DAIRY BUSINESSES FOR FUTURE CLIMATES

RESEARCH FINDINGS FOR THE MURRAY DAIRY REGION

July 2019

RESEARCH FINDINGS

The Dairy Businesses for Future Climates project was established in 2012 to model and answer the question: 'How are our current dairy businesses vulnerable to a 2040 climate?' Economic and biophysical modelling of four different dairy farm systems across central Gippsland, Victoria; the Fleurieu Peninsula, South Australia; north west Tasmania; and Murray Dairy was undertaken. While it is difficult to compare development options across regions because they are specific to location, some general trends were evident. This document provides an overview of the outcomes from the modelling of a dairy farm business in Murray Dairy.

What was the aim of the research?

This research explored how dairy farm systems in the Murray Dairy region might perform under predicted climate changes in 2040 and how they could adapt to a changing climate.

RESEARCH AT A GLANCE

Climate variability will continue to be a challenge to dairy farm businesses

Dairy farm managers will need to continue to adapt their farm systems to manage risks

Skilled farm managers are essential to the future success of the dairy industry, and training and skill support for farmers to manage future climate challenges will be required

The profitability of the case study farm and all three other options investigated were negatively affected by the 2040 climate change scenarios that were modelled

The changed climate scenarios will alter the growth and utilisation of pastures and forage crops, creating feed challenges and suggesting more irrigation water will be required

Milk price has a substantial impact on business performance in addition to climate, as milk payment systems may alter the attractiveness and returns of different production systems

THE MURRAY REGION AT A GLANCE

1,372 dairy farms

2,072 million litres of milk in 2017–18

$916 million farmgate value of milk in 2017–18

$730 million farmgate returns spent in local economy

More than **8,700 people** directly working in dairy

INVESTMENT IN DAIRY IN THE MURRAY REGION

$500 million in new and upgraded processing facilities since 2014

$2 billion in irrigation infrastructure upgrades

Almost **$10 million** for a new milk logistics and distribution hub

Increased offering of localised education and training in agriculture

$493 million invested on farm in the last five years

Source: Dairy Australia

How was the research carried out?

- An irrigated case study dairy farm located in northern Victoria was selected as a case study farm with the intention that other farms in the region could relate to the research findings.
- Three development options for the base farm were modelled in a 2040 climate by an economist and biophysical modellers.
- A working group made up of farmers and service providers in the Murray Dairy region guided the research.

What was the base farm system and what development options were explored?

The base (or case study) farm was an irrigated farm with 724 usable ha of land. The farm grows most of their own fodder and grain and has a split calving herd of 475 milking cows. The feedbase on the milking area was predominately annual pasture (Persian clover, ryegrass). The farm owned 1,300 ML of high reliability water share (HRWS).

The three development options were defined by the working group members as:

1 Feedlot option (total mixed ration, TMR) – maximise yield per ML of irrigation water with no grazing by milking cows. The feedbase relied on a maize-wheat double crop, lucerne and cereal silage

2 High grazing option – attempt to keep the proportion of grazed pasture high throughout the year. The feedbase incorporated more perennial forages – lucerne and perennial ryegrass

3 Low irrigation option - managing with less irrigation water, mainly reliant on rainfall with some irrigation of annual pastures and cereals. The feedbase was annual pasture (irrigated and dryland) and lucerne that was only irrigated in spring.

Details of the base farm and each of the options are outlined in Table 1.

Table 1 Key features of the base farm and three development options that were modelled

	Base farm	Feedlot	High grazing	Low irrigation
Milking herd size	475	800	475	475
Calving pattern	60% spring, 40% autumn	Year round	60% spring, 40% autumn	25% spring, 75% autumn
Milking area pasture types (ha)		All cut and carry		
Long season annual	180	0	128	148 (100 ha irrigation)
Lucerne	28	64	40	60 (partial irrigation)
Perennial ryegrass	0	0	40	0
Wheat-maize double crop	0	80	0	0
Cereal silage	0	64	0	0
Runoff area pasture types (ha)				
Irrigated annual	130	174	130	85
Dryland annual	129	85	129	174
Cropping area (ha)				
Silage irrigated	77	157	77	0
Silage dryland	0	100	0	207
Grain irrigated	180	0	180	0

Milking area pastures were irrigated unless otherwise specified

How different is a 2040 Murray Dairy climate predicted to be?

- In 2040, under a high climate change scenario, it is predicted that temperatures will increase by 2°C with an annual rainfall decline of 19 per cent. The rainfall reductions occurring predominantly in winter and spring (current annual rainfall average at the case study farm is 370mm).
- Rainfall events are predicted to vary from year to year and to occur in fewer, larger events, with longer dry spells in between.
- Extreme weather events are predicted to continue under a changing climate – including heat waves and extreme rainfall events.

NB: modelling was undertaken using IPCC (Intergovernmental Panel on Climate Change) medium and high climate change scenarios. The high scenario (8.5) is discussed in this document.

Figure 1 shows the historical average rainfall distribution on the Murray Dairy case study farm (dark blue columns) and the modelled rainfall distribution (light blue columns) in a 2040 high climate change scenario. The graph shows a reduction in rainfall for every month of the year. It also indicates increasing year-to-year variability in rainfall (note that the size of the error bars relative to the columns is relatively larger in the 2040 scenario). Minimum and maximum temperatures will be higher in 2030 (Figure 2). The 2040 scenario was based on climate projections from the best performed climate models across southern Australia.

How different will pasture production be in 2040?

- At the case study farm, the modelling suggested that shallow rooted pastures (such as annual or perennial ryegrass) would have lower winter growth rates in 2040 due to water stress because irrigation cannot be supplied (Figures 3–5).
- This reduction in winter growth rates would be less substantial in the higher rainfall parts of the Murray Dairy region.
- Lucerne growth was predicted to increase in winter and early spring due to warmer temperature. It was more productive in the 2040 climate, but also required more irrigation.
- Perennial ryegrass growth was lower in 2040 from October to April due to hotter temperatures.

Figure 1 Monthly average rainfall in the historical and 2040 climates

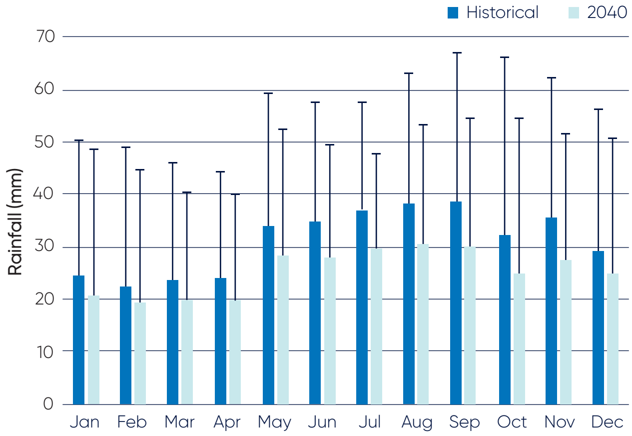


Figure 2 Monthly max/min temperatures in the historical and 2040 climates

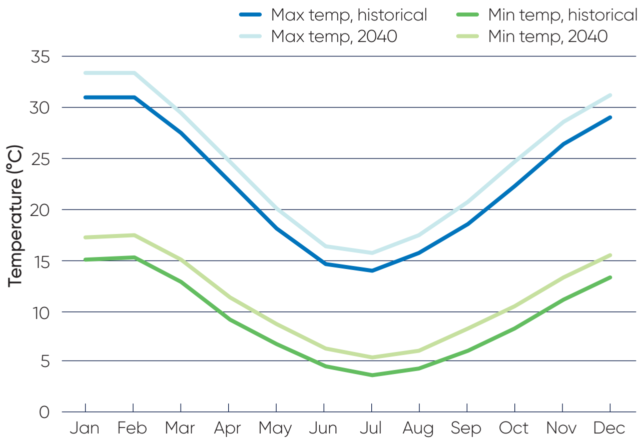
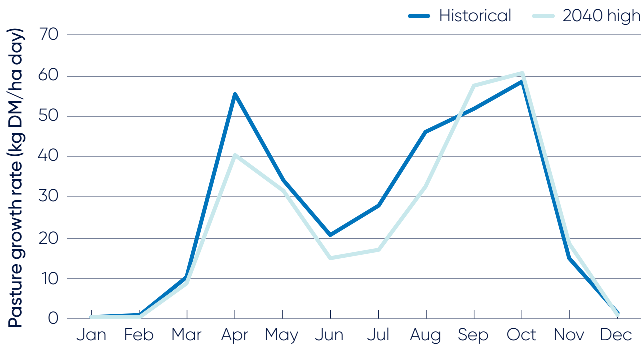
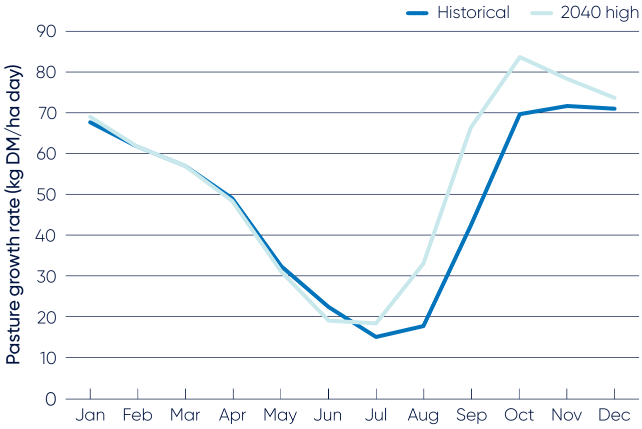


Figure 3 Monthly average pasture growth rates of annual pasture in the historic and 2040 climate scenario



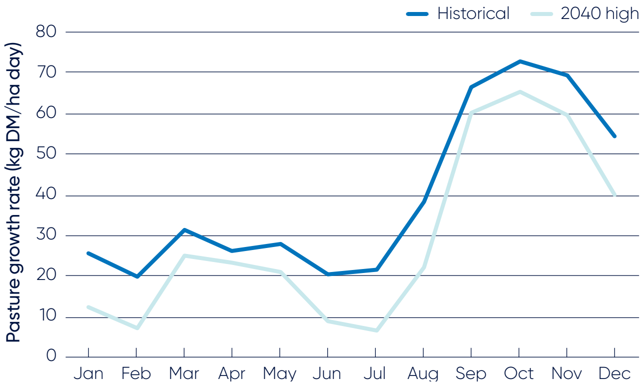
The pastures are irrigated as required except during the period 15 May to 15 August.

Figure 4 Monthly average pasture growth rates of lucerne in the historic and 2040 climate scenario



The pastures are irrigated as required except during the period 15 May to 15 August.

Figure 5 Monthly average pasture growth rates of perennial ryegrass in the historic and 2040 climate scenario



The pastures are irrigated as required except during the period 15 May to 15 August.

Extreme weather events are predicted to continue under a changing climate – including heat waves and extreme rainfall events

At the whole farm level, in the 2040 climate home grown feed was predicted to decrease and irrigation required was predicted to increase (Table 2). Reduced home-grown feed will increase the reliance on purchased feed. The feedbase used in the feedlot option, based on maize and cereals, was impacted less than the other options.

Table 2 Home grown feed and irrigation applied

		Historic climate average	% change in 2040 climate
Base farm	Home grown feed (t DM)	3,924	-16
	Irrigation applied (ML)	1,861	+10
Feedlot	Home grown feed (t DM)	5,535	-5
	Irrigation applied (ML)	1,901	+7
High grazing	Home grown feed (t DM)	3,982	-18
	Irrigation applied (ML)	1,995	+8
Low irrigation	Home grown feed (t DM)	3,328	-24
	Irrigation applied (ML)	902	+13

How was water price in 2040 included in the analysis?

In 2040, lower rainfall was assumed to reduce the supply of irrigation water and competition for water is likely to increase. In a wet decade in the 2040 climate, it was assumed that the irrigation water allocation would be 100 per cent of HRWS, but in a dry decade the allocation of HRWS was reduced and temporary water price increased (Table 3).

Table 3 Water allocation and temporary price assumptions in the historic and 2040 climate

	Historic climate average	% change in 2040 climate
Wet period	**100% HRWS**	**100% HRWS**
Temporary irrigation water($/ML)	110 (50–200)	110 (50–200)
Dry period	**75% HRWS**	**60% HRWS**
Temporary irrigation water($/ML)	240 (125–415)	320 (205–495)

$/ML, annual weighted average price, the values in brackets represent the range assumed in 90% of years

What is the impact of 2040 climate on farm profit? Does it matter whether the change is implemented at the start of a wet or dry period?

There is a noticeable impact from the 2040 high climate change scenario on farm profit (Figures 6 and 7). The impact is predicted to be much more severe in a dry period than a wet period. The 2040 high climate change scenario in the dry period has a large impact because of the 'stacking' of events, i.e. irrigation requirement increases, irrigation allocation decreases, irrigation water price increases and supplementary feed price is high. This is a more substantial 'stacking' of events than in the other regions analysed.

When comparing how the 2040 high climate change is predicted to impact the four regions analysed, the overall impact predicted is greatest in the Murray Dairy region (about a 38 per cent decrease in operating profit compared to about 25 per cent for Gippsland, 23 per cent for SA and 13 per cent for Tasmania). However, the most dramatic impact for the Murray Dairy region is predicted to occur when there is a dry period on top of the 2040 climate change. Real internal rate of return (IRR) is predicted to decrease from 4.6 per cent to 0.4 per cent (see Figure 6). The other regions do not appear to have the same 'stacking' of events. During a wet period, the impact of the 2040 high climate change prediction is much smaller than during a dry period (real IRR is predicted to decrease from 6.9 per cent to 5.4 per cent).

Feedlot – TMR	This option is substantially different if it is implemented at the start of a 'wet' or 'dry' period. If the feedlot – TMR option is implemented at the start of a 'dry' period, it is a much less attractive option than if it is implemented at the start of a 'wet' period. This is mainly due to a higher reliance on purchased feed for the feedlot option, and the higher supplement prices in the 'dry' period have a large impact on this option. There is also increased debt as a result of capital development and machinery purchases.
High grazing	Overall the impact of the 2040 high climate change scenario for this option appears similar to the base farm. There is little difference between the profitability of the base farm and the high grazing option. The high grazing option has higher temporary irrigation water costs and nitrogen fertiliser costs, but less spent on fodder conservation, purchased hay and silage, fuel and oil, and repairs and maintenance. The high grazing option appears to be a slightly more profitable option than the base farm in a wet period, but slightly less profitable in a dry period due to more exposure to the temporary irrigation water market.
Low irrigation	Overall the impact of the 2040 high climate change scenario for this option appears similar to the base farm. The impact of reduced rainfall on yields on the dryland areas is important for this option. The low irrigation option has much lower irrigation water costs (these are also offset by selling water when there is an excess) and slightly lower N fertiliser costs, but much higher purchased grain costs, higher fodder conservation costs and slightly more hay purchased. The low irrigation option performs relatively well in the dry period due to lower exposure to the irrigation water market. There is a relatively small amount of capital investment in upgrading the feedpad that we assumed was required to move to this option from the base farm.

Figure 6 IRR (real) for case study farm during dry period

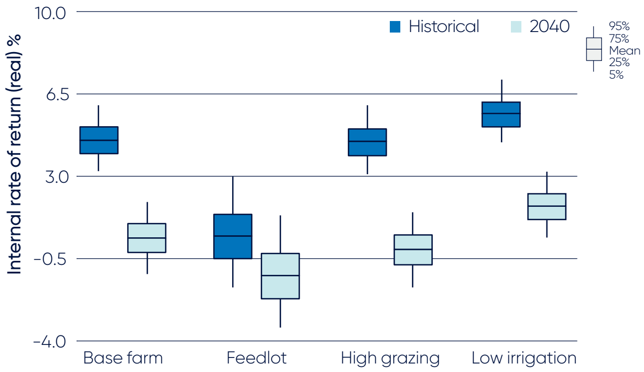
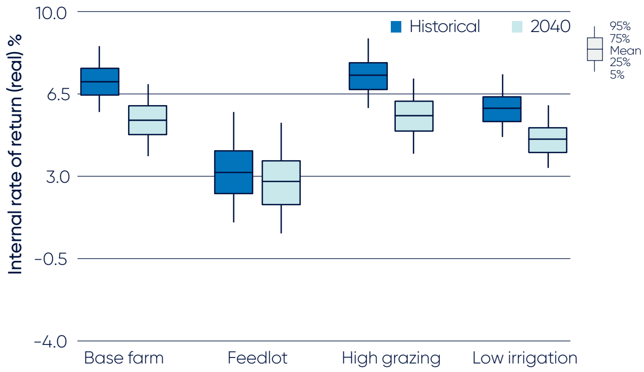


Figure 7 IRR (real) for case study farm during wet period



The above graphs show an internal rate of return (IRR real) for the base farm business if each option was implemented at the start of a 'wet 10-year period' (similar rainfall to 1986–87 to 1995–96 and below average supplementary feed prices) and the start of a 'dry 10-year period' (similar rainfall to 2000–01 to 2009–10 and above average supplementary feed prices). The IRR represents the average annual earning rate of each investment over each decadal period (in real terms, i.e. excluding inflation). The bigger the box in the graph, the more variability is likely (or predicted). The boxes cover 50 per cent of the variability that is predicted, while the lines (or whiskers) cover 90 per cent of the variability that is predicted. The same milk price distributions used for all options.

Will milk price have an impact on farm development into the future?

The variation in milk price is a significant source of variability in profit in addition to the 2040 climate change projections. A change in milk price of $0.70/kg milk solids (MS) has a similar impact on IRR to the 2040 high climate change scenario.

If the same milk price ($6.00/kg MS) was used for all options under the historic climate the base farm and all three options all had similar annual operating profits – earnings before interest and tax (EBIT).

However, there are different amounts of capital invested in the options and those with additional capital invested require a higher operating profit to be attractive investments.

The results presented on the graphs (Figures 6 and 7) include milk price variability, but the average and range are assumed to be the same for all options. It would be expected that the options with more milk produced outside of the spring months, and those with a larger quantity of milk production, are likely to receive a higher milk price than the base farm (however, the seasonal incentives may change if the predominant calving pattern changes).

The feedlot (year-round calving and more milk produced) and low irrigation (predominantly autumn calving) options would be expected to receive a higher milk price than the base farm in the current operating environment. This would lead to a substantial increase in the profitability of these options.

The feedlot – TMR option is highly sensitive to milk price, and higher milk price would be expected for the flatter supply and larger scale. With a milk price that is $1.00/kg MS higher than the other options (an average of $7.00/kg MS) the feedlot option is predicted to generate returns that are commensurate with the extra risk (Table 4) and could make it an attractive investment.

Given that there is no change from the base farm in total milk production or calving pattern for the high grazing option, an increase in milk price is unlikely.

Table 4 Sensitivity of IRR for the options to variation in milk price

IRR	Base farm		Feedlot		High grazing		Low irrigation	
	Historical %	2040 high %	Historical %	2040 high %	Historical %	2040 high %	Historical %	2040 high %
Wet 10–year period (similar to 1986–87 to 1995–96)								
Milk price average $7.00/kg milk solids	9.9	8.3	8.3	7.9	10.1	8.6	8.9	7.5
Milk price average $6.50/kg milk solids	8.4	6.9	5.8	5.4	8.7	7.1	7.4	6.0
Milk price average $6.00/kg milk solids	6.9	5.4	3.2	2.8	7.2	5.7	5.9	4.6
Dry 10–year period (similar to 2000–01 to 2009–10)								
Milk price average $7.00/kg milk solids	7.5	3.3	5.5	3.9	7.4	2.8	8.6	4.7
Milk price average $6.50/kg milk solids	6.0	1.8	3.0	1.4	5.9	1.3	7.1	3.2
Milk price average $6.00/kg milk solids	4.6	0.4	0.5	-1.2	4.5	-0.1	5.7	1.7

Which development option is the riskiest? What financial risk is associated with transitioning to the development options?

The feedlot option has significantly higher variability and risk, and the predicted profit would not justify the additional risk if the milk price was the same as the base farm. An additional scenario with a higher milk price for this option is provided in Table 4 and shows that this option could be an attractive investment if it commands a higher milk price (about $1.00/kg milk solids, increase to average $7.00/kg MS) with the flatter supply.

The feedlot option is predicted to be impacted less by climate change than the other options. This is because it has relatively high exposure to purchased feed prices and relatively low exposure to irrigation water prices in comparison to the other development options. It was assumed that irrigation water becomes more expensive (and scarce) under climate change, but it was assumed that purchased feed prices do not increase under the 2040 changed climate. The feedlot option is more attractive if implemented during a wet period than a dry period. This is partly due to a high reliance on purchased feed, which is assumed to be dearer in the dry period.

The feedlot option has by far the greatest variation in profitability of all the options (Figures 6 and 7). Large profits can be made when milk prices are high and feed is relatively cheap, but large losses are likely if milk price is low and feed is expensive (Table 4). A successful manager of this type of system is likely to monitor operating conditions closely and make reasonably significant adjustments between years depending on the conditions. The IRR was also sensitive to the assumptions regarding the feed conversion efficiency.

The feedlot option combines increased farm system variability (business risk) with increased financial risk (due to increased borrowings for infrastructure and machinery). This combination leads to significantly greater risk overall. A combination of lower initial equity, and the 2040 climate change scenario in a dry period, shows a substantial increase in the peak debt for the feedlot option (Table 5). In the feedlot option, the potential for wealth creation may also alter as a greater proportion of the assets will decrease in value over time, e.g. infrastructure (barn, feeding facilities, etc.) and machinery.

The high grazing and low irrigation options have similar risk overall to the base farm. The high grazing option is more exposed to the temporary irrigation water price and the low irrigation option is more exposed to grain price.

Table 5 Sensitivity of the options to initial business equity level

	Base farm		Feedlot		High grazing		Low irrigation	
Initial equity	**Historic $M**	**2040 $M**	**Historic $M**	**2040 $M**	**Historic $M**	**2040 $M**	**Historic $M**	**2040 $M**
Wet period								
65%	2.7	2.7	6.2	6.3	2.7	2.7	2.7	2.7
50%	4.3	4.3	7.9	8.1	4.3	4.3	4.3	4.4
Dry period								
65%	2.7	4.8	6.8	9.4	2.7	5.6	2.7	2.80
50%	4.3	7.7	9.2	12.3	4.3	8.5	4.3	5.5

What are the opportunities and trade-offs with each development option?

This research did not find a clear 'winner' in the form of the most resilient farming system for the future. All of the development options explored had positive and negative aspects. The following tables explore the opportunities, vulnerabilities and dependencies of each pathway.

Table 6 Opportunities, vulnerabilities and dependencies for each option

Option	Opportunities	Vulnerabilities	Dependencies
Base farm	• Flexibility in directing business trajectory towards high grazing or low irrigation • Flexibility in adjusting farm system to maximise seasonal conditions e.g. weather, input costs	• Sound decision making and planning abilities to adjust operations seasonally to take advantage of conditions • Adaptive management requires constant scanning of seasonal and global parameters • Less opportunities to capitalise on favourable conditions compared to feedlot	• Reliant on knowledge of global situation – milk and fodder prices, climate patterns
Feedlot	• Greater capacity to take advantage of economies of scale and favourable operating conditions i.e. high milk prices, low feed prices • Operational flexibility in response to variable seasonal conditions • Opportunity to have a lot of control over production levels	• Potential for 'lock-in' effects from investing in expensive infrastructure that requires farming in a certain way that may prove maladaptive to climate challenges • Greater effluent concentrations and output to manage • May be exposed to greater variability (high and lows) in profit-making over the mid to long term under variable climate conditions	• Likely to be attractive to dairy manager/owner who operates a mature dairy business • Requires high equity levels and/or the ability to take greater financial risks • Stability in milk prices, relatively low feed costs and grain supply • Reliant on accessing and managing skilled staff • Reliant on knowledge of global situation – milk and fodder prices, climate • Access to capital resources, own or borrowed funds
High grazing	• Profitable in favourable conditions (wet decades) • Relatively simple to transition between the base farm and this option	• Highest exposure to temporary irrigation water price	• Good grazing management, pasture management and irrigation management would be required (particularly through late spring and summer) • Requires good understanding of the water market to purchase temporary water efficiently • Reliant on knowledge of global situation – milk and fodder prices, climate patterns
Low irrigation	• Possibility of stabilising annual profit making over the mid to long term • Possibly less labour required over summer	• More exposed to risks of wet winter due to autumn calving • Reduced capacity to take advantage of favourable operational conditions i.e. high milk price, low feed costs • Yields can vary markedly between years	• May require additional infrastructure for wet winters, as well as good management • Conserving good quality silage is important, as is feeding it out with low wastage

What are the limitations of the modelling approach?

The main modelling assumptions of this research included:

- Development options were imposed directly rather than sequentially. In reality, each adaptation would be imposed gradually over time as allowed by borrowing constraints.
- Climate change scenarios followed the trajectory of high greenhouse gas emissions as predicted by the IPCC (RCP8.5), with atmospheric carbon dioxide levels in 2040 of 489 parts per million (ppm).
- The changing nature of the irrigation water market makes it difficult to predict the market price for future scenarios.
- The economics and risk analysis assume the options are implemented in the same way each year regardless of the seasonal conditions, and milk price, etc. It is too difficult to build the responsive tactical adaptation into the models.
- 'One-off' events such as a large flood or bushfire can be very costly to farm businesses but are difficult to represent in the modelling.

CONCLUSIONS

The profitability of dairy farm businesses in this research was negatively affected by the 2040 climate change scenarios modelled. This impact was greater than other dairy regions

The feedlot option offers potential for substantial profits in good operating conditions, but is likely to result in low returns in poor years. It is very dependent on a high and stable milk price and high initial equity position

The low irrigation option had less difference between wet and dry periods. This option offers advantages for managing risk but will be challenging to capitalise on favourable conditions

The high grazing option offers advantages when periods of cheaper water occur. Success for this option would be dependent on efficient adjustment of the system during times of higher water price

Milk price is a key factor determining profitability

The interaction between the level of debt and climate change and variability is also important

There is no clear evidence that any of the options are superior to others in a changed climate. It is likely that there will continue to be a wide range of options implemented in the future

Successful implementation of all options will be heavily dependent on excellent management skills

This project was funded by Dairy Australia.

Key researchers included Brendan Cullen and Andrew Smith, University of Melbourne and Daniel Armstrong, D-ARM Consulting.

This research was undertaken between June 2018 and June 2019. The decision to change a farming system is contextual – an industry wide response is not appropriate.

For further information please contact Alison Kelly at **Dairy Australia**.

Other fact sheets in this series are available **here**.

- Dairy Businesses for Future Climates – national information sheet
- Dairy Businesses for Future Climates – South Australia, Gippsland, Tasmania information sheet

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