THE ECONOMICS OF SUB-SURFACE DRIP IRRIGATION

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ABSTRACT

Irrigators in the Callide Valley of central Queensland have identified the economic appraisal of sub-surface drip (SDI) as an issue requiring investigation. A partial discounted cashflow analysis was undertaken to examine the profitability of SDI in comparison with spray irrigated systems, in a traditional cropping system in this district. It showed for the assumptions used in the analysis that SDI has the highest cumulative net cashflow of the systems evaluated. This is dependent upon the yield increase and water savings assumptions attributed to the use of SDI.

An analysis of the optimal investment strategy for a case study farm within the Callide Valley indicated that diversification into annual horticultural crops, coupled with investment in SDI was the most profitable approach to coping with diminishing ground water supplies. It also showed that lucerne, although a large water user, remains an important part of the cropping system (at least until water is restricted to 50% of allocation).

There is limited comparative data on the performance of SDI with alternative irrigation systems, but what is available indicates that yield and water saving benefits do exist. Current studies being undertaken in the cotton and grains industries, offer the potential to further clarify these benefits and enable more complete whole-farm analysis to be undertaken.

INTRODUCTION

One of the concerns expressed by irrigators considering the adoption of SDI is an economic appraisal of it and other irrigation systems (Harris, 1998). This paper presents a partial discounted cashflow analysis of alternative irrigation systems within the Callide Valley of central Queensland. The analysis was conducted using Microsoft Excel® and is a preliminary attempt at examining the profitability of irrigation systems in a traditional cropping system in this district.

SUBSURFACE DRIP IRRIGATION COSTS

The cost of SDI installation is dependent on several factors that include:

- shape of block (and hence of length of run)
- slope of block
- bore capacity
- water quality
- lateral spacing

A cost comparison between alternative irrigation systems and SDI has been undertaken for the Callide Valley in Central Queensland. The assumptions used in this comparison are:

- an area of 28 ha (700m wide by 400m long)
- an irrigation allocation of 280 ML per annum
- a bore flow rate of 93600 L/hour
- fixed costs of depreciation and interest on the cost of bore, land development, and irrigation equipment. Life of equipment is 25 years for bore and shed, 25 years for pump and mainline, 20 years for gated and hand shift pipe, 15 years for boom and travelling irrigator, and 10 years for side roll and SDI. Interest is charged at a real rate of 8.50% (12.00% nominal and an inflation rate of 3.5%).

- operating costs made up of electricity and fuel, water charge ($15.05/ML), repair and maintenance costs (3% of new value for bore and shed, 20% of new value for pump and mainline, gated and hand shift pipe, 40% of new value for side roll, 50% of new value for boom and travelling irrigator, 3% of new value for SDI systems), and labour ($15/hour).

The results of this comparison are summarised in *Tables 1 and 2.* SDI systems have higher fixed costs than other irrigation systems (depreciation and interest) but lower operating costs (with respect to repair and maintenance and labour costs). Overall cost per ML for SDI is comparable with existing spray irrigation systems (hand shift systems are, however, around 30% cheaper than SDI systems). In comparison with furrow systems, SDI is from 44% to 79% dearer, primarily due to a greater fixed cost.

Table 1: Irrigation cost comparison ($/ML) for Callide Valley spray and SDI irrigation systems

	Hand shift	Side roll	Travelling boom	Travelling gun	1.0m Spacing SDI	1.5m Spacing SDI
Fixed Costs						
Depreciation	$5.80	$21.91	$15.61	$10.21	$33.68	$30.13
Interest	$12.76	$26.50	$25.91	$18.94	$32.47	$29.45
Total Fixed Costs	**$18.57**	**$48.41**	**$41.52**	**$29.15**	**$66.15**	**$59.58**
Operating Costs						
Electricity, fuel	$21.31	$21.31	$21.31	$28.52	$21.31	$21.31
Water Charge	$15.05	$15.05	$15.05	$15.05	$15.05	$15.05
Repair Costs	$1.12	$8.63	$7.09	$3.85	$2.20	$2.09
Total Operating Costs	**$37.48**	**$44.99**	**$43.45**	**$47.42**	**$38.56**	**$38.45**
Labour Costs						
Labour	$18.75	$8.33	$5.21	$7.35	$2.97	$2.97
TOTAL	**$74.80**	**$101.73**	**$90.18**	**$83.91**	**$107.67**	**$101.00**

Table 2: Irrigation cost comparison ($/ML) for Callide Valley furrow and SDI irrigation systems

	Furrow	1.0m Spacing SDI	2.0m Spacing SDI
Fixed Costs			
Depreciation	$6.51	$32.15	$22.33
Interest	$14.40	$31.24	$22.89
Total Fixed Costs	$20.91	$63.39	$45.21
Operating Costs			
Electricity, fuel	$12.30	$12.30	$12.30
Water Charge	$15.05	$15.05	$15.05
Repair Costs	$1.28	$1.92	$1.63
Total Operating Costs	$28.64	$29.28	$28.98
Labour Costs			
Labour	$4.00	$2.99	$2.99
TOTAL	**$53.55**	**$95.66**	**$77.19**

CROP PROFITABILITY

Crop profitability can be improved with SDI through water savings and yield improvements. The extent of water savings for SDI is dependent upon the irrigation system with which the comparison is made. Camp (1998) reports on a range of comparative studies of SDI with traditional irrigation systems, where irrigation water savings ranged from 0 to 50% for crops as diverse as cotton (40% less water), lucerne (no change in water use), maize (30% less water) and potatoes (30 to 50% less water). In these studies, crop yields for SDI systems were equal or better than other systems – crops compared have included asparagus, cotton, cucurbits, grain sorghum, lucerne, maize, peanuts, potatoes, sugarcane, tomatoes. Yield increases have resulted from:

- more even application of water
- less stress days
- more efficient application of nutrients
- ease of application of crop protection chemicals
- reduced damage from saline or sodic water.

The crops that have been successfully grown with SDI in the Callide Valley have included cotton, cucurbits (pumpkins, cucumbers and watermelons), culinary herbs, grain sorghum, lucerne, maize, mungbeans, navy beans and wheat. In this analysis the assumptions for prices, yields and water requirements for Callide Valley crops in *Table 3* are used. For SDI systems yield increases of 20% for all crops is assumed (except for lucerne where an increase of 25% is used, based on commercial experience). Water savings through the use of SDI are assumed to be 10% for spray irrigated winter crops, 20% for spray irrigated summer crops and 30% for furrow irrigated summer crops (for lucerne it is assumed that no irrigation water is saved). The nil water saving from irrigating lucerne with SDI is the result of commercial practice of under irrigating commercial lucerne in this district with traditional spray systems.

Table 3: Price, yield and irrigation requirement assumptions used in economic evaluation of irrigation systems

		Traditional Irrigation Systems			**SDI Irrigation Systems**	
CROP	**On-farm Price[a] ($/t)**	**Common system used**	**Irrigation Requirement (ML/ha)**	**Yield[b] (t/ha)**	**Irrigation Requirement (ML/ha)**	**Yield[b] (t/ha)**
Barley	$111	Side roll	2.5	4.4	2.3	5.3
Chickpea	$328	Side roll	2.5	2.5	2.3	3.0
Cotton	$425	Furrow	6.0	6.9	4.2	8.3
Lucerne – Establishment		Hand shift	1.5		1.5[c]	
Lucerne – Year 1	$200	Hand shift	8.5	15.0	8.5	18.8
Lucerne – Year 2	$200	Hand shift	10.0	20.0	10.0	25.0
Lucerne – Year 3	$200	Hand shift	5.0	10.0	5.0	12.5
Maize	$132	Furrow	5.0	7.5	3.5	9.0
Millet	$297	Side roll	2.5	2.5	2.0	3.0
Mungbean	$465	Side roll	2.5	1.9	2.0	2.3
Navy bean	$842	Side roll	2.5	1.8	2.0	2.2
Peanut	$710	Furrow	6.0	5.0	4.2	6.0
Sorghum	$106	Furrow	4.0	6.3	2.8	7.5
Soybean	$374	Furrow	5.0	3.8	3.5	4.5
Sunflower	$307	Furrow	4.0	1.8	2.8	2.2
Wheat	$159	Side roll	2.5	4.0	2.3	4.8

[a] Cotton price is on a $/bale basis
[b] Cotton yield is on a bale/ha basis
[c] Spray irrigation used to establish lucerne

Table 4 summarises the gross margins for traditionally irrigated crops in the Callide Valley, compared with SDI irrigated crops.

Under traditional irrigation systems, the highest returns per ML of water occur with peanuts, lucerne, navy beans and cotton. With SDI, peanut, navy beans, lucerne and cotton also have the highest return per ML. More importantly, the improvement in gross margin for these crops is from 31% to 48% (that is, from $338/ha for navy beans to $947/ha for second year lucerne). Clearly SDI has the potential to significantly increase the returns from a limited water resource. This is critical for the continued use of the aquifer in the Callide Valley.

Table 4 Gross margin comparisons between traditionally and SDI irrigated crops in the Callide Valley

	Traditional Irrigation Systems			SDI Irrigation Systems	
CROP	**Common system used**	**$/ha**	**$/ML**	**$/ha**	**$/ML**
Barley	Side roll	$87	$35	$210	$84
Chickpea	Side roll	$500	$200	$690	$276
Cotton	Furrow	$1,506	$251	$2,141	$357
Lucerne - Year 1	Hand shift	$1,928	$193	$2,648	$265
Lucerne - Year 2	Hand shift	$3,078	$308	$4,026	$403
Lucerne - Year 3	Hand shift	$1,528	$306	$2,002	$400
Maize	Furrow	$446	$89	$684	$137
Millet	Side roll	$413	$165	$596	$239
Mungbean	Side roll	$505	$202	$717	$287
Navybean	Side roll	$710	$284	$1,048	$419
Peanut	Furrow	$2,312	$385	$3,071	$512
Sorghum	Furrow	$116	$29	$281	$70
Soybean	Furrow	$937	$187	$1,259	$252
Sunflower	Furrow	$137	$34	$280	$70
Wheat	Side roll	$238	$95	$391	$156

DEVELOPMENT BUDGETING FOR ALTERNATIVE IRRIGATION SYSTEMS

Cumulative net cashflow budget

Discounted cashflow budgeting was used to evaluate the profitability of investment in each of the following alternative irrigation systems:

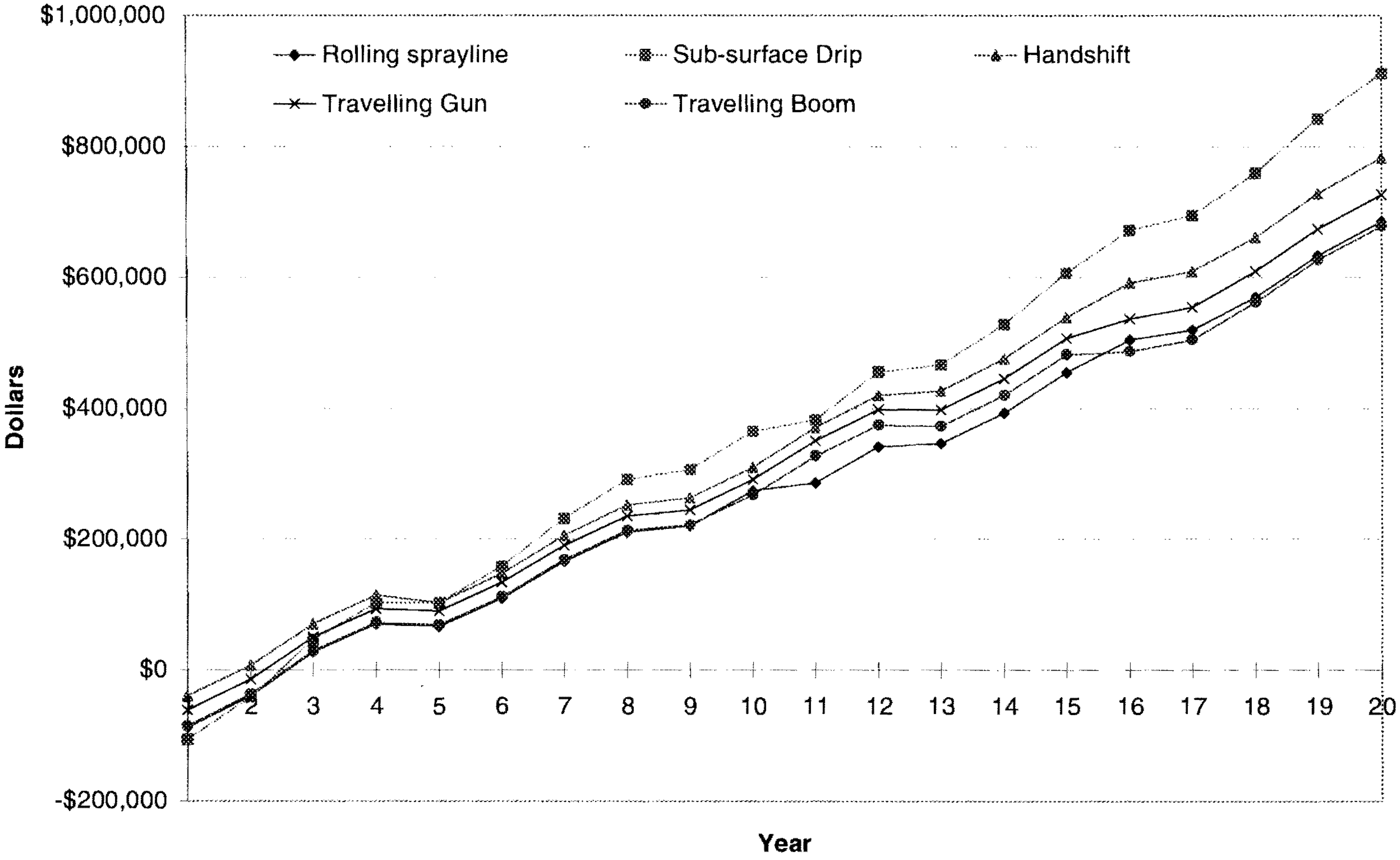
- hand shift irrigation
- rolling sprayline
- travelling gun
- travelling boom
- SDI on 1.5m spacings.

The assumptions used in drawing up these discounted cashflows were:

- a traditional rotation of the grain crops barley, millet, and navy beans, and lucerne for hay used
- all systems installed from a bare paddock base, on an area of 28ha
- yield improvement from SDI assumed to be 20% for grain crops, 25% for lucerne grown for hay
- water savings of 10% for winter crops and 20% for summer crops under SDI compared with spray irrigation. A nil saving on water use for SDI lucerne due to the commercial practice of not fully irrigating lucerne.
- overdraft interest rate of 10% and savings interest rate of 3%
- capital cost of irrigation system is written off over 3 years under Section 387-125 of the Australian Tax, plus a 10% investment allowance in year of purchase for water conveyancing equipment (provided installation is part of approved farm plan and exceeds $5000 cost)
- tax payable as per the Australian Tax Schedule 1998-99
- 20 years chosen as the time period over which comparison made. Replacement schedule for irrigation systems is 10 years for rolling sprayline and SDI laterals, 15 years for travelling gun and travelling boom, and 20 years for hand shift after initial installation.

The cumulative net cashflow for each system over the period of comparison is shown in *Figure 1*. These values are in 2000 dollars. The figure shows that the SDI, rolling sprayline and travelling boom systems are the most expensive to establish, with the hand shift system the least costly to set up. The breakeven point for all systems occurs in the second year after installation. The SDI system has the highest cumulative net cashflow of the five systems. The high cumulative net cashflow for the SDI system is dependent on water savings and yield increases from this system.

Figure 1: Cumulative cashflows for the five irrigation systems for the traditional Callide Valley irrigated cropping system



Net Present Value Comparison

A sum of money in the hand today is worth more than a similar sum in the future. This is regardless of the effects of inflation. It results from the fact that money can be used in different ways to earn an annual rate of return. A sum of money invested today will grow at a rate of 3% to 7% over the year. Thus a dollar you have in a year's time is equal in value to a smaller sum today.

This time effect on the value of money needs to be considered when assessing the worth of undertaking a particular investment project. The technique used to do this is `discounting' - it allows you to determine the contribution that different projects can make to the net worth of a business. Discounting means deducting from a project's expected earnings the amount that the investment fund could earn in its most profitable alternative use. Discounting the value of money to be received or spent in the future, is a way of adjusting the future net rewards from the investment back to what they would be worth in the hand today.

The discounted cashflow analysis was used to compare the five irrigation investment alternatives. It involved budgeting all the expected flows of cash out and cash in, and adjusting these flows back to equivalent present value. The results of this analysis are presented as Net Present Values (NPVs) and Internal Rates of Return (IRR) in *Table 5.*

The NPV is a measure of the discounted value of a number of future receipts, minus the discounted value of a number of future expenditures. The investment that gives the highest NPV is the one that promises to add the most to the businesses net worth.

The IRR is that interest rate which just balances the present values of cash receipts and cash outlays. It is the discount rate that makes the discounted NPV equal to zero. With the IRR method, an investment is worthy if the IRR exceeds the interest cost of using the capital in this way. It can be thought of as being a bit like the average annual return on capital invested in the project. It can also be interpreted as the maximum interest rate that a business could afford to pay for the funds to carry out the project and not lose any money.

Table 5: Net Present Values and Internal Rate of Return for alternative irrigation developments

	Discount Rate %	Hand shift	Side roll	Travelling Boom	Travelling Gun	SDI
Net present value of	0%	$588,033	$534,551	$523,530	$551,502	$703,079
annual cash flows	5%	$354,026	$311,162	$309,493	$330,135	$412,726
after tax	10%	$231,607	$194,923	$196,423	$213,629	$261,485
	15%	$161,771	$128,820	$131,184	$146,678	$175,324
	20%	$118,776	$88,194	$90,605	$105,163	$122,236
Internal rate of return %		127%	57%	59%	82%	64%

The NPV is greatest for the hand shift and SDI irrigation systems. The IRR value for the SDI system places it behind hand shift and travelling gun systems. Where two projects have conflicting NPV and IRR values (for example where a project has a lower NPV than another but a higher IRR), then the project with the greatest NPV should be chosen. On this basis, the installation of a SDI is the preferred option.

WATER SUPPLY AND SDI

The foregoing analysis assumes that the supply of irrigation water is fixed, as is the choice of cropping rotation used. For several decades groundwater reserves in the Callide Valley have been diminishing. By 1990 irrigators had used several minor adjustments in their irrigation strategies to cope with this decline, while retaining familiar cropping systems and irrigated areas (Huf, 1991). These adjustments included:

- quick, even application of irrigation water
- increased fallow moisture storage

Since then, irrigators have adopted significant enterprise changes aimed at maximising their returns to water - their most limiting resource. The observed changes have included:

- cropping intensification, using crops with greater potential returns than traditional grain crops. Horticultural crops such as cucurbits and grapes have been grown because of their greater return per unit of land and water.
- the adoption of SDI to irrigate traditional and alternative crops
- development of new industries which have a high return per unit of water – redclaw crayfish, native flowers and eucalypts, fresh and processed herbs.

A static and multi-period programming model was developed by Harris (1996) to examine the most appropriate approach for irrigators to cope with diminishing groundwater supplies. The study concluded that:

- farm profitability is significantly improved by diversification into horticultural crops and the installation of SDI for high returning crops
- investment in SDI is supported by the shift to high returning horticultural crops and the retention of lucerne within cropping systems, even as water allocations fell to 50%.
- the availability of casual labour is an important constraint affecting the scale at which horticultural activities could be undertaken
- high capital investment in infrastructure for redclaw production prevents its adoption within the 5 year time frame for the multi-period model developed
- current market prices for water provide no incentive towards the adoption of more efficient water use – the limitation in supply is the chief driving force for this.

Subsequent to this study the author has developed Farm Profit Planner, a Microsoft Excel® model, which is currently being evaluated with irrigators as a means to examine the profitability of alternative enterprises and technologies where groundwater supplies are declining.

COMMERCIAL VERIFICATION OF SDI

As in all economic analyses, that in this paper is dependent upon underlying assumptions. For this study, the assumptions pertaining to water savings and yield increases through the use of SDI are critical. It has been difficult to get good data on the yields and water use of SDI and alternative irrigation systems – many central Queensland irrigators who have adopted SDI have continued expansion of installations in the firm belief that it is economic. Water use and yields recorded from commercial crops would seem to support this (see *Tables 6 and 7*).

Table 6: SDI and spray irrigated lucerne comparisons

		Subsurface Drip			**Spray Irrigation**		
Grower	**Year**	**Yield (bales/ha)**	**Irrigation (ML/ha)**	**Rain (mm)**	**Yield (bales/ha)**	**Irrigation ML/ha**	**Rain (mm)**
Stringer	1994-95	24.95	12.19	294			
Stringer	1995-96	26.45	11.19	543			
Stringer	1996-97	22.98	6.91	647			
Biloela RS	1996-97	21.23	5.59	720	18.88	9.03	720
Biloela RS	1997-98	16.98	6.48	400	12.68	11.30	400

Table 7: SDI and Furrow irrigated cotton comparison from commercial cotton areas

		Subsurface Drip			**Furrow Irrigation**		
Grower	**Year**	**Yield (bales[1]/ha)**	**Irrigation**	**Rain (mm)**	**Yield (bales/ha)**	**Irrigation ML/ha**	**Rain (mm)**

			(ML/ha)				
Manwaring	1995-96	10.13	4.69	430	8.40	5.68	430
Sullivan	1995-96	8.65	2.17	n/a	8.65	5.43	n/a
Manwaring	1996-97	9.26	3.71	364	8.89	5.19	364
Manwaring	1996-97	10.32	3.71	364	8.89	5.19	364
Brosnan	1997-98	7.46	1.98	n/a	7.11	4.04	n/a

1 Bales assumed to weigh 225 kg

There are currently a number of research and extension initiatives that will go some way towards obtaining the necessary data to verify the yields, irrigation requirements and profitability of crops irrigated with SDI and alternative irrigation systems. These include:

- the current National Centre for Engineering in Agriculture's project 'Scoping study of trickle irrigation use in the Australian cotton industry' (funded by the Cotton Research and Development Corporation); and,
- the Australian Cotton Cooperative Research Centres project 'Improving on farm irrigation water use efficiency in the Queensland cotton and grain industries' (funded by the Queensland Department of Natural Resources Rural Water Use Efficiency Initiative).

These are steps towards addressing some of the research, development and extension priorities in relation to SDI that were identified in Harris (1998).

CONCLUSION

The partial economic analysis of SDI in this paper, indicates that the system has the potential to not only save on irrigation water and increase crop yields, but also increase the profitability of irrigated cropping systems in the Callide Valley of central Queensland. It must be remembered, however, that any economic analysis is only as good as the data used to carry it out. Conservative estimates of the benefits of this technology have been used, together with the best possible information available for a `theoretical' irrigation block. Because of different assumptions operating in the real world, anyone considering SDI as an alternative system to their existing one needs to carry out their own analysis of the benefits that may accrue, and the costs incurred in establishing SDI on their farm. The preceding analysis provides a suitable framework for them to initiate such an analysis.

As more information becomes available on the costs and benefits of SDI it will become possible to update this analysis and move to a whole farm analysis where a more complete evaluation is possible.

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