Climate Change Impacts on Dairy Farming and Adaptation Options

Impacts

New Zealand's climate is ideal for pasture-based dairy systems. With climate change, the combined effects of rainfall changes, temperature shifts and increasing CO_2 fertilisation are likely to result in:

- Changes in seasonal timing of production, with shifts in spring break-even dates and, subsequently, planned calving dates.
- Increased seasonal growth rates during winter and spring, due to reduced temperature limitation.
- Shorter spring seasons, but with higher potential growth. More variable autumns and earlier summer onset, with more water deficiencies.
- Increased growth rate variability, bringing additional feed deficits and higher surpluses.

These impacts have been determined from detailed understanding of biological processes under a changing climate. They consider plant photosynthetic and respiration responses under warmer temperatures, as well as increases or decreases in rainfall, given existing pasture tolerances to moisture stress. They also consider CO_2 fertilisation, including key interactions with nitrogen. Overall, there is a positive impact on growth under climate change, but with important seasonal and regional differences. Importantly, greater year-to-year and month-to-month variability in growth is expected.

Farm System Implications

Although there is good knowledge about climate change impacts and pasture productivity, it is important to extend this to the whole system and evaluate adaptation options.

Pasture growth changes are the main impact examined by the whole farm modelling study in this review. With improvements to climate information and use of the systems approach, it is possible to examine variability along with adaptation options.

Ministry for Primary Industries
Manatū Ahu Matua

A resource developed through the Climate Change Technology Transfer Programme

These anticipated changes signal a need for greater management flexibility because preparedness for both feed deficits and surpluses will be needed. Warming temperatures are also expected to exacerbate a number of animal health and production issues. Cattle have a ‘thermoneutral’ zone, i.e. an optimal environmental temperature range in which animal heat production is minimal, and core body temperature normal. Beyond this range, cattle show a number of negative responses:

- Reduced intake and milk solids production.
- Pressure on rumen health.
- Difficulty conceiving.

The thermoneutral zone depends on a range of cow variables such as age, breed, size, body insulation, milk yield, feed intake, diet composition, and prior acclimation. As a general rule of thumb, on days warmer than 25°C, New Zealand cattle may start to suffer heat stress, but this is not a rigid threshold. In the case of other potential modifying impacts, our understanding is either incomplete, or inferred from overseas experience. Such impacts include:

- The possibility of genetic responses giving animals and pastures a degree of natural resilience to factors like rising temperatures.
- Shifts in the botanical composition and forage quality of pastures in warmer climates, and increasing weed species. Higher temperatures favour C4 grasses such as kikuyu, and accelerated pasture development with associated seasonal reduction in dry matter digestibility.
- An increase in pests and diseases in a warming, more humid climate, e.g. black beetle and facial eczema. Reduced cold stress in dairy cows.
- The prospect of drought-induced feed deficits, and their consequences for animal health and welfare
- Increased flood and storm intensities.

The role and impact of multiple stressors is also important. If only one climatic driver, or a single production element, is considered in isolation, it raises the risk of misinterpreting threats from climate variability and change. This study has endeavoured to look at the most critical elements together to avoid this problem. Whole-farm modelling indicates that retaining current management regimes in a warmer future will produce mild to moderate negative impacts on the farming system as a whole. By 2040, most of the modelled locations experienced productivity and profitability losses under both high and low climate scenarios.

Tactical adaptation

Current dairy systems are inherently flexible, and some New Zealand field studies indicate that adjusting current management within its known range of flexibility (tactical adaptation) could provide a way of turning potential negative climate change impacts into positive outcomes. Existing options offer New Zealand dairy farmers moderate to high degrees of tactical adaptive capacity (Table 1). They deal with a variable climate by changing pasture rotation and feed wedge strategies to maximise pasture growth. Those same strategies also offer some capacity to manage long-term changes in pasture growth variability. Broader impacts can, to some extent, be reduced or avoided by a range of other pasture and cow-specific technologies and practices. The example of ‘producing more silage and hay’ was evaluated. Across the five representative sites, increasing feed flexibility, by having more reserve feed on farm and feeding to good animal condition when excess fodder was available, was examined. The results showed an increase in median operating profit in the future climate, and appeared to mitigate any negative impacts from retaining current management. This adaptation allows managers to capitalise on good years, with increased operating profit at those times.

Table 1: Tactical adaptation options

Systems	*Cows*	*Pastures*
Lengthen lactations	Cooling during milking	Sow species containing novel endophyte
Produce more silage/hay	Minimise animal movement	Improve pasture assessment and monitoring
Alter calving patterns	Shelter	Use crops to break pest cycles
Alter grass rotation lengths	Supplementary feeding to animal condition	Use alternative pasture/crop
Change stocking rates	Manage soil damage through rotation	Pasture renewal

Strategic adaptation

The range of current New Zealand dairy farming systems vary in their exposure to the effects of climate change (direct and indirect) and other risks (Table 2). These systems range from very low-input, pasture-only dairy ('System 1') to high-input systems which supply up to 60 per cent of the cow's diet from purchased supplements ('System 5'). Shifting between systems is a form of strategic adaptation. Both profitable and non-profitable farms can be found within this spectrum, as profitably is less a function of system choice than farm management.

Table 2: Strategic adaptation options aviaable to the New Zealand dairy sector

Systems	*Cows*	*Pastures*
Minimal input grass based farming (System 1)	Install infrastructure in milking shed, shade sprinklers, fans, adequate drinking water	Change species base of grass farming
Medium input dairy: strategically use supplementary feeds (System 2-3)	Farm design (trees) to provide paddock shade and reduce wind chill	Irrigation to supplement water deficits and improve water use efficiencies
High input dairying that extend production through supplementary feed (System 4-5)	Refrigeration to cool drinking water	Ongoing pasture renewal
Southern wintering systems	Decrease fibre, increase digestible proteins and fats with supplements	Introduce new forage crops

A number of adjustments can change the way current dairy systems respond to shifts in climate that reduce the impacts of climate change. For example, infrastructural changes can be made to the milking platform and farm landscape to reduce heat and cold stress. Permanent change to the pasture species base is also an option, as are irrigation, sustained pasture renewal and the use of new forage crops. In the whole-farm modelling, irrigation, pasture species change and reduced stocking rates (lower system intensity) were chosen as examples of strategic adaptation. When those options are pooled across all sites the spread of results shows:

- A small negative change in average operating profit overall, compared with past climate under current management.
- Reducing stocking rates at all sites by 15 per cent placed sustained downward pressure on production and profitability.

- At the other end of the scale, some strategic adaptation options captured more profit in good years, much the same as tactical adaptation did.
- Although some adaptation options reduce production losses, they are not always cost-effective with only slightly positive, or even negative shifts in operating profit.
- Some adaptation options, like irrigation, provided positive production and profit outcomes at some sites, but failed at others.

  These results reinforce the point that the strategic adaptation options which demand greater financial risk and/or capital investment need careful planning. There is no single best approach, and a degree of fine tuning is required at the farm level to bring about success. This highlights a critical role for rural professionals in helping dairy operators plan the implementation of strategies for climate change.

Transformational adaptation

New technologies could change the way dairy systems function under climate variability and change:

- Pasture technologies could lift potential pasture yields from 20 t DM/ha per year at present, to 25 t DM/ha per year.
- Modifying plant morphology and increasing the rooting depth could mitigate moderate to severe water shortages.
- Pasture technologies could reduce the effects of environmental stressors on plants.
- Breeding could produce cattle with increased tolerance to heat and cold stress, as well as with improved productive performance.

Key knowledge gaps

Emerging knowledge of whole-farm system responses reveals a complexity of impacts, but also the flexibility and resilience of modern dairy systems. Nevertheless, the dairy sector still faces some key knowledge gaps around climate change impacts. It is important to recognise both the benefits and limitations of holistic farm analysis. It is useful for illustrating some general principles, but does not provide 'management prescriptions'. Continual active engagement with farm managers is an important driver of adaptation. Exploring future targets for nutrient-use efficiency is also an important consideration for the sector, because more nitrogen is needed to capture potential benefits from carbon dioxide fertilisation. The effects of rising CO_2 concentrations, and changing temperature and rainfall patterns, on pasture and crop plants are not fully understood, especially the implications from any interactions between those variables. It is important to balance modelling estimates with field-based verification in operating dairy systems. Furthermore, research into the effects of these variables on plant molecular processes in many pasture species is either still in its infancy, or not yet begun. Projected climate changes are more likely to affect dairy cow performance through indirect effects on disease, feed supply and quantity, and extreme weather events. To improve the information available for tactical adaptation, this broader range of impacts still needs to be assessed through future whole-farm systems analysis.

Further Information

- The full technical report that this summary is based can be found at
  www.climatecloud.co.nz/CloudLibrary/2012-33-CC-Impacts-Adaptation_SLMACC-Chapter3.pdf

An assessment of the dairy farming system under climate change is available in:

- Dairy Exporter Great Farming Guide to Climate Change - provides regional exposure information and practical adaptation case studies specifically for the dairy sector.

Disclaimer June 2014

Ministry for Primary Industries
Manatū Ahu Matua

While every effort has been made to ensure that this publication is accurate, the Ministry for Primary Industries does not accept any responsibility or liability for error of fact, omission, interpretation or opinion that may be present, nor for the consequences of any decisions based on this information. All users of this document should satisfy themselves, and their client(s), concerning the application of this document to their situation – and seek expert advice where there is uncertainty.