

Economic analysis of irrigation re-use systems in the Macalister Irrigation District of Eastern Victoria

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Abstract. Irrigation re-use systems are a common way of improving water use efficiency on irrigated dairy farms in the Macalister Irrigation District. A partial budget analysis of installing a range of irrigation re-use systems on an existing dairy farm was conducted using a case study approach. Two re-use dam sizes were tested – 6 ML and 9 ML. The analysis quantified the benefits of installing a re-use system through growing and consuming additional grazed pasture. There are also potentially other benefits of installing a re-use system both on and off farm, including improved irrigation management and reduced nutrient transfer from the capture area. The analysis found that irrigation re-use systems were almost always a good investment, regardless of the volume of water re-used or the amount of additional pasture consumed. The 9 ML dam had some economies of size, and therefore a lower pasture response per megalitre of water re-used was needed to meet the decision criterion (10% nominal internal rate of return). Only in the situation where both the value of pasture and percentage of water re-used were low ($100/t DM and 10% respectively), was the investment not justified on economic grounds. For a 6 ML re-use dam, a pasture price of $150/t DM and a re-use rate of 10% was still able to achieve a nominal internal rate of return of 12%.

Keywords: Dairy farming systems, economics, irrigation re-use system.

Introduction

Dairy farmers continually strive to use water more efficiently on their farms. One way to improve irrigation water use efficiency is to construct a water re-use system. Irrigation re-use systems capture water that runs off the end of each bay after irrigation. Re-use systems are also a way for farmers to collect nutrient rich water which may otherwise be lost from the property. Generally, a re-use system will comprise a capture dam, pump and a series of drains or pipes to channel water into and away from the dam. Runoff from irrigation and rainfall accumulates in the dam and can be pumped to locations around the farm.

The Macalister Irrigation District (MID) is located within the Gippsland region of Victoria, and covers an area of approximately 53,000 hectares (Southern Rural Water 2011). Around 33,500 hectares of this area is under irrigation, with irrigated dairy farming the predominant land use. It is estimated that approximately 30% of irrigators in the MID operate water re-use systems. Farms with high reliability water share allocations per hectare. This leads to a more secure irrigation water supply, and as a consequence they are less likely to have re-use systems (McAinch 2003).

Improved irrigation management leads to higher productivity, and reduces the environmental impact of irrigation by capturing water and nutrients before they leave the property. (G. Lamb [Department of Primary Industries] pers. comm. 2010). There are also a range of benefits of capturing irrigation water that extend beyond the farm boundary; for example, reducing the amount of nutrients, agrochemicals and pharmaceuticals that enter waterways where they can degrade natural ecosystems.

There are a range of costs and benefits associated with installing an irrigation re-use system.

Some benefits of re-use systems on dairy farms are:

- Additional water leads to increased pasture production and decreased reliance on purchased fodder
- Increased flexibility within the system
- Increased water use efficiency
- More flexibility in the timing and duration of irrigation
- Creation of a closed system (resources of water and nutrients remain on farm)

Some costs, disadvantages and risks of re-use systems include:

- Initial investment cost
- Increased repairs and maintenance costs (pump, motor and drains)
- On-going operating costs of using the system
- Loss of productive milking area
- Not a drought strategy (only get sufficient runoff in years with high allocations and average rainfall)

The aim of this analysis was to investigate the economic impacts of installing an irrigation re-use system on an irrigated dairy farm. For the purpose of this analysis, the assumed benefits of installing an irrigation re-use system were restricted to:

1. Additional perennial pasture available (t DM/ha) for grazing

2. The value of extra perennial pasture consumed ($/t DM)

It was expected that the installation of a re-use system in the MID would be a good investment when the quantifiable benefits were achieved.

Approach

Partial Budget

A partial budget, including a discounted net cash flow analysis, was used to investigate the economic feasibility of installing an irrigation re-use system on an existing dairy farm located in the Macalister Irrigation District. A partial budget considers the balance of economic costs and benefits of a proposed change affecting only part of the farm (Malcolm et al. 2005). The method for this analysis included use of a 10-year development budget as described in Malcolm et al. (2005). The measures used in assessing the profitability of re-use systems were nominal internal rate of return (IRR) for the extra capital invested and years for cumulative net cash flow to break-even. A description of these measures can be found in Appendix 1. The partial budget method was used because the adoption of a re-use system should make little difference to the overall way that the farm is managed. In the analysis that follows, a nominal IRR of 10% or greater was used to indicate a profitable investment. This was considered appropriate as re-use systems are a well established technology. Although variability in performance between years could be expected, it is considered a relatively low risk investment.

In consultation with a steering committee of farmers and industry specialists, costs for each major aspect of installing a re-use system were estimated (Table 1). Assumptions associated with these costs, along with other general assumptions are outlined below. Six scenarios were used to test the profitability of the system under a range of defined conditions; four have been reported here. However, it is unlikely that uniform conditions would occur over a 10-year period. Therefore, a sensitivity analysis was conducted to determine the minimum average pasture response per megalitre of irrigation water (t DM pasture consumed/ML) that was required to achieve a nominal IRR of 10%.

General assumptions

The following general assumptions have been made in the analysis:

- Before installing the system, irrigation management followed best practice as defined by the farmer steering committee.
  - 6 ML/ha irrigation water applied annually
  - 12-14 irrigations per year
  - 0.5 ML/hr flow rate
- Water re-use (irrigation and rainfall) was estimated annually and based on the total amount of water used. An annual rainfall of 450 mm was assumed.
- Dam size was limited to 1 ML for every 10 ha of titled area, in line with the Farm Dams Act (Farm Dams Act 2002).
- The dam was built to the maximum volume for each titled area i.e. if 90 ha were available; a 9 ML dam was constructed. All water re-used from the dam was returned to the paddock using flood irrigation.
- After installing the re-use system, it was assumed that the area collecting runoff on the farm was properly drained so excess water was captured by the re-use dam. Before installing the re-use system, all runoff water was assumed to flow to the lowest point of the farm and into the district drainage supply.
- The percentage of water re-used was assumed to be either 10 or 20% of total water applied. These values are estimated averages across years. Actual runoff will vary with season, time of year and irrigation practice.
- The pasture response per ML was averaged across seasons. It is recognised that responses vary across the season, and that the average will depend on a range of factors.
- Additional pasture consumed at grazing was valued as a substitute for purchased hay. Again, this would be expected to vary between seasons, so the values here have been used as an average across years.
- The value of additional vehicle use (and depreciation) to operate the system was considered minimal and has not been included.
- No additional labour was required to operate the system.
- Irrigation water and rainfall were assumed to be re-used at the same rate, for example, 10% of the water applied (either by rainfall or irrigation) ended up as runoff.
- Insurance costs for the pump, motor and fencing were excluded.

Construction Costs

Construction costs for the re-use system were based on five variables:

- The application and land survey fees
- Construction of the dam
- Installation of the pump
- Installation of the pipes
- Fencing of the system

Total System Installation Cost

Total system installation costs for a 6 ML and 9 ML dam are presented in Table 1. These are two common sizes installed on farms in the MID. If the dam is any smaller, the fixed costs would outweigh the benefits of the system. If the dam is much bigger than 9 ML, it becomes difficult to provide adequate drainage across the farm into the re-use system.

System Operating Cost

Maintenance and operating costs were included as $4/hour and $8/hour respectively of pump operation. The same sized pump was used for all scenarios and thus, maintenance costs varied proportionally with the volume of water re-used. The value of pasture lost as a result of building the re-use dam was estimated using the area expected to be lost from production, current pasture consumption and estimated value of the pasture lost (Table 2).

Benefits from installing a re-use system

The benefits of the re-use system were valued in terms of additional pasture consumed. The value of additional pasture to the farm system was based on the price of local pasture hay ($/t DM). The sensitivity of the analysis to changes in the value and quality of additional pasture consumed was also tested. Initially, pasture hay was valued at $150/t DM, and an average of 1 t DM pasture was consumed for every ML of water re-used. All additional pasture was assumed to be consumed by cows at grazing.

Results

The results for each scenario are presented in Table 3. The decision rule for the analysis was:

- >10% nominal IRR justifies the investment on economic grounds alone. This includes an allowance for paying interest, inflation and a risk premium.
- <10% nominal IRR requires non-economic benefits to justify the investment.

For both the 6 ML and 9 ML sized dams, the performance of the investment increased with the volume of water re-used. For example, scenario 6A (6 ML dam re-using 10%, pasture valued at $150/t DM) was an attractive investment under the initial assumptions, earning a nominal IRR of 12%. However, if the farmer was re-using 20% of water applied, installing a re-use system seemed even more attractive, earning an IRR of 29% for the extra capital invested (Table 3).

Sensitivity analysis

Pasture consumption required to justify the investment (nominal IRR of 10%)

The amount of pasture consumed (t DM) per ML of re-use water required to achieve a nominal IRR of 10% is presented in Table 4. As the value of pasture or the percentage of water re-used increases, the amount of pasture consumed per ML needed to achieve the desired returns, decreases. However, both fodder price and pasture response will vary between seasons. If a run of years of poor seasonal conditions occurred, it may be difficult to achieve a nominal IRR of 10% despite best management practices. However, it is unlikely that a low pasture price would occur consistently with a low re-use rate in the long-run.

Proportion of water re-use required for an IRR of 10%

The performance of an investment in an irrigation re-use system is highly dependent on the amount of water re-used (as a proportion of total irrigation water), the pasture response achieved and the value of the pasture to the farm (Table 5). When both the value of pasture and pasture response rate were low, a greater proportion of water needed to be re-used to produce enough pasture and achieve the desired nominal IRR of 10% (Table 5). Given that these scenarios were simulated under 'best practice' management, the re-used water is equivalent to water that would have previously flowed off the farm into the regional drainage system.

Discussion

Installing a re-use system would be a good investment on an irrigated dairy farm in the Macalister Irrigation District under most circumstances. The performance of the investment depended on three variables: 1) pasture response per megalitre of water re-used; 2) value of pasture per tonne of dry matter; and 3) the volume of water re-used. These variables are linked. For example, as the volume of water re-used increases, the pasture response per megalitre required to justify the investment, decreases. This increase in water re-used spreads the substantial fixed costs of the investment over a greater volume of water, decreasing the required pasture response rate. Situations where installing a re-use system is not a good investment occur when two of the three variables are low. For example, low pasture response and low pasture price.

The analysis also showed that economies of size exist when comparing a 9 ML dam on 90 ha with a 6 ML dam on 60 ha. This was because of the relatively high fixed costs associated with construction of the dam and the relatively low variable cost of pumping re-use water. As construction costs contain a large fixed component ($30,000 for pump, motor and pipes), they are only partly related to dam size, making a 9 ML dam relatively less expensive on a per ML storage basis than the 6 ML dam. This is further compounded by the additional runoff stored and re-used through a 9 ML dam. The greater volume further dilutes the initial construction costs, reducing the savings required to justify the investment. Therefore, re-using 10% of irrigation water was sufficient to justify the investment for a 9 ML dam but, not enough to justify the 6 ML system.

With both the 6 ML and 9 ML sized dams, it was clear that if low water re-use occurred, particularly with a low fodder price, a substantially higher pasture response was required to achieve the same economic returns (Table 5). Seasonal variations would be expected to affect the amount of water re-used and hence, the pasture consumption response.

In the analysis described above, it was assumed that the operator had the management skills to utilise additional pasture and hence reduce the amount of purchased fodder. Had this not been the case, the economic benefits from the re-use system would not be fully realised, and the re-use system may add little value to the farm system. If additional pasture cannot be consumed at grazing, then the cost of consuming the feed may offset some of the benefits of the re-use system. For example, in option 6A (Table 4) where additional pasture is valued at $200/t DM, accounting for conservation and feed out costs of $100/t DM reduces the marginal value of the additional pasture consumed to $100/t DM. Consequently, the pasture response required per ML of water to achieve the desired IRR of 10% increases from 0.7 t DM/ML to 1.4 t DM/ML.

Conclusion

A 10-year partial discounted net cash flow budget analysis has shown that installing an irrigation re-use system for pastures grazed by dairy cows would be an economically attractive capital investment in many situations. Provided the operator can utilise the additional pasture, installing an irrigation re-use system will most likely have a positive impact on farm profit.

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Appendices:

Appendix 1 – Definitions of economic measures

<u>*Internal rate of return (IRR)*</u> is the discount rate at which the present value of future expected benefits from the project will equal the present value of all the costs of the project. This measure is used to compare different investment options. For this analysis any option able to achieve an IRR of greater than 10% was considered worthwhile, with 10% being the expected return from another investment, such as investment on the stock exchange (i.e. the opportunity cost).

<u>*Years to positive net cash flow*</u> This is a measure of the time taken for the returns from an investment to pay for the investment's purchase. This occurs when the cumulative net cash flow becomes positive. It is not a measure of economic or financial benefit, simply the time taken to remove the debt and regain positive cash flow.

Table 1. Estimated installation costs for an irrigation re-use system

Size of re-use dam	*6 ML*	*9 ML*
Application fees	$ 3,500	$ 4,500
Construction of the dam	$ 42,000	$ 63,000
Installation of the pump	$ 20,000	$ 20,000
Installation of pipes	$ 10,000	$ 10,000
Installation of fencing	$ 900	$ 1,100
Total	$ 76,400	$ 98,600

Table 2. Annual operating cost for each option tested

Size of re-use dam	*6 ML*		*9 ML*	
Option	6A	6B	9A	9B
Water re-use rate (%)	10	20	10	20
Area of pasture lost (m^2)	1,500	1,500	2,250	2,250
Current pasture consumption (t DM/ha)	13	13	13	13
Value of lost pasture ($/year)	$300	$300	$440	$440
Total volume re-used (ML)	63	126	95	189
Pump capacity (ML/hr)	0.5	0.5	0.5	0.5
Annual operating hours	126	252	189	378
Annual operating cost	$1,030	$2,070	$1,560	$3,100
Annual maintenance cost	$500	$1,010	$760	$1,510
Total cost ($/Yr)	$1,830	$3,380	$2,760	$5,050

Table 3. Nominal internal rate of return (IRR) and years to positive net cash flow when installing an irrigation re-use system. It was assumed 1 t DM additional pasture was consumed per ML re-use water, and additional pasture was valued at $150/t DM

Size of re-use dam	*6 ML*		*9 ML*	
Option	6A	6B	9A	9B
Water re-use rate (%)	10	20	10	20
Total capital cost	$76,400	$76,400	$98,600	$98,600
Water re-used (irrigation + rainfall) (ML)	63	126	95	189
Annual net benefit in the steady state ($)	7,620	15,520	11,490	23,300
Years to positive net cash flow	9	4	8	4
Nominal IRR (%)	12	29	15	35

Table 4. The pasture response (t DM/ML) required to achieve a nominal internal rate of return (IRR) of 10% under different systems

	Pasture response (t DM/ML) to achieve a nominal IRR of 10%			
	6 ML dam		9 ML dam	
Option	6A	6B	9A	9B
Water re-use rate (%)	10	20	10	20
Value of pasture – $100/t DM	1.4	0.8	1.2	0.7
Value of pasture – $150/t DM	0.9	0.5	0.8	0.5
Value of pasture – $200/t DM	0.7	0.4	0.6	0.4

Table 5. Percentage of water re-used, as a proportion of total water used, required to achieve a nominal internal rate of return (IRR) of 10% at three pasture values ($/t DM), and different pasture responses (t DM/ML). The percentage of water re-used was based on the volume of water originally applied to the area

Pasture response (t DM/ML)	*Value of pasture ($/t DM)*	*Percentage of water re-used to achieve a nominal IRR of 10%*	
		6 ML dam	*9 ML dam*
0.5	$ 100	42%	35%
	$ 150	23%	19%
	$ 200	15%	13%
1.0	$ 100	15%	13%
	$ 150	9%	8%
	$ 200	7%	5%
1.5	$ 100	9%	8%
	$ 150	6%	5%
	$ 200	4%	4%