 

# Economic analysis of automatic flood irrigation for dairy farms in northern Victoria

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**Abstract.** Interest in automatic flood irrigation is strong, given the labour and lifestyle benefits it can provide. An economic analysis of three automated flood irrigation systems for a dairy farm in northern Victorian indicated that automatic irrigation can be a profitable labour saving investment in many cases. However, profitability was sensitive to the amount and value of the labour saved.

Pneumatic and timer systems were good investments regardless of the area they were installed to service. The supervisory control and data acquisition (SCADA) system was a good investment when more than 50 ha were serviced by the system. Irrigation water savings are unlikely to have a significant effect on the profitability of automatic irrigation, particularly if the price of water is under $100/ML. The labour efficiency of the irrigation system before automation has an important effect on the magnitude of benefits that might be achieved by automation. Larger bay sizes and fewer bay outlets enable the capital cost of automatic irrigation to be substantially decreased. However, this reduces the economic advantage of automatic irrigation systems as the labour savings are reduced.

**Keywords:** dairy farming systems, automatic irrigation, economics.

## Introduction

The labour involved in flood irrigation can be significant, and it is often not possible to schedule irrigation at a convenient time of the day. Therefore, use of automatic flood irrigation is of interest to farmers because it can potentially provide both labour and lifestyle benefits. Automation of flood irrigation may also enable water savings in some situations. There have been various automatic flood irrigations systems available in northern Victoria for some time, with a number of developments and improvements occurring in recent years. Approximately 11% of dairy farms in the Central Goulburn area have some form of automatic irrigation (Goulburn-Murray Water 2006) with an average of around 25 ha per farm serviced by automation.

There appears to be little information available on the economics of automatic flood irrigation. This paper presents an economic analysis of some automated flood irrigation systems for a northern Victorian dairy farm. It is expected that automatic flood irrigation systems are potentially worthwhile investments as they provide labour and water savings.

## Background

Automatic flood irrigation is defined in this report as bay outlets and channel structures being opened and closed automatically.

A number of different automatic irrigation systems have been developed over time. The three systems that are currently most commonly installed are briefly described below. A more detailed description is provided in a booklet by Department of Natural Resources and Environment, Tatura (unpublished data).

### *Pneumatic system*

The pneumatic system is a permanent system that is activated by a bay sensor located at the cut-off point. The bay sensor is connected to the irrigation structures by a small polythene pipe buried in the ground. When the water enters the sensor it pressurises air which activates the opening and closing of the irrigation structures. The pneumatic systems are relatively simple and can generally be repaired by the irrigator. This system could be described as semi-automatic as it needs to be 'set up' prior to

each irrigation event. The sequence in which bays are irrigated is not flexible. The permanent nature of the pneumatic system and fixed cut-off point also means it tends to be better suited to perennial-type pastures than annual crops or pastures. This is because there is generally less variation between irrigation events for perennial pasture than annual pasture (the 'cut off point' would need to be significantly different between the first and second irrigations for annual pasture in autumn).

***Timer system***

The timer system is a portable system using battery operated clocks to open and close bays on a time basis. However, this system is not well suited to situations where the channel supply is inconsistent. The portable nature means that this system could also be described as semi-automatic as there is still a labour requirement to set up and move the timers. The flexibility and portability mean that the system can be used on a range of pasture/crop types. Unlike the pneumatic system, the timer system can be used to automate the meter outlets.

***SCADA system***

The supervisory control and data acquisition (SCADA) system uses a personal computer and software package to control irrigation via a radio link. Signals are sent from the computer to control modules in the paddock that open and close irrigation structures with linear actuators. The radio network can operate in a 10 km radius from the computer. The SCADA system is essentially a permanent system with minimal labour requirements. Bays are opened and closed on a time basis. The flexibility of this system allows it to be suitable for a range of pasture and crop types. The system has the capacity to automatically alter the time that an outlet is open if the channel supply is inconsistent, but water authorities generally do not allow this feature to be used.

**Method**

A partial discounted net cash flow budget over 10 years was used to analyse the economic suitability of installing the three automatic flood irrigation technologies. This was a modified version of an analysis conducted by Rabi Maskey (R Maskey, pers. comm., 2010). The methods used for farm management economic assessments are described in Malcolm et al. (2005). The key measures considered were net present value (NPV), real internal rate of return (IRR) and years to break-even (i.e. when the cumulative net cash flow before interest becomes positive).

***Assumptions***

The assumptions that were made when conducting the economic analysis of automated flood irrigation systems are outlined below.

*General Assumptions*

- Perennial pasture required 20 irrigations per year, at 0.5 ML/ha/irrigation.

- A labour cost of $25/hour was assumed ($12.50 and $37.50/hour were also tested).

- When irrigated manually, water flowed onto the bay for two hours.

- Channel supply was consistent, delivery of water was reliable and not an impediment to automation.

- It was assumed no water savings were generated from automation, except when a 10% saving was tested in a sensitivity analysis. The amount of irrigation water that was applied before automation was 8.25 ML/ha.

- An irrigation water price of $40/ML was assumed. A price of $100/ML and $200/ML was also tested.

- It was assumed that there was no change in pasture production as a result of installing automatic irrigation. Many farmers perceive that pasture production increases after automatic irrigation has been installed (Maskey and Lawler 2002), but this has not been quantified.

- A salvage value of 10% of the original capital value was assumed at the end of the 10-year period for all systems.

- The cost of vehicles used when irrigating was assumed to be $0.50/km.

The automation of a 16.5 ha area on a case study farm in northern Victoria has been analysed by Maskey (unpublished data). However, the 16.5 ha area is smaller than would generally be developed under the SCADA system, so situations with larger areas (three fold and six fold) were also tested. Most of the information relating to the larger areas was extrapolated from the 16.5 ha area. A description of the irrigation infrastructure that was required under the different areas is outlined in Table 1.

Without automation technology, it is estimated that around six hours of labour would be needed at each irrigation of the 16.5 ha area. This time is used for opening and closing irrigation structures, and for monitoring the flow of water down the bay. Each irrigation event would also involve approximately 30 km of travel. The costs and savings generated when irrigation was automated are given in Table 2. Assumptions relating to costs and labour and vehicle

savings for the larger areas were extrapolated from the 16.5 ha area.

**Results and Discussion**

The pneumatic and timer systems were good investments regardless of the area they were installed to service (Table 3). The economic performance of the pneumatic system was not affected significantly by the area installed. In all situations analysed, the pneumatic system took two to three years to break-even, had a real internal rate of return (IRR) of 47 to 57%, and the net present value at 10% discount rate was between $10,000 and $65,000.

The results from the analysis of the Timer system appear to be overly optimistic for the 49.5 and 99 ha areas. The labour savings assumed may be an overestimate, as general farmer behaviour does not support these results. Timer systems are generally used for smaller areas and farmers often switch from a timer system to a more permanent system, such as the SCADA system, when they increase the amount of area under automation (R Maskey and C Nicholson, pers. comm. 2010). A farmer would rarely purchase more than about six timers for one farm, as a large number of timers makes correct sequencing of individual units difficult. The timer units are also relatively bulky, which makes transport of a large number of units difficult.

The SCADA system was a good investment when it was installed to service more than 50 ha. When the SCADA system was installed on the 99 ha area it took 4 years to break-even, the IRR was 23% and the NPV at 10% discount rate was $35,000.

***Sensitivity to labour savings***

The analysis was sensitive to the amount of labour saved as a result of installing automatic irrigation (Table 4). If the labour savings were only half of what was assumed, for example if the crop grown was only irrigated 10 times per year instead of 20 and labour use was halved, the SCADA system was not a good investment. The pneumatic and timer systems also become marginal investments for the 16.5 ha area when the labour savings were halved.

In the analysis described above, it was assumed that water flowed onto each bay for about two hours when irrigated manually. This amount of time for irrigation may be appropriate to minimise losses to deep drainage on some of the lightest soils in the region. However, on many of the heavier soils opening two outlets, or even three outlets on the heaviest soils, at the same time (equivalent to four to six hours of water flowing onto a bay) would be appropriate to give uniform infiltration without excessive deep drainage (Bethune et al. 2006). If it was initially assumed that two bays were irrigated at the same time before automation, the labour and vehicle savings from automation would be less substantial than if one bay had been irrigated at a time previously.

***Sensitivity to labour price***

The effect of a 50% decrease in the value of the saved labour was the same as a 50% reduction in the amount of labour saved (Table 4 and 5). A 50% increase in the value of the saved labour increased the attractiveness of all types of automatic irrigation. If the value of labour increased by 50%, the SCADA system was a reasonable investment even for the 16.5 ha area, with an IRR of 22%, five years for cash flow to break-even and a positive NPV at 10% discount rate ($7,900).

***Sensitivity to irrigation water savings and price***

The profitability of automatic irrigation was not particularly sensitive to water savings when the water price was $40/ML. However, when water price was $100/ML, or $200/ML, a 10% water saving had a more substantial impact and even the SCADA system on a 16.5 ha area appeared to be a reasonable investment. A 10% water saving from automatic irrigation is unlikely in this case, as irrigation water applied was 8.25 ML/ha before automation, indicating that the system was already reasonably efficient. Water savings of less than 10% would be common (Lavis 2007). It should also be noted that the timer system is less likely to provide a 10% water saving than the other systems, particularly if the supply is inconsistent.

***Sensitivity to bay size/number of outlets***

Doubling the average bay size and halving the number of bay outlets enabled the capital cost of automatic irrigation to be substantially decreased. However, the economic advantage of all automatic irrigation systems is reduced as the labour savings were roughly halved (data not shown).

**Conclusions**

It appears that automatic irrigation can be a profitable labour saving investment in many cases. However, the magnitude of the benefits is particularly sensitive to the amount and value of the labour saved.

The labour efficiency of the system prior to automation also influences the profitability of investing in automatic irrigation technology. Larger bay sizes and fewer bay outlets enable the capital cost of automatic irrigation to be substantially decreased. However, this also reduces the comparative economic advantage

of automatic irrigation systems as labour savings are reduced.

The pneumatic and timer systems appeared to be very good investments regardless of the area they are installed to service. The SCADA system was a good investment when more than 50 ha were serviced by the installation of the system. Irrigation water savings are unlikely to have a significant effect on the economics of automatic irrigation, particularly if water price is under $100/ML.

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## Appendix

Table 1. Irrigation infrastructure and irrigation time for different areas

| Area of perennial pasture irrigated (ha) | 16.5 | 49.5 | 99 |
|---|---|---|---|
| Number of bay outlets | 10 | 30 | 60 |
| Number of channel checks | 1 | 3 | 6 |
| Number of wheels | 1 | 1 | 2 |
| Time taken to apply 0.5ML/ha at flow rate of 9.2ML/day (hours) | 21.5 | 64.5 | 129 |

Table 2. Costs and labour and vehicle use savings associated with installing different automatic irrigation systems under different areas

| | Pneumatic | Timer | SCADA | Pneumatic | Timer | SCADA | Pneumatic | Timer | SCADA |
|---|---|---|---|---|---|---|---|---|---|
| Area serviced by automation | 16.5 | 16.5 | 16.5 | 49.5 | 49.5 | 49.5 | 99 | 99 | 99 |
| Labour savings (hours/irrigation) | 5 | 4 | 5.5 | 15 | 12 | 16.5 | 30 | 24 | 33 |
| Vehicle use saved (km/irrigation) | 17 | 15 | 19 | 51 | 45 | 57 | 102 | 90 | 114 |
| Annual maintenance (% of original equipment value) | 5 | 10 | 5 | 5 | 10 | 5 | 5 | 10 | 5 |
| Total capital cost | $7,700 | $5,200 | $18,100 | $20,600 | $6,500 | $39,000 | $41,100 | $13,000 | $72,000 |

Table 3. Years to break-even, net present value and real internal rate of return for three types of automatic irrigation

| | Pneumatic | Timer | SCADA | Pneumatic | Timer | SCADA | Pneumatic | Timer | SCADA |
|---|---|---|---|---|---|---|---|---|---|
| Area serviced by automation | 16.5 | 16.5 | 16.5 | 49.5 | 49.5 | 49.5 | 99 | 99 | 99 |
| Years to break-even (before interest) | 3 | 2 | 8 | 2 | 1 | 5 | 2 | 1 | 4 |
| Net present value @ 10% discount rate | $9,800 | $7,200 | -$2,000 | $32,500 | $35,900 | $13,500 | $65,100 | $71,800 | $34,700 |
| Real internal rate of return (%) | 47 | 54 | 7 | 57 | Over 100 | 19 | 57 | Over 100 | 23 |

Table 4. Sensitivity to labour savings of years to break-even, net present value and real internal rate of return for three types of automatic irrigation

| | Pneumatic | Timer | SCADA | Pneumatic | Timer | SCADA |
|---|---|---|---|---|---|---|
| Area serviced by automation | 16.5 | 16.5 | 16.5 | 99 | 99 | 99 |
| Labour saved (hours/irrigation) | 2.5 | 2 | 2.75 | 15 | 12 | 16.5 |
| Years to break-even (before interest) | 6 | 7 | 11 | 5 | 2 | 10 |
| Net present value @ 10% discount rate | $900 | $100 | -$11,800 | $11,500 | $29,000 | $24,300 |
| Real internal rate of return (%) | 13 | 11 | -9 | 17 | 92 | 1 |

Table 5. Sensitivity to labour price of years to break-even, net present value and real internal rate of return for three types of automatic irrigation. Area serviced by automation is 16.5 ha.

| | Pneumatic | Timer | SCADA | Pneumatic | Timer | SCADA |
|---|---|---|---|---|---|---|
| Value of saved labour ($/hour) | 12.5 | 12.5 | 12.5 | 37.5 | 37.5 | 37.5 |
| Years to break-even (before interest) | 6 | 7 | 11 | 2 | 1 | 5 |
| Net present value @ 10% discount rate | $900 | $100 | -$11,800 | $18,800 | $14,400 | $7,900 |
| Real internal rate of return (%) | 13 | 11 | -9 | 97 | Over 100 | 22 |

Table 6. Sensitivity to water price, assuming irrigation water savings of 10% (0.8 ML/ha), on years to break-even, net present value and real internal rate of return for three types of automatic irrigation. Area serviced by automation is 16.5 ha

| | Pneumatic | Timer | SCADA | Pneumatic | Timer | SCADA | Pneumatic | Timer | SCADA |
|---|---|---|---|---|---|---|---|---|---|
| Irrigation water price ($/ML) | 40 | 40 | 40 | 100 | 100 | 100 | 200 | 200 | 200 |
| Years to break-even (before interest) | 2 | 2 | 6 | 1 | 1 | 5 | 1 | 1 | 3 |
| Net present value @ 10% discount rate | $13,700 | $11,100 | $1,900 | $19,600 | $17,000 | $7,800 | $29,300 | $26,700 | $17,500 |
| Real internal rate of return (%) | 65 | 88 | 13 | Over 100 | Over 100 | 22 | Over 100 | Over 100 | 37 |

 