting cost | $375/ha | SBWB surf water low price | $5.40/ML |
| Fertiliser cost (plant) | $250/ha | SBWB surf water high price | $13.67/ML |
| Fertiliser cost (ratoon) | $275/ha | GW electricity charges | $9.11/ML |
| Herbicide cost (plant) | $133/ha | Surface water electricity charges | $4/ML |
| Herbicide cost (ratoon) | $75/ha | Volumetric water charges (BRI) | $39/ML |
| Insecticide cost (plant) | $0-300/ha | | |
| Insecticide cost (ratoon) | $0-300/ha | **System Capital Outlay and Operating Cost** | |
| Labour (plant) | 40 hours /ha | Furrow capital outlay | $0/ha |
| Labour (ratoon) | 20 hours/ha | CP capital outlay | $2667/ha |
| **Tax/Discount Rates** | | Trickle capital outlay | $4200/ha |
| Marginal tax rates (%) | 0,17,30,42 and 47 | Furrow operating cost | $50/ha |
| Taxation limits ($'000) | $6,$20,$50,$60, above | CP operating cost | $8/ha |
| Discount rate | 7% (real) | Trickle operating cost | $240/ha |
| Planning horizon | 20 years | | |

Source: Modified from Qureshi *et al.* (2001)

To carry out the complex calculations involved in different groundwater-surface water proportions per hectare of cane, differential surface water charges and the progressive Australian taxation regime, the CANEIRRI model (a multi-period algebraic model developed by Qureshi *et al.* (2001) using GAMS software (Brooke *et al.*, 1998), has been used to estimate farm cash surplus from the three alternative irrigation technologies over a 20-year planning horizon. The net present value of each irrigation system has also been computed. The CANEIRRI model allows analysis of investment in trickle irrigation at the same time as each new section of crop is established over a five-year period (one plant, three ratoons, and one year fallow) while immediate investment in the centre pivot irrigation system during the fallow period is assumed in the analysis. It should be noted that most of the Burdekin delta area has been developed for sugarcane farms by fulfilling the requirements of the furrow irrigation system and no new development for cane farming is expected in the area. Therefore, no capital cost is required for the furrow system, and only regrading costs are included at the start of each crop cycle on the basis of fallow area which goes under plant cane. Operating costs during the transition from furrow to trickle irrigation are based on the proportion of area under the respective irrigation systems as it is assumed that the trickle replaces furrow irrigation (either Furrow A or Furrow B). The model also allows provision for deductions from income for capital investments on irrigation equipment, and for carrying forward business losses for taxation purposes. The model does not make any allowance for scrap value of the irrigation equipment at the end of the 20 year investment period.

All the cost and revenue items are assumed to be representative of a 60 ha farm in either the North or South Burdekin Water Board (NBWB and SBWB) area. The CANEIRRI model has been used to compare case study farms in these two areas, since there are differences in the structure of groundwater and surface water charges in these two areas as well as in the proportion of groundwater and surface water supplied by the two water Boards. The model estimates the relative profitability of these three alternative irrigation systems and determines their ranking according to the criterion of Net Present Value.

## Results and discussions

Results of preliminary analyses for case study farms in the NBWB and SBWB areas are presented in Table 3 along with an example of a volumetric water charging policy option. The volumetric option used the Burdekin River Irrigation Area (BRIA) water price of $39/ML. According to these results, the NPVs of the southern area farm are higher than the northern area farm. The higher NPVs are due to the relatively greater use of less expensive groundwater in the SBWB farms compared to the NBWB farms. The ranking, according to NPV of the four different irrigation systems (two furrow, one centre pivot, and one trickle irrigation) is the same in each district. Furrow A has the highest NPV followed by the Centre Pivot, then Furrow B and the Trickle irrigation system. When the volumetric water charges are used instead of area-based groundwater and differential surface water charges, the ranking of the irrigation systems changes and the Centre Pivot has the highest NPV followed by Furrow A, Furrow B, and Trickle. Under the volumetric water charging option, the overall NPVs for each irrigation system are lower than the NPVs for area-based water charges. Table 3 also presents the NPVs for the Trickle system assuming it replaces either Furrow A or Furrow B system. The NPVs of the Trickle irrigation system which replaced Furrow A (high yield/high water use) were higher (for both districts) than the NPVs of the Trickle irrigation option which replaced Furrow B system. The final column in Table 3 shows the NPV related to the amount of irrigation water and indicates the relative value being extracted from each unit of water (for example, in SBWB).[1] Again the Centre Pivot gives the highest return for the water used. Using this efficiency term reverses the previous ranking of the two Furrow systems. Furrow B with its moderate yield and low water use extracts almost double the value from each ML of water applied. Furrow A return is the lowest among all the irrigation

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[1] Such values are useful when dealing with a system where water is limited and there are choices between different uses of water and allow benchmarking with other crops/uses.

options evaluated. It is to be noted that the analyses only considered on-farm financial values and did not account for environmental impacts of the alternative irrigation options and inclusion of these impacts may change their ordering.

**Table 3**-Net present values for three irrigation options suitable for the NBWB and SBWB areas and the BRI volumetric water charge option ($'000).

| Irrigation system | NBWB | SBWB | Volumetric water charge option | SBWB (NPV/ML) |
|---|---|---|---|---|
| Furrow A | 664 | 690 | 492 | 29 |
| Furrow B | 515 | 519 | 439 | 52 |
| Centre Pivot | 549 | 554 | 500 | 92 |
| Trickle with Furrow A | 385 | 397 | 251 | 33 |
| Trickle with Furrow B | 377 | 382 | 268 | 32 |

The values for key parameters – discount rate, sugar prices, capital investment costs, farm ownership arrangement, and other important variables – were also varied systematically to examine their effect on the rankings of the three systems. Discount rates of 5%, 7% and 9% were used for these analyses. The price of sugarcane and capital cost of the centre pivot and trickle systems were altered by ± 20% from base values. Here, the results for the SBWB situation only are reported. The findings are the same relatively for the NBWB.

The rankings of the irrigation options are not changed by altering values of any of the parameters listed above. The NPV of the centre pivot system exceeds that for Furrow A when the capital cost is reduced by about 70%. The NPV of the trickle irrigation (when replacing Furrow B system) exceeds that for both Furrow B and Centre Pivot systems when there is a 40% and 50% reduction in their capital costs, respectively. Such a reduction in these capital outlays is not likely to happen, which indicates that there is little incentive (at least economically) to change under current water pricing. Additional analyses also showed that switching from sole owner to a partnership basis for farm ownership increases after-tax income, but does not change the NPV ranking of the irrigation options.

## Conclusions

An integrated bioeconomic modelling approach has been used to compare alternative irrigation technologies for sugarcane farms in the Burdekin delta where differential water charges, volumetric charges for surface water, and area-based charges for groundwater, are common practice. The Furrow A system is clearly most attractive to farmers. The Centre Pivot irrigation system is the second most attractive option as it has a higher NPV than the Furrow B system. Trickle irrigation is the least attractive to growers due to its high initial capital costs. Centre pivot emerges as the best option when the volumetric water charges are used in the analysis. Here again trickle remains the least attractive option because of the high capital outlay. A simple sensitivity analysis where values of the key parameters are varied shows that the rankings do not change, with Furrow A remaining the most attractive option under the current water-pricing regime. These results indicate that the current water charges are not a major driver for changing from existing furrow irrigation to an alternative irrigation system. These findings, which are based on experimental data, support results of an earlier simulation study based on the APSIM model (Qureshi *et al.*, 2001). The current analysis did not compare profitability of these irrigation systems for a new development but rather examines an existing sugarcane farming system which is already under furrow irrigation. Therefore capital costs to establish the furrow system are not considered. The rankings of these systems may differ if the analysis is carried out for a new development and initial capital cost of installing the furrow irrigation system has to be considered.

The information provided by this analysis can be used with farmers to explore the likely long-term consequences of investment decisions involving alternative irrigation systems. The model can be easily adapted to analyse the impact of farm size as the costs and revenues used in the model are based on area estimates. The model could also be used to assist natural resource managers and regulatory agencies in examining the potential impact of different water charges on growers' incomes. The framework provides a useful means for examining various scenarios and testing policy options that affect either input costs or farm incomes of growers. The potential implications of changes at the farm enterprise scale on the environment and broader regional economy is the subject of ongoing studies.

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