Impact of irrigation modernisation on farm performance and productivity: a case study

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Abstract. In northern Victoria irrigators are investing in farm irrigation upgrades at an unprecedented rate. This is mainly to gain benefits from the Goulburn-Murray Water Connections Project that is modernising the irrigation supply system and a consortium of regional partners' Farm Water Program assisting irrigators to achieve water savings by improving on-farm irrigation systems. A case study was conducted on a dairy farm to assess the financial viability of the irrigation infrastructure upgrade where a border check irrigation system is used to irrigate pasture. Data were collected from the landowner to identify changes in farm pasture production, water, labour and savings in vehicle use associated with irrigation 'with' and 'without' the project. The case-study farmer observed improved production after the irrigation upgrade, which he attributed mainly to improved surface drainage. Other benefits mentioned by the landowner were water, labour and savings in vehicle use. A field day held on the case-study farm was the centrepiece of the extension package, which resulted in other irrigators making informed decisions about irrigation upgrades and more productive and profitable use of irrigation water on-farm.

Keywords: benefit-cost analysis, farm investment, field day

Introduction

In northern Victoria, governments are investing in farm irrigation upgrades at an unprecedented rate due largely to the modernisation of irrigation supply systems with more than two billion dollars being invested over a ten-year period. Federal and State Governments are investing over $250 million in farm irrigation upgrades via the Federal Government's On-Farm Irrigation Efficiency Program and the Victorian Government's Farm Modernisation Project (GBCMA 2013). Developed as a consortium of regional partners, the Farm Water Program has delivered farm irrigation upgrades with funding from State and Federal Governments within the region since 2010-11. The Farm Water Program provides co-investment opportunities for farmers to achieve water savings by modernising their farm irrigation infrastructure in return for water savings shared between the irrigator and the government. Such investment can provide significant opportunities for farmers to improve their irrigation efficiency as well as deliver benefits to the region.

Questions often asked by those considering participation in irrigation upgrades include: Will I benefit from participating in the program? Is it viable to invest in irrigation infrastructure given the production system that I have? What water savings and or productivity benefits do I need to achieve to make the project financially viable?

While the answers to these questions will differ depending on the unique circumstances of each farm business, the following case study provides learnings and useful information to those who are thinking of investing in similar technologies. These learnings have also been incorporated into an extension package that included a field day at the case study site to help other irrigators and the wider industry make informed decisions about irrigation upgrades and productive and profitable uses of irrigation water on-farm.

Method

Case study approach

A case study approach was chosen to examine the financial viability of the irrigation upgrades. This approach was considered more appropriate than surveying a large random sample, given the complexity behind the farm business management decision-making process (Malcolm, Makeham & Wright 2005).

Data collection

Both qualitative and quantitative data were collected during the structured interview with the case study dairy farmer. This provided the information used to complete the partial budget analysis.

Partial budget analysis

A partial financial discounted cash flow analysis was applied to determine the financial worth to a farmer of investing in irrigation infrastructure with and without government incentives. The partial analysis is a form of marginal analysis designed to show the net increase or decrease in income resulting from the proposed changes, rather than the profit and loss of the farm as a whole (Brown 1979). The analysis examined the 'with' project and 'without' project situation. It identified the value of costs and benefits that will arise 'with' the proposed project and compared them with the situation 'without' the project.

A seven percent real discount rate was used based on maintaining the existing return on capital from the investment. Three key economic criteria which were used for the analysis are net present value (NPV), benefit-cost ratio (BCR) and internal rate of return (IRR). In addition, the 'years to break-even' criterion was used to estimate the time taken for the returns from an investment to pay for the purchase. The analysis period was 20 years, which is the estimated productive life of the irrigation technologies. The approach used in the study was similar to the analysis conducted by Maskey (2003), Armstrong & Ho (2011) and Dalton & Armstrong (2012).

Assumptions

Production changes, water savings, time savings and vehicle-use savings were calculated based on the information provided by the landowner from his records collected during the interview process. These details were checked by the authors against on-farm observations, management practices used by the farmer and dairy farm performance data for the region. The costs of water and feed at the time of the study were used: $200 per megalitre (ML) and $250 per tonne dry matter (DM) respectively. A labour cost of $25 per hour was assumed. The cost of vehicles used for travel when irrigating was assumed to be $0.50 per kilometre.

Case study description

The property is a dairy farm with an effective grazing area of 83 ha and is located near Kyabram in northern Victoria. In the 2014/15 season, 300 cows were milked and produced 528 kg milk solids per cow compared to milking 220 cows and producing 500 kg milk solids per cow before the upgrades. The property is served by three 450-Mag Flow meter outlets each capable of delivering 15 ML of water per day.

The landowner owns 240 ML of high reliability water share with low reliability water attached. The landowner purchases an additional 460 ML of temporary water from the market depending on the seasonal conditions and the price of water. The price of temporary water has fluctuated a lot since the project was implemented; however, for the purposes of this analysis it was assumed that the price of water was $200 per ML.

The landowner believed it took three years for new pasture to reach full production and hopes to increase pasture production with the irrigation system upgrades. The landowner commented that he is focusing on lifting the amount of home-grown feed in the cows' diet, recognising it is usually the cheapest feed source.

The project area for the irrigation upgrades covers 54 ha which was transformed from an inefficient irrigation layout to an improved border-check irrigation system. This transformation was assisted by the Government's Farm Water Program in 2011/12 with automation also installed independently of the Farm Water Program in the 2014/15 season all 83 ha of the irrigated farm area, including the project area.

Soil types consist of Lemnos loam, Goulburn loam and Goulburn clay loam. The project area grew perennial pasture before and after the upgrades.

Without the irrigation system upgrade

Prior to the farm upgrade, there was an old style irrigation layout consisting of relatively small irrigation bays, with the majority less than 20 metres wide and served by six inch (150 mm) pipe outlets. Flow rates up to 8 ML per day were achievable from the three supply outlets; however, the supply channel flow rates fluctuate making it difficult to estimate the required irrigation duration. It could take two weeks to irrigate the whole farm with some of the bays taking 16-18 hours to irrigate.

With the irrigation system upgrade

An improved border-check irrigation system was installed that served a project area of 54 ha. Of the 54 ha project area, 18 ha was laser graded and a gravity channel system constructed with modernised irrigation outlets to service the total project area. The landowner also invested in connecting drainage from the northern section of the farm through a pipeline under a GMW channel to connect a reuse system located on the southern part of the farm.

The landowner has installed spinner cuts on all the irrigation bays to help drain water more quickly off the bays. He has been maintaining these spinner cuts after every second grazing using a rotary digger on the back of the tractor. The spinner cuts have allowed the landowner to have cows on the bays 24 hours after irrigation with an increase in production due to the improved drainage.

The analysis in this report is focused on the 54 ha project area, including the installation of automation during 2014/15.

Results

A range of different costs and benefits were identified and financial viability was calculated as a result of the irrigation infrastructure investments.

Project costs

Capital cost This cost covers the capital expenditure for improved on-farm infrastructure which consisted of laser grading and construction of the gravity channel system including modernised bay outlets and channel structures. An additional $22,000 was used to install a pipeline linking drainage water between the northern and southern parts of the farm. Irrigation investment costs also included the erection of fencing, laneway construction, stock water troughs and the installation of automation in 2014/15.

Maintenance cost A maintenance cost of two percent of the capital cost amounting to $4,640 in Year 1-3 and $6,300 per year from Year 4 onwards was included. The maintenance cost increased from Year 4 because of the installation of automatic irrigation in Year 3.

Production foregone During the 12 months of construction works, there was no production from the entire 18 hectares of laser graded area. This was considered and accounted for in the gross margin analysis during the first year after the irrigation upgrades.

The project costs are presented in Table 1 below.

Table 1. Project costs

Cost items	$
Capital costs:	
Laser grading 18 ha, earthworks for channel construction serving 54 ha	90,000
Purchase and installation of bay outlets and channel structures	50,000
Installation of pipeline across the delivery channel	22,000
Fencing, laneway construction and water troughs	70,000
Purchase and installation of automation during Year 3	54,000
Total investment costs	286,000
Annual costs:	
Maintenance cost: 2% of capital cost ($4,640 from Year1-3 & $6,300 from Year 4 to Year 20)	6,300

Project benefits

The project benefits are the Farm Water Programs financial incentive, a production increase from pasture, water, labour and vehicle travel savings and a salvage value.

Incentive The landowner was involved in the Farm Water Program during 2011/12. As part of the Farm Water Program, 50 percent of the water savings from the proposed upgrade were transferred to the government in exchange for a payment towards the project. The farm business traded 55 ML of high reliability water share for a payment of $183,807 which funded a large proportion of the irrigation upgrade. The net value of the Farm Water incentive to the farm business was obtained by subtracting the value of the water share transferred to the government from the incentive. The total estimated incentive is $91,904.

Production benefits The landowner believes that there has been a substantial increase in production after the irrigation upgrades. The consumption of pasture increased from 7 t DM/ha/year to the peak of 15t DM/ha/year. This amounts to a pasture consumption increase of 432 t per year on the 54 ha project area. There has been some variation in pasture consumption due to the seasonal conditions. The consumption of pasture increased from 7 t DM/ha/year to 10 t DM/ha/year immediately after the irrigation upgrade. It then peaked at15 t

DM/ha/year for the next two irrigation seasons and then reduced back to 13 t DM/ha/year with the onset of dry conditions. The figure of 13 t DM/ha/year has been used for the analysis from Year 5 to Year 20.

Pasture production increased largely as a result of improved irrigation and drainage management with spinner cuts. Hussain, Morris, & Githui (2016) conducted an irrigation field experiment on one of the bays at this property and measured water ponding time on the bay surface before and after installing spinner cuts. They found that there was substantial reduction in water ponding time and that the duration of inundation on the bay surface was more uniform after installing spinner cuts.

During this period, the landowner has also developed his skills in pasture management after completing a pasture management course and consulting with pasture management specialists to grow better pasture on-farm. The landowner also improved his skills in fertiliser management and sourced fertiliser advice and has since lifted their low phosphorus levels and is now applying fertiliser according to soil test results. The landowner believes the improvements made to the irrigation system and layout, together with his improved skills in fertiliser and pasture management, have helped increase pasture consumption.

Dunbabin, Jume & Ireson (1997) observed a pasture production increase of 53 percent from 8.8 t DM per ha to 13.5 t DM per ha with a reduction in the irrigation interval from 10 days to 7 days in summer. They also observed a drop in pasture production of 17 percent with 12 hours of ponding compared to just 4 hours of ponding when the pasture was irrigated every 7 days. Table 2 shows that the production increase has more than doubled from 378t DM to 810t DM after the upgrade, an increase of 432t DM.

Table 2. Production benefits

Production type	**Without project**		**With project**		***Increase in production (t DM)**
	ha	Total production (t DM)	ha	Total production (t DM)	
Perennial pasture	54	378	54	810	432

*at peak production period

Water use The water use 'with' and 'without' the project was difficult to accurately quantify. The overall water use 'with' and 'without' the irrigation upgrades have been calculated using the landowner's observations and water use records, as evapotranspiration data were not available.

Estimated water volumes 'without' and 'with' the project are shown in Table 3. Water savings of 54 ML are achieved with the project. This is equivalent to savings of 1ML/ha/year.

Table 3. Estimated water savings per year

Water use	**Water use (ML)**		
	Without project	With project	Water savings
Water use in the project area to grow perennial pasture	594	540	54

The landowner is of the opinion that the water savings in his case was linked more to production increase. When asked about water savings, the landowner responded by saying, 'We don't think we have saved lots of water, but we have definitely grown more grass'.

Time saved operating outlets and chasing water Labour savings are considered by the landowner to be a key benefit achieved with the irrigation upgrades. The exact labour savings after the upgrades are difficult to estimate; however, the landowner reported that he no longer had to monitor water on the paddock like he did before the upgrades. After the installation of the automation system, there was no longer a need to manually open and shut bay outlets and channel structures.

As a result of implementing the initial project, it was estimated an annual labour saving of 220 hours was achieved. These savings increased to 400 hours after the later installation of automation. Key factors that initially contributed to this labour saving are a reduction in the number of irrigation bays and bay outlets, a more consistent flow rate on to irrigation bays, a reduced irrigation requirement for pasture production and less maintenance required compared to the existing inefficient system. Estimated time savings associated with irrigating are shown in Table 4.

Table 4. Estimated time savings per year

Enterprise	Time savings after initial irrigation investment (hours)	Time savings after the installation of automation (hours)
Perennial pasture (20 irrigations)	220	400

Vehicle of travel savings The landowner identified that there had been significant vehicle travel savings after the upgrades. 'Overall, over the whole farm area, Dad used to do 200,000 km in four years, now we would be lucky to do 20,000 km per year. Now we water more area more often than Dad'. Vehicle use savings associated with irrigating are shown in Table 5.

Table 5. Estimated annual vehicle use saved

Enterprise	Vehicle travel savings after irrigation investment (km)	Vehicle travel savings after the installation of automation (km)
Perennial pasture (20 irrigations)	2,500	6,000

Salvage value Salvage value represents the residual value of assets used in the project. The salvage value of $14,780 is based on 20 percent of the initial capital cost of the investment at the end of Year 20 of the project life in today's dollars.

The case study analysis indicated that water productivity doubled as a result of implementing the project. It is estimated that water productivity on the case study farm increased from 0.64 t DM consumed per ML 'without' the project to 1.5 t DM consumed per ML 'with' the project during the peak production season (Table 6). This means that the landowner was able to produce more feed per ML of water used.

Table 6. Estimated water productivity on the project area (54 ha) 'without' and 'with' the project

	Without project	With project
Pasture production (t DM)	378	810
Irrigation water use (ML)	594	540
Water productivity (t DM/ML)*	0.64	1.50

*Pasture production varied from season to season, the figures in the 'with' project column show the maximum water productivity reported by the case study farmer

Financial Viability

Table 7 below shows that this project is viable 'with' and 'without' the incentives considering all three economic criteria. However with the incentive, the investments appeared more attractive. If the project was to be implemented without the incentives, it would require a substantial upfront cost and would take longer to break-even.

Table 7 Financial indicators for irrigation infrastructure investments

Financial indicators	With incentive	Without incentive
Net present value @7% real discount rate	$307,930	$222,040
Benefit-cost ratio @ 7% real discount rate	1.90	1.66
Internal rate of return (%)	20.1	14.6
Year to break-even (years)	7	10

Extending the learnings from the case study

A field day was held at the case study farm, which was organised in collaboration with other stakeholders including staff from the Farm Water Program. This field day was structured to offer more than a simple awareness raising exercise – an attempt to improve the decision-making capacity of participants was targeted by providing opportunities for participants to see and hear from the host farmer about the implementation, operation and practicalities of the new irrigation technology and how it fitted into the commercial farm operation. The on-farm benefits of participating in the Farm Water Program and irrigation system modernisation were also evident through this process to promote adoption of improved irrigation management practices.

Summary factsheets were provided on the case study findings as well as other similar case studies investigating a range of different irrigation technologies. Subject experts and representatives from different organisations including the local rural water authority, irrigation contractors and irrigation surveyors and designers were also present to answer participant questions. Key messages outlined at the field day have also been reinforced through extensive coverage in local newspapers. Technical articles focusing on the findings of the benefit-cost analysis from the case study have also featured in a local monthly farmer newsletter.

Discussion and conclusion

The study has found that in this case, the investment in the farm irrigation upgrade is financially viable with and without government incentives. The viability of the project depends on good farm management over the life of the irrigation project in order to achieve higher pasture consumption.

Farm business owners considering an irrigation upgrade need to be mindful that the investment is sensitive to a change in pasture production and should take into account the likely production gains for their particular situation. Production gains are often more easily achieved starting from a situation where production is relatively low. Where pasture production is already high, a sizable increase in production is likely to be more difficult to achieve.

With increasing water prices, water savings will continue to be an important driver of investment viability. This is more likely to occur in instances where irrigation applications substantially exceed plant water requirements and where significant water savings can be made. In the case study farm, water was being used relatively efficiently and the water savings made with the irrigation upgrade were limited.

Higher flows through delivery outlets have resulted in larger areas being irrigated or the same area watered in less time. Consistent flow rates, automatic irrigation and larger bay sizes have resulted in labour and vehicle use savings.

The Farm Water Program provided funds for the case study landowner to implement irrigation upgrades more quickly than would have been possible if using cash flow alone, resulting in less time to break-even on irrigation investments.

The farm field day held at the case study site also provided an opportunity for local irrigators to view the latest irrigation technology on-farm and understand the works completed at this site, which also proved to be quite an effective means of improving participant decision-making capability related to implementing farm irrigation upgrades.

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