

Economic analysis of irrigation modernisation connection options for a dairy farm in northern Victoria

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Abstract. Limited availability of irrigation water has placed pressure on farmers and water authorities to improve the efficiency of their operations. 'Modernisation' of irrigation infrastructure systems is occurring throughout Australia in order to improve system delivery efficiency and reduce water losses.

A case study farm was used to examine the economic impacts of investing in a range of on-farm infrastructure connection options to improve irrigation efficiency. The analysis determined the required incentive payment for each connection option along with the impact from additional pasture/saved water/saved labour for a selected option.

None of the irrigation upgrade options analysed were profitable investments for the case study farm business, without the payment of a substantial incentive. The amount of incentive required to ensure the farmer was no 'worse off' varied markedly between the options analysed. The options with low capital expenditure, but higher water losses, appear the most profitable in all water availability scenarios, particularly under low irrigation water availability.

Key Words: dairy, irrigation, water.

Introduction

The dairy industry is Victoria's largest rural industry, with a gross value of raw milk production of around $2.4 billion in 2008-09. In northern Victoria, the industry makes up one-third of the value of Victoria's milk production and generates significant flow on effects through downstream processing into export products, such as milk powder, butter and cheese (Department of Primary Industries 2011). ABARE (2009) estimates this regional economic multiplier effect to be in the order of 2.5 from the dairy industry.

The Victorian dairy industry uses more than half of Victoria's total irrigation allocation primarily to grow pasture as fodder for milk production (Linehan et al. 2004; Qassim et al. 2008). The recent drought conditions faced by irrigators in northern Victoria and southern New South Wales have resulted in a substantial decrease in the availability of irrigation water. Accelerated structural adjustment has taken place in northern Victoria due mainly to drought, low irrigation water allocations and fluctuating milk prices (Dairy Australia 2010).

Limited availability of irrigation water has also placed pressure on water authorities to deliver water more efficiently. Irrigation infrastructure upgrades are currently underway across most states in Australia to improve delivery efficiency and to reduce system losses. Water savings can be recovered through reducing leakage, seepage, evaporation and system inefficiencies by way of reconfiguring, rationalising and modernising irrigation systems. Investments are being made in automating channel regulators, renovating/replacing channels, rationalising obsolete infrastructure and installing more accurate meters. In some cases a shift between the public and private irrigation asset boundary occurs, with the public supply system retracting to larger channels and farmers taking ownership and control of smaller channel infrastructure.

Upgrading irrigation delivery infrastructure is often seen as 'the answer' to address the objectives of improved delivery efficiency for the water authority and improved water efficiency and profitability at the farm level. However, there are several 'conflicts' that can occur when upgrading irrigation infrastructure:

- increasing the sophistication of the delivery system will generally lead to an increased cost per unit of water delivered to the farm;
- transferring channels from the water authority to individual farmers will reduce the volume of water available for irrigation as the delivery losses are also transferred to the farmer; and
- replacing Dethridge wheels with more accurate meters is likely to reduce the volume of water delivered to many farms.

The aim of this project was to analyse the profitability of various irrigation connection options available to a case study farm in northern Victoria. Given these options involve the farmer taking over a section of the delivery infrastructure and the associated water losses, a key focus of the analysis was to determine the required incentive payment for these options to be attractive investments for the case study farm business. The impact

of factors such as labour savings, and increased pasture production, that may occur through upgrading the irrigation infrastructure were also analysed.

Method

The approach comprises several key aspects, namely a steering committee, the use of a case study farm and spreadsheet modelling. The incentive required for the case study farm to be no worse off has been examined by imposing different scenarios on the case study farm without changing the current production system.

Steering committee

Considerable inputs were obtained from a steering group comprised of dairy farmers, consultants, a rural counsellor, a water industry representative, an extension officer, economists and scientists. The project steering group met at least every three months and provided overall direction on the systems to be analysed, the issues that needed to be considered and communication of the outcomes from the analysis. This ensured the analyses carried out were subject to rigorous questioning and a broad range of perspectives were considered.

Case study

A case study farm approach was chosen to examine the impact of a range of irrigation connection options. This approach was considered appropriate given the complexity behind the farm business management decision-making process (Malcolm et al. 2005). An in-depth examination of a small number of businesses is generally more beneficial than surveying a large random sample Crosthwaite et al. (1997). The options were developed with support from an irrigation surveyor in conjunction with the case study farmer. A total of four water delivery options were assessed and different scenarios investigated under each option. A fifth option where the area of perennial pasture is moved from one part of the farm to another is also evaluated. The analysis compares each option to the status quo where the farm irrigation network continues to be operated in its current state.

The case study farm is located in the Murray Valley Region of Victoria approximately 40km north of Shepparton on the Murray Valley No. 6 channel. The farm consists of six separate allotments or part allotments, which were originally soldier settler blocks. All allotments have at least one water supply outlet and the farm has a total of 12 outlets. An internal laneway system links each allotment to allow stock movement.

The land available for pasture or feed production is 213 ha (out of a total area of 250 ha) with a high reliability water share of 921 ML and a 640 ML groundwater pumping licence through a spearpoint.

The farm family have worked there since 1979 assuming most of the farm management responsibilities during the late 1980s from the previous generation. The business employs two full time equivalent members of staff, plus a casual employee every second weekend.

The irrigation system is border-check (flood). Three-quarters of the farm has been laser levelled and half is automated (with bay outlets opening and closing automatically). The high level of existing irrigation development and automation reduces the marginal benefits from the different connection options on this farm.

Modelling

Analysis of current farm performance The first stage of the analysis involved developing a performance profile of the case study farm. This profile provided a 'starting point' from which to look at marginal changes that would help determine the likely on-farm benefits from infrastructure upgrades. The methods used for farm management economic assessments are described in Malcolm et al. (2005). The three basic financial statements used to develop the business picture or starting point were:

- the profit and loss;
- cash flow; and
- balance sheet.

To get a measure of the overall performance of the farm business, physical and financial data for the 2007/08 season were collected from the case study farm through a personal interview. Due to the unseasonable conditions during that year estimates for the farm under more typical conditions were also made. For instance it would be expected that the amount of bought in feed required in a more normal year would be reduced. To represent a more average situation, total feed costs in the profit and loss were adjusted based on less bought in feed and a lower grain price. Equally milk prices were at record highs during the 2007/08 season and were adjusted to a more typical average price closer to $4.50/kg (milk protein + fat).

Analysis of options A partial budget over 20 years with discounted cash flow analysis was used to determine the likely return on investment for the irrigation connection options. The main measure considered was net present value (NPV). This approach is consistent with previous studies that have analysed irrigation technologies such as Armstrong (2007), which looked at the economics of automating flood irrigation on a

case study farm. As the options examined involved the farmer taking over a section of channel and the associated water losses (plus replacing Dethridge wheels with new meters), there will be ongoing losses over the life of the investment. Hence, it was important to determine the incentive payment required in order to 'break-even' at a set discount rate. This is highlighted in Figure 1. In addition, the effects of potential increases in pasture production, reduction in water use, and labour savings were examined for a selected scenario.

A 5% real discount rate was used across the options based on maintaining the existing average return on capital for the farm. For the farmer to be no worse off from the extra investment, the NPV of each option must equal zero at 5%. If the NPV is negative then the farmer will be worse off and requires an incentive.

The irregular nature of the stream of cash flow creates challenges when trying to analyse the investment with the set of standard indicators. This is because each option begins with a positive injection of cash in year zero as a result of an incentive payment, and is followed by a series of costs rather than benefits. Hence, costs that are incurred later in the period are discounted. This is opposite to most investment streams which begin with a payment (negative cash item) and are followed by a stream of positive returns.

The atypical cash flow pattern means the internal rate of return (IRR) was not considered an appropriate economic indicator. This can be explained by the phenomenon that under higher discount rates the NPV of the investment actually increases due to the calculation reducing negative values (costs) as well as positive values (benefits). As the reduction in negative values is larger than the reduction in positive values, the NPV increases and higher discount rates make the NPV value bigger, and lower discount rates make the NPV smaller. The relationship between the discount rate and the NPV is the reverse of what we see with "normal" investments.

The main measure considered in this study was NPV, specifically where it equals zero at a set real discount rate. Commentators generally agree that the NPV gives better guidance than the IRR alone particularly if the investments being considered have different shapes (that is, very different timing of costs and benefits). The higher-IRR-is-better rule can recommend the wrong investment if the cash flow pattern is atypical. The NPV is a better indicator to evaluate an investment over time in this case.

Options analysed

The following options were developed by an irrigation surveyor in conjunction with the case study farmer as part of a reconfiguration proposal. All options involved taking over (or replacing) 1.96 km of channel previously owned by the water authority and replacing Dethridge wheel outlets with electro-magnetic meters. A total of four water delivery options are assessed along with the different scenarios investigated under each option. A fifth option where the area of perennial pasture is moved from one part of the farm to another is also evaluated. The analysis compares each option to the status quo where the farm irrigation delivery infrastructure continues to be operated in its current state.

Option 1 The minimum works needed to maintain the status quo production system of the farm. Connecting under option 1 involved taking over 1.96 km of water authority spur channel and piping some sections, reducing the number of outlets from 12 to 4 and replacing the remaining dethridge wheel outlets with high flow electro-magnetic (magflow) meters located on the backbone. Option 1 was assessed under a 43% water allocation (actual 2007/08 allocation in the Murray system) (1A), accounting for losses to spearpoint water (1C), excluding groundwater all together (1D), under an allocation of 100% of high reliability water share (1B) and including taxation (1E).

Option 2 A Rob Rye designed pipe and riser system was assessed in Option 2 under a 43% irrigation water allocation (2A). One of the ways to reduce or eliminate water losses due to evaporation and channel leakage is through a pipe and riser irrigation system. The system replaces existing on-farm open channels (authority owned and farm supply) with a network of pipes and risers, which replace existing bay outlets (Figure 2).

Option 3 A fully automated AWMA designed pipe and riser system was assessed in Option 3 under both a 43% (3A) and 100% water allocation (3B). Although the technical specifications are very different to the Rob Rye system as it allows for much larger flow rates of up to 20 ML per day, the AWMA system utilises the same base design as the Rob Rye system. However, the labour requirements of the AWMA system are dramatically lower.

Option 4 Option 4 is a modification to Option 1, which looks at the impact from lining the on-farm channel with a PVC material to reduce leakage and seepage. Most of the same assumptions apply as Option 1.

However, extra capital costs occur during the construction phase and reduced water losses are assumed.

Option 5 Option 5 is also a modification to Option 1 and investigates the impact from moving the area of perennial pasture away from the existing area on farm 5 to farm 3. This strategy reduces the amount of time water is held in the open channel on the farm by using a pipeline to deliver the water to the perennial pasture and the open channel only to irrigate annual pastures. By doing this, the open channels can be emptied for several months (November – March), and water losses as leakage and seepage should be reduced. This option is assessed under both a 43% (5A) and 100% water allocation (5B).

The options are presented in Table 1 and were approved by the steering committee for the project and are considered a logical mix as they account for varying water allocations and groundwater availability.

Costs and benefits

A range of different cost categories are associated with connecting an irrigator to the modernised system. These are categorised into costs that are borne by the organisation modernising and costs borne by the farmer. Only costs borne by the farmer were included in the partial budget analysis (see Table 2).

Farmer costs include:

- Construction such as the actual installation cost of new channels, pipelines, pumps, land remediation and other structures. They also include survey, design, supervision, fencing and forestry costs.
- On-going costs, such as water losses (leakage, seepage, evaporation and reduced water through more accurate metering), new tariffs, and maintenance of new infrastructure.
- Non-construction costs, such as production downtime during construction.

Reduced water delivered through more accurate metering is a significant ongoing cost to the farmer in the first five years of the analysis period, but is removed from year five onwards when it is expected that all meters off the backbone will be replaced with the more accurate meters regardless of the connection option.

A modernisation connection may also result in a range of benefits to irrigated dairy farmers mainly as a result of higher and more consistent flow rates including:

- on farm water savings,
- pasture production benefits, and
- labour savings associated with automation.

Not all of these benefits apply to every farmer who connects. Many farmers have existing automated bay outlets, high flow rates and laser levelled paddocks.

In paddock water savings (i.e. those beyond the metered outlet) could be expected due to the soil type of the case study farm. However, the savings are likely to be small as the existing farm irrigation infrastructure is already well developed. The farm has an efficient re-use and groundwater pumping system along with laser grading and automation. In addition, the farmer already receives adequate flow rates due to proximity to the backbone supply. However, some water savings will result under certain scenarios that are an improvement rather than replacing like with like. For example, where a pipe and riser system is installed and there is an elimination of losses such as channel leaks and evaporation, where the piped system replaces the existing in paddock channel network. After consultation with the farmer, local water authority and steering committee these savings were estimated at 5% of metered water in a given year for all pipe and riser scenarios assessed (Options 2 and 3).

Water savings amount to between approximately 20–50 ML per annum. These were valued at the price of water available for trade on the temporary market, which was estimated according to the opportunity earning rate (8%) on the average capital value ($2,300) of a ML of high reliability water share in the Murray system at the time of writing, plus the base water authority charge of about $50/ML.

Hence, for an allocation of 100% of high reliability water share the temporary sales water price would be estimated as follows:

- $138 (opportunity cost) / 1 (allocation) + $50 (base G-MW price) = $188 / ML

Faster irrigation may reduce water logging. This in turn may lead to improved pasture quality and/or quantity. The slope and light soil types of the case study farm mean that prolonged water logging is unlikely to have a significant impact on pasture production. This, in addition to the relatively high levels of existing development and constant flow rates, as a result of the farm's proximity to the backbone, means that pasture production benefits have not been included in the initial analysis.

Labour and vehicle use savings are only assumed for two of the options assessed where an AWMA pipe and riser system with remote automation is installed. The benefits amount to between $3,800 - $7,000 per year.

Total system wide water savings are the major benefit from modernisation and are normally distributed between organisations that invest in irrigation upgrades including State and Commonwealth Governments and irrigators themselves. System wide benefits reallocated to irrigator's entitlements are not included in this analysis due to uncertainty around an actual water saving amount and that all irrigators will receive a reallocation regardless of whether their infrastructure is upgraded or not.

Sensitivity testing

The effect of varying on farm water losses on NPV for each option was tested in a sensitivity analysis for the case study farm. The impact on NPV of increasing and decreasing losses by 20% was assessed and visually represented using error bars.

Results and Discussion

Profitability and Incentives

The profitability and required incentive payment for a range of infrastructure investment options were determined. Without any incentive to connect, none of the selected options are profitable, each returning a negative NPV (Figure 3). Each option requires an incentive payment (equal to the negative NPV amount) or significant efficiency improvement (water savings, pasture production) in order for it to be a profitable investment decision for the case study farm. The lower the capital costs and the higher the benefits through efficiency improvements from the different options, the more likely a farmer is to undertake the investment with a smaller incentive. Figure 3 shows the profitability of each option including sensitivity to on farm water losses (the latter is described in the following section).

Option 3A and 3B (AWMA pipe and riser) and Option 2A (Rob Rye pipe and riser) require the largest incentive in order for the farm system to maintain current profit levels. These are the options with lowest irrigation water losses and the largest labour savings, but highest capital expenditure.

The options with low capital expenditure but higher losses appear the most profitable in all water availability scenarios, but particularly under low water availability. Option 5A and Option 1A require the smallest incentive in order to maintain a five% return on capital and therefore remain viable.

Variation in the estimated water losses appears unlikely to change the ranking of the three lowest ranked options. The AWMA pipe and riser system does not appear very sensitive to water availability as losses and labour requirements are minimal to begin with. This system becomes slightly more favourable when compared to the base system (Option 1A) under higher allocations or under a perennial rather than annual pasture system. Most options would change if the farm was a perennial-based pasture system, as there would be more individual irrigations and subsequently labour requirement, and water applied and lost. For example, this would make the difference between Option 2A and 3A greater as there would be additional benefits from labour savings resulting from the increased number of irrigations. Under a perennial system the incentive required for Option 3A would be less.

Water losses associated with operating a new channel can be mitigated by moving perennial pastures to areas of the farm where they can be watered from a pipeline. This reduces the proportion of the irrigation season that the open channel needs to be used thereby reducing seepage and leakage. This was shown in Option 5A, which was the most profitable of the options tested. A mix of water delivery systems, such as open channel and a piped system, may allow for flexibility and additional management options across the farm.

Sensitivity testing – on farm water losses

The least sensitive of the options are 2A, 3A and 4A. Options 2A and 3A are both pipe and riser systems whilst option 4A includes a fully lined channel. These are all options with few water losses to begin with and are profitable under higher water allocations. It is therefore logical that these are the options that are least affected by a change to the existing water losses in each partial budget. On the other hand, the most sensitive to changes in water losses are options 1B, 1C and 1D, where more seepage and leakage will occur when more water flows down the on farm channels (see Figure 3).

Sensitivity to value of labour savings, water savings and pasture production

The economic impact from potential labour savings, improvements in pasture production and water savings were also investigated for Option 5A. If 150 hours of labour savings result from implementing Option 5A, this is equivalent to a present value of $45,000 over the life of the analysis period which effectively reduces the incentive required to $379,000.

Alternatively, if additional water savings of 30 ML per ha are achieved through a more efficient farm irrigation system then the incentive can be reduced by a further $9,000.

An overall increase in pasture production of 0.1 t Dry Matter (DM)/ha has the greatest impact over the life of the project when compared to the benefits of labour and water

savings. This assumes additional DM replaces conserved DM valued at a net conserved feed price of $150/t DM (supplementary feed market price of $250/t DM minus conservation cost of $100/t DM). An additional 0.1 t DM/ha resulting from Option 5A is equivalent to a present value of $63,000 over the life of the analysis period. This effectively reduces the incentive required.

It is important to note that all farms will be different. For example farms closer to the main backbone channels may only require meter replacement and therefore are likely to need less of an incentive to connect than a farm that is further from the backbone requiring more significant infrastructure upgrading.

Conclusion

None of the irrigation upgrade options analysed were profitable investments for the case study farm business, without the payment of a substantial incentive. The amount of incentive required to ensure the farmer was no 'worse off' varied markedly between the options analysed.

The options with low capital expenditure, but higher water losses, appear the most profitable in all water availability scenarios, particularly under low water availability. The systems with high capital expenditure and lower water losses, such as the automated pipe and riser, would require a much higher incentive to be attractive, even with high irrigation water availability.

The connection decision is complex and farmers will need to make well informed decisions factoring in future water losses. Benefits from productivity improvements will depend on the degree of existing irrigation development on individual farms. Those farms that are less developed will have more to gain from modernisation, providing the operators have the skills to capture the potential improvements. The method also revealed the importance to farmers of understanding the water cycle on their farms and the value of different water sources. Soil types and the ability to recycle water will be important factors affecting decisions by irrigators. There is also additional complexity related to structural adjustment issues and the investment of large sums of money in irrigation infrastructure that may not be utilised in the future.

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Disclaimer

References

ABARE 2009, 'Australian Dairy' 09.1, Australian Bureau of Agricultural and Resource Economics, Canberra.

Armstrong D 2007, *Economic Analysis of Automatic Flood Irrigation for Dairy Farms in Northern Victoria*, Department of Primary Industries, Ellinbank, Victoria.

Crosthwaite J, MacLeod N, Malcolm B 1997, 'Case studies: theory and practice in agricultural economics', presented to the 41st conference of the Australian Agriculture and Resource Economics Society, Jan 22-24 1997, Gold Coast, Queensland.

Dairy Australia 2010, 'Australian dairy industry in focus – 2010', Dairy Australia: Southbank, Victoria http://www.dairyaustralia.com.au/~/media/Documents/Statistics-and-markets/Australian%20Dairy%20Industry%20in%20Focus/2010/Australian%20Dairy%20Industry%20In%20Focus%202010.ashx Accessed 30 May 2012.

Department of Primary Industries 2011, 'Victoria's Dairy Industry – Summer 2011' http://www.dpi.vic.gov.au/agriculture/about-agriculture/publications-resources/industry-profiles-archive/dairy-industry/dairy-industry-profile-summer-2011 Accessed 30 May 2012.

Linehan CL, Armstrong DP, Doyle PT and Johnson F 2004, 'A survey of water use efficiency on irrigated dairy farms in northern Victoria', *Australian Journal of Experimental Agriculture*, 44(2): 131-136.

Malcolm B, Makeham J and Wright V 2005, *The Farming Game – Agricultural Management and Marketing*, 2nd edition, Cambridge University Press, Melbourne, Victoria.

Qassim A, Dunin F and Bethune M 2008, 'Water balance of centre pivot irrigated pasture in northern Victoria, Australia', *Agricultural Water Management*, 95: 566-574.

Appendix

Table 1. Summary of options analysed

	Water Allocations and Groundwater Availability				
	43% (A)	**100% (B)**	**43% + (spear losses) (C)**	**43% excl ground water (D)**	**43% + TAX (E)**
Option 1 (min works)	1A	1B	1C	1D	1E
Option 2 (pipe & riser)	2A	-	-	-	-
Option 3 (pipe & riser auto)	3A	3B	-	-	-
Option 4 (lined channel)	4A	-	-	-	-
Option 5 (move perennials)	5A	5B	-	-	-

Table 2. Summary of the costs and benefits associated with the various options

	Reduction in water available for irrigation (ML)		Extra operating costs ($'000/year)		Capital Costs ($'000)	Benefits ($/year)
	(Year 1-5)	(Year 6-20)	(Year 1-5)	(Year 6-20)		
Option 1A (min works)	44	22	21	14	321	1,600
Option 1B (min works)	93	43	25	16	335	1,600
Option 1C (min works)	38	16	26	20	321	1,600
Option 1D (min works)	73	34	29	17	321	1,600
Option 2 (pipe & riser)	22	0	34	27	664	4,500
Option 3A (pipe & riser auto)	22	0	20	13	1,040	8,500
Option 3B (pipe & riser auto)	22	0	25	16	1,050	15,400
Option 4 (lined channel)	28	6	16	9	394	1,600
Option 5 (move perennials)	35	13	18	12	321	1,600

Figure 1. Cash flow with required incentive in order for farmer to be no 'worse off'

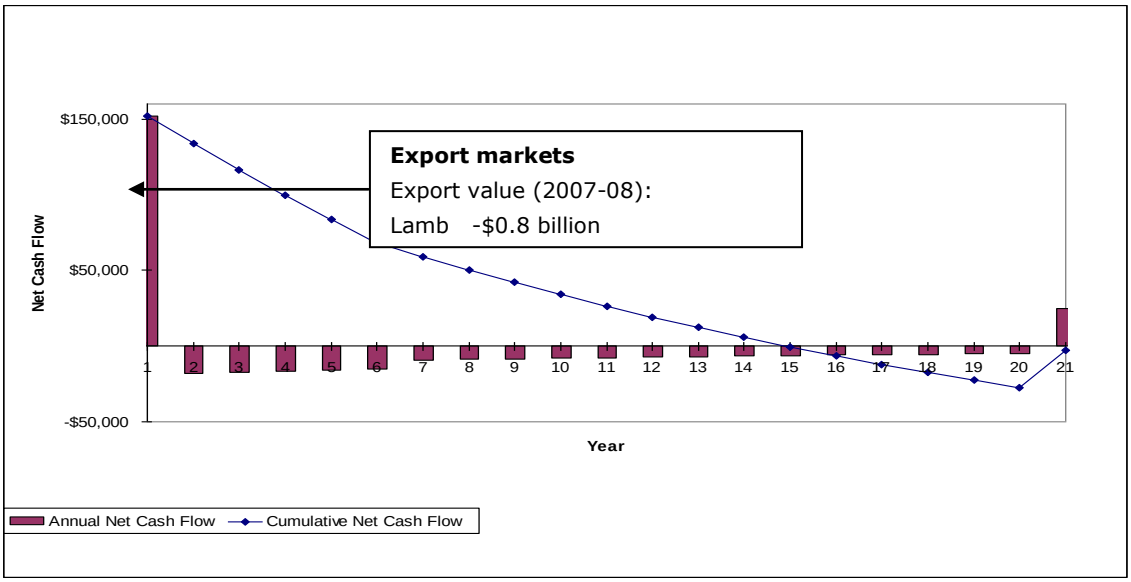

Figure 2. A riser irrigation outlet

Figure 3. NPV and sensitivity to water losses (error bars show the NPV sensitivity when water losses on farm are varied by +/- 20%)