Agriculture: adapting to climate change

Say 'climate change' and most of us start thinking of a dark cloud with no silver lining.

Major variation in our climate patterns does have the potential to seriously jeopardise our agricultural productivity. But Australian farmers can lessen the impact of climate change by developing more 'resilient' agricultural systems.

Nick Goldie and Monica van Wensveen report.

TRAPPING OF HEAT by the atmosphere is a natural phenomenon that has been occurring ever since the atmosphere formed billions of years ago. However human activities since the Industrial Revolution in the mid-eighteenth century have increased the concentrations of 'greenhouse gases' in the atmosphere. Current carbon dioxide levels in the atmosphere are 30% higher than in pre-industrial times. Methane and nitrous oxide have increased by about 145% and 15% respectively in the same period.

According to the Intergovernmental Panel on Climate Change, the Earth may become 1.4–5.8°C warmer by the year 2100. CSIRO's climate change projections for Australia† indicate that our continent will warm at a slightly faster rate than the global average, reaching –0.4–2.0°C above average by the year 2030 and 1–6°C by 2070. Modelling also suggests that associated with this warming will be marked reductions in rainfall over southern and eastern Australia, more evaporation and a global sea level rise of nine to 88 centimetres.

A whole range of impacts are tied in with these changes: a marked decrease in snow in the Australian Alps; more severe tropical cyclones and storm surges; more fires; and an increase in 'moisture stress' due to reduced water availability for Australia as a whole.

This may be bad news for skiers, coastal communities and some ecosystems, but is it necessarily bad news for farmers?

According to Dr Mark Howden of CSIRO Sustainable Ecosystems, climate change may reduce the amount and the quality of produce, as well as the reliability of production and the sustainability of the natural resource base on which agriculture depends.

But in a report[1] commissioned by the Australian Greenhouse Office, Dr Howden and his colleagues argue that there are practical and financially viable options which are immediately available that can reduce the risks of negative impacts and take advantage of opportunities.

'The first requirement is that farmers accept that climate change really is happening,' says Dr Howden. 'Then they will be motivated to avoid risks, and also to look out for opportunities. Farmers are already adapting to the reduction in frost frequency that has occurred over much of Australia in the past 50 years,

† CSIRO climate change projections for Australia (8 page brochure) www.dar.csiro.au/publications/projections2001.pdf

[1] *An Overview of the Adaptive Capacity of the Australian Agricultural Sector to Climate Change – Options, Costs and Benefits.* A report to the Australian Greenhouse Office by Dr Mark Howden *et al*, CSIRO Sustainable Ecosystems 2003

To investigate the possible interactive effects of carbon dioxide and climate change on agricultural crops, scientists have used an existing computer model of Australian wheat cropping systems, and applied the doubled carbon dioxide levels and climate changes that are expected by the year 2100[2]. A 'test run' of the program was carried out using climatic and agricultural data from the Burnett region of south-east Queensland.

The results indicated that under these climate change conditions:

- Average wheat yields were 26–37% higher under doubled carbon dioxide than under today's carbon dioxide, and this response was greatest in dry years.
- The risk of frost is already low in the Burnett region. This risk is almost removed with global warming, greatly increasing the planting window and the varieties that can be planted.
- Water limitations at the end of the season were still likely to restrict production in most years. Use of faster-maturing varieties, combined with early planting may be advantageous.
- The high protein levels currently achieved were significantly reduced (11–12 %) with elevated carbon dioxide. The models suggest that increased temperatures could moderate this reduction and that increased fertiliser application could be used to maintain nitrogen at current levels.
- The increase in temperature would almost double the frequency of 'heat shock days' (temperature >32°C) during grain filling. These conditions would change the protein composition and reduce grain quality.
- Adaptations such as breeding of heat tolerant cultivars, changing planting windows and changing fertiliser management may be needed to counter changes in wheat quality associated with elevated carbon dioxide and temperatures.

[2] P. J. Reyenga, S. M. Howden, H. Meinke, and W. B. Hall. (2001). Global change impacts on wheat production along an environmental gradient in south Australia. *Environment International* **27**,195-200.

Reyenga, P.J., Howden, S.M., Meinke, H., and McKeon, G.M. (1999). Impacts of global change on cropping in SE Queensland. *Environmental Modelling and Software* **14**, 297-306.

To investigate the possible impacts of climate change on grazing systems, scientists again used an existing model (this time a soil-pasture-livestock model) as a basis, changing carbon dioxide, temperature and rainfall to reflect possible future climate scenarios.

The results indicate that:

- Doubling carbon dioxide is likely to have a beneficial effect on plant growth and hence ground cover
- The effects of climate change on plant growth are likely to promote increases in animal production through improved pasture productivity, increased growing season length and reduced variability in liveweight gain.
- Erosion may be reduced due to a lower amount of runoff and increased ground cover, but increased subsoil drainage may pose problems where there are salinity and waterlogging risks
- Growth responses are likely to be greater in drier years than in wetter years, partly due to soil nitrogen limitations.
- Small increases in temperature in combination with carbon dioxide are likely to further increase animal production due to the increased number of growing days in the cooler months. However larger increases will have negative effects through increased evaporation and hastening of plant life cycles.

[3] S. M. Howden, W. B. Hall, and D. Bruget. (1999). Heat stress and beef cattle in Australian rangelands: recent trends and climate change. *Proceedings of the International Rangeland Congress* 6th v. **1**, 43-45.

S. M. Howden, G. M. McKeon, L. Walker, J. O. Carter, J. P. Conroy, K. A. Day, W. B. Hall, A. J. Ash, and O. Ghannoum. (1999). Global change impacts on native pastures in south-east Queensland, Australia. *Environmental Modelling and Software* **14**, no. 4, 307-316.

reducing risk of frost damage and increasing productivity.'

This positive aspect of climate change needs to be balanced with the prospect of significant reductions in growing season rainfall across the southern Australian cropping zones, coupled with higher temperatures and evaporation– a recipe for reductions in crop yields, as seen in the 2002–2003 drought.

'Of course there will always be uncertainties in future climate scenarios, because we can't predict how quickly future greenhouse emissions will rise, and we are still coming to grips with the global climate system,' he says. 'However it is certain that there will be ongoing technological, cultural and institutional change.

'This means that it is essential that we develop management systems which can adapt to change as the change happens, in effect learning as we go along,' he says.

'Seasonal forecasting will become very much more important,' says Dr Howden. 'Forecasts such as those based on El Niño, La Niña and ocean temperatures around Australia will be vital to help farmers, industry and policy makers incrementally adapt to climate change while managing for climate variability, especially when these forecasts are linked to on-ground measurements, market information, and systems modelling.'

Successful adaptation to climate change will need both strategic preparation and tactical responses, according to Dr Howden, including proven technologies to allow change to occur, as well as support for agriculturalists during periods of transition.

'Transport and market infrastructures will have to be as flexible and ready to change with the industries they service,' says Dr Howden. 'These sectors will need to share a common understanding of the risks and the opportunities which climate change will bring.'

Dr Howden and the CSIRO Climate Impacts and Adaptation Working Group note that many potential adaptation options are common across industries, including the need for linkages to and between existing government policies and initiatives dealing with matters such as greenhouse, salinity, water quality and catchment management.

Other areas of commonality are transition management, communication, and the collection and monitoring of climate data.

'Effective water use will also become even more important than it is today,' says Dr Howden. 'This will mean the introduction of water-trading systems that allow for climate variability and climate change, as well as improving the actual water distribution systems to reduce leakage and evaporation.

'Farmers themselves will need to become even more adept at water management and the use of sophisticated water-saving technologies,' he says.

What effect will climate change have on Australia's livestock industry? The projected reductions in rainfall across the southern half of Australia and the prospects of even more variable climate indicate that our expectations of forage growth and consequent animal production based on past experience may need to be changed. In addition to effects on feed supply, projected increases in heat stress from higher temperatures could have a detrimental effect on animals, affecting liveweight gain in beef cattle, milk production in dairy cattle, and conception and mortality rates.

There will be a marked increase of heat stress days in most locations, with the most severe increases (30% increase by 2070) predicted for the Northern Territory and northern Queensland.

This suggests that it would be prudent at least for pastoralists and graziers to select stock breeding lines with efficient temperature regulation if livestock production is to be maintained. Increased heat stress also suggests that water requirements will increase, and the probability of overgrazing near water points, which in turn will require specific management regimes.

Dr Howden says that, as well as looking at livestock and grain, the report analyses the impacts of climate change on viticulture, horticulture, the sugar industry and farm forestry, and pays special attention to water resources. The value of the report, he says, lies in the comprehensive view that the panel of authors were able to take in investigating the enormously complex effects of climate change on Australian agriculture.

'Climate change is occurring,' he says, 'and this report outlines the number and range of adaptations to climate change that we can and should start to develop now.'

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