

On-farm management in a variable and changing climate: A participatory approach to adaptation.

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Take Home Messages

There is now firm evidence that, in addition to climate variability, there are also changes (trends) in key climate indices (i.e. rainfall and temperature) resulting from human activity.

This means that good risk managers need to consider both climate variability and change in their on-farm plans in order to ensure future sustainability.

Many of the actions required for adapting to climate change are extensions of those currently used for managing climate variability.

Using seasonal climate forecast information to vary planting times, sowing rates, nitrogen application, cover and crop varieties is shown to result in both production and natural resource management (NRM) benefits under variable climate conditions.

Under changed climate conditions (warmer and variable rainfall) simulation studies show that yields can be improved by changing crop varieties and planting windows.

Local crop management adaptations are likely to have a significant role in maintaining or increasing current productivity under variable and changing climate conditions.

Climate variability and change are likely to continue having different impacts in different regions, requiring locally specific adaptation strategies.

Background

Historical climate information clearly shows climatic trends in response to human activity and land use change. These include increases in temperature, changes in annual rainfall, and length of dry spells. Given that both climate variability and change interact, good risk managers should begin to consider both climatic elements in operational and strategic farm planning (Meinke and Stone 2005).

Regional projections of future climate change have been produced by CSIRO on behalf of the Victorian Government, and are available from the Department of Sustainability and Environment website at

<http://www.greenhouse.vic.gov.au/greenhouse/impacts/climatechangeaffect.htm>.

The Wimmera-Mallee region is projected to experience annual warming of 0.2°C to 1.6°C by 2030 above current average annual temperature conditions, possibly resulting in an increase of up to 40% in the number of hot summer days (over 35°C) and up to 70% decline in the number of frost days. Annual precipitation is projected to decrease (changes of +3% to -15% by 2030), with declines strongest in the winter and spring.

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Many of the options for adapting to projected changes in climate are extensions of those currently used for managing climate variability. For this reason, ongoing efforts to manage climate variability represent a useful first step toward adapting to climate change. Interaction with farmers suggests a number of stumbling blocks that need to be addressed in order to increase the use of climate information for both operational and strategic decision making:

1. Farm managers must be convinced that the inclusion of climate information in current practises will provide tangible benefits in both profitability and natural resource management (NRM) terms over both the short and long term.
2. Farm managers must have the capacity (*both financial and technical*) to implement proposed management changes.
3. Where major land use changes are required, governments can facilitate structural adjustments through policies that enable the free flow of resources between industries and sectors.
4. New infrastructure, policies and institutions to support the new management and land use arrangements can be encouraged.
5. Proposed management changes to adapt to climate variability and change must be continually monitored and evaluated to determine what is working, what is not and why (Howden et al., 2003, McKeon et al., 1993).

A participatory research project is currently underway that begins to address some of these stumbling blocks through greater engagement with producers to develop better understanding of the value of climate information in on-farm productivity and NRM decisions. The project involves the collaborative efforts of BCG, CSIRO and RM Consulting Group with support from the Australian Greenhouse Office, the Brigalow-Jimbour Floodplains and Mingenew-Irwin Landcare groups.

The participatory research approach recognises that much of the knowledge resides with the producers and that the most appropriate and practical adaptation options are most readily identified through this approach.

Methods

This project seeks to identify the options that farmers would, and in some instances are, using to manage climate variability and adapt to climate change. Simulation modelling is being used to explore the potential of these management options to maintain crop yields and promote NRM.

During the course of this project a series of group workshops and interviews have been conducted in three case study regions: Wimmera-Mallee (Vic), Brigalow-Jimbour (Qld) and Mingenew-Irwin (WA). Participants were asked to respond with their views on:

1. Critical climate-related management decisions currently providing resilience to farming systems.
2. The extent to which these management decisions may be influenced by climate variability and change.
3. How some of these management decisions can be adapted to improve the resilience of the farming systems to the effects of variability and change.
4. The feasibility of these adaptation options in production, natural resource management and economic terms.

In the interviews, individual producers were asked to identify key decision points where they thought either seasonal climate forecasting or climate change information may be of value.

The participant responses from the group sessions and individual interviews hosted in each of the three regions were summarised and these key decision points are now in the process of being implemented in a modelling framework for a number of farms in the Brigalow-Jimbour, Wimmera-Mallee and Mingenew-Irwin regions. The range of farms will be modelled using the **Agricultural Production Systems sIMulator (APSIM)** (Keating et al., 2002). This model has been used to understand the net result of adapting current management strategies to respond more effectively to climate due to its flexibility in examining a range of crops, pastures and trees, soil processes including water balance, nitrogen (N) and phosphorus (P) transformations, soil pH, erosion and a full range of management controls. Using this framework allows a comprehensive assessment of possible changes in crop yields and key natural resource management issues (e.g. run-off, drainage and nitrogen leaching).

Results

The group workshops and interviews identified a range of adaptation measures including:

1. Altering planting decisions to be more opportunistic – more effectively taking into account environmental condition (e.g. soil moisture), climate (e.g. seasonal climate forecasting) and market conditions.
2. Development of additional risk amelioration approaches (e.g. zero tillage and other minimum disturbance techniques, retaining residue, extending fallows, row spacing, planting density, staggering planting times, controlled traffic, erosion control infrastructure).
3. Incorporating seasonal climate forecasts and climate change into farm enterprise plans.
4. Selection of varieties with appropriate thermal time and vernalisation requirements, heat shock resistance, drought tolerance, high protein levels, and perhaps varieties that can produce flowers in hot/windy conditions.

A number of additional adaptation measures have also been identified in previous research (i.e. Howden et al., 2003), although not assessed in this project. They include:

1. Expanding routine record keeping of weather, production, degradation, pest and diseases and weed invasion.
2. Improving efficiency of water distribution systems (to reduce leakage and evaporation), irrigation practices and moisture monitoring.
3. Learning from farmers in currently more marginal areas.
4. Enhancing current consideration of decision support tools/training to access/interpret climate data and analyse alternative management options (e.g. Yield Prophet).
5. Enhancing current access to climate change information through increased linkages to research and government agency websites.

Adapting to Climate Variability

To date a number of adaptation options to cope with climate variability have been examined and assessed by comparing production (estimates of gross margin), run-off, drainage and nitrogen leaching simulated under “current management” conditions with those simulated under “adaptive management” conditions.

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The “adaptive management” conditions include varying planting times, sowing rates, nitrogen application, cover and crop type in response to climatic conditions likely to occur over the subsequent three months. The climate conditions are assessed using a range of climate indicators (e.g. mean sea level pressure changes, sea-surface temperature changes, pressure variation over central Australia etc.). In the case study below two different climate indices have been considered namely the Southern Oscillation Index (SOI) and the Southern Oscillation Phase system (SOI phase). The SOI is a well established index calculated from the monthly or seasonal fluctuations in the air pressure difference between Tahiti and Darwin. The SOI phase system is a similar measure of pressure difference between Darwin and Tahiti, however the pressure difference index is placed into different phases. Phases of the SOI are calculated using cluster analysis to group all sequential two-month pairs of the SOI (from 1882 to 1991) into five clusters (Stone et al., 1996).

On a case study farm in the Wimmera-Mallee region, the comparison of “current management” with “adaptive management” informed by “prior climate knowledge”, the SOI phase system and SOI revealed that gross margins could be improved only slightly by considering some aspect of this climate information. The simulated average gross margins (1960 to 2005) from “current management” was \$144.26/ha/annum, \$145.57/ha/annum for “adaptive management” considering the SOI phase climate information and \$136.78/ha/annum for “adaptive management” considering the SOI. In contrast, if the farmer had prior knowledge of what the climate was going to be the gross margin would be \$165.52/ha/annum. The gap between the three strategies and ‘prior knowledge’ can be thought of as the maximum potential value of climate knowledge.

On a year by year basis, the adaptive management practices achieved higher gross margins than “current management” in 44 out of 46 years for “prior climate knowledge” (96%); 23 out of 46 years (50%) using the SOI phase system; but only in 16 out of 46 years (35%) using the SOI (Figure 1). For the cases of “adaptive management” informed by the SOI phase information and SOI, higher gross margins were largely simulated in years with low rainfall (i.e. lowest 58% and 20% of years respectively) and extremely wet years (i.e. highest 2% and 15% of years respectively; Figure 1), thus suggesting value in the use of climate information to mitigate the impact of dry years and maximise the benefits of wet years. The corollary to this however, is that in many years, little benefit accrues from the use of a given seasonal climate forecasting approach. However, this observation also opens up the potential for the use of ‘hybrid’ approaches to seasonal climate forecasting that recognise that in some years a particular index may have little skill but that other approaches may convey more information and *vice versa*.

In terms of NRM outcomes, adapting management practises that incorporate climate indices resulted in only a 0.5% to 1% annual reduction in run-off, drainage and nitrogen leaching using the SOI phase information and a 1.5% to 10.5% annual reduction using “perfect climate knowledge”.

Further analyses are currently being undertaken with improved climate information to determine if additional profitability or NRM gains can be made.

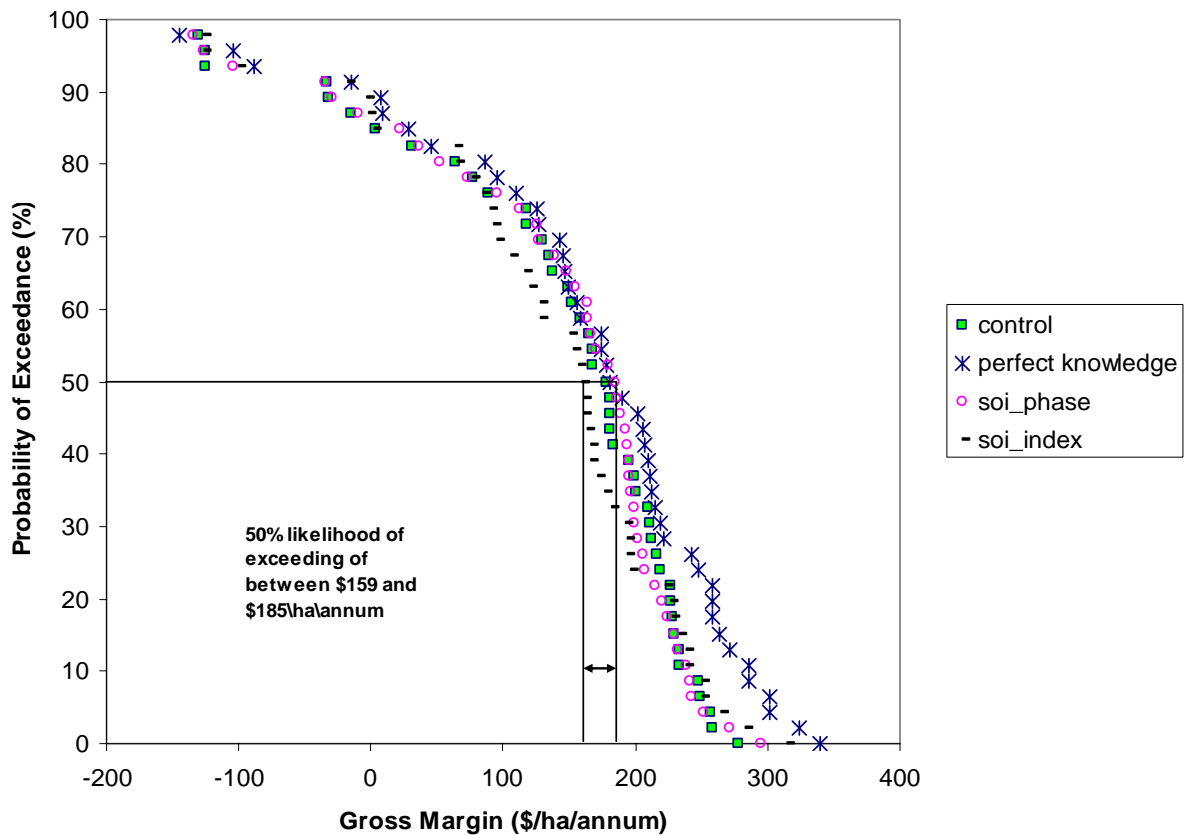


Figure 1: Probability of exceedance curves for gross margins for a case study farm in the Wimmera-Mallee region. Exceedance curves are generated using the APSIM model for “current management” practises (control), and “adaptive management” informed by the, SOI index, SOI phase and “perfect climate knowledge” for the period 1960 to 2005.

Adapting to Climate Change

Management options such as changing crop varieties and changing planting windows were also identified by farmers as having potential in adapting to changing climatic conditions. These options will be fully explored in the remainder of the project but preliminary analyses (Howden and Crimp, 2005) suggest clear yield benefits from considering these options.

Given the magnitude of climate changes are uncertain at regional levels, particularly in the case of rainfall, many assessments have been structured to examine a range of possible future climatic conditions. In the case study below the APSIM model was used to test the impact of varying crop varieties and planting window in response to a range of warming and rainfall conditions. The simulated yield benefits emerging from this case study did not fully consider extreme temperature impacts on yields and for this reason some variation in benefit may occur by considering these factors.

Wheat yields were simulated in the Horsham region under a range of different temperature (i.e. 1 to 4°C warmer) and rainfall conditions (+20%, 0% and -20%). With no change in rainfall and no adaptation (i.e. no change in crop variety and planting window), simulated yields increased for warming of up to 1°C (Howden and Crimp, 2005). Temperatures higher than this resulted in lower yields (Figure 2 a).

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When adaptation was considered, higher productivity was maintained up to 2°C of warming. When rainfall was increased by 20% higher productivity was maintained until a warming of 3°C (Figure 2b). In contrast, elevated temperatures and reduced rainfall produced negative impacts on yields in this region irrespective of the absence or presence of adaptation (Fig 2 a,b). The inclusion of adaptation served to elevate some of the negative impacts on productivity up to 1°C of warming, but at higher temperatures little difference in yields was measured between the adaptation and no adaptation case (Figure 2b).

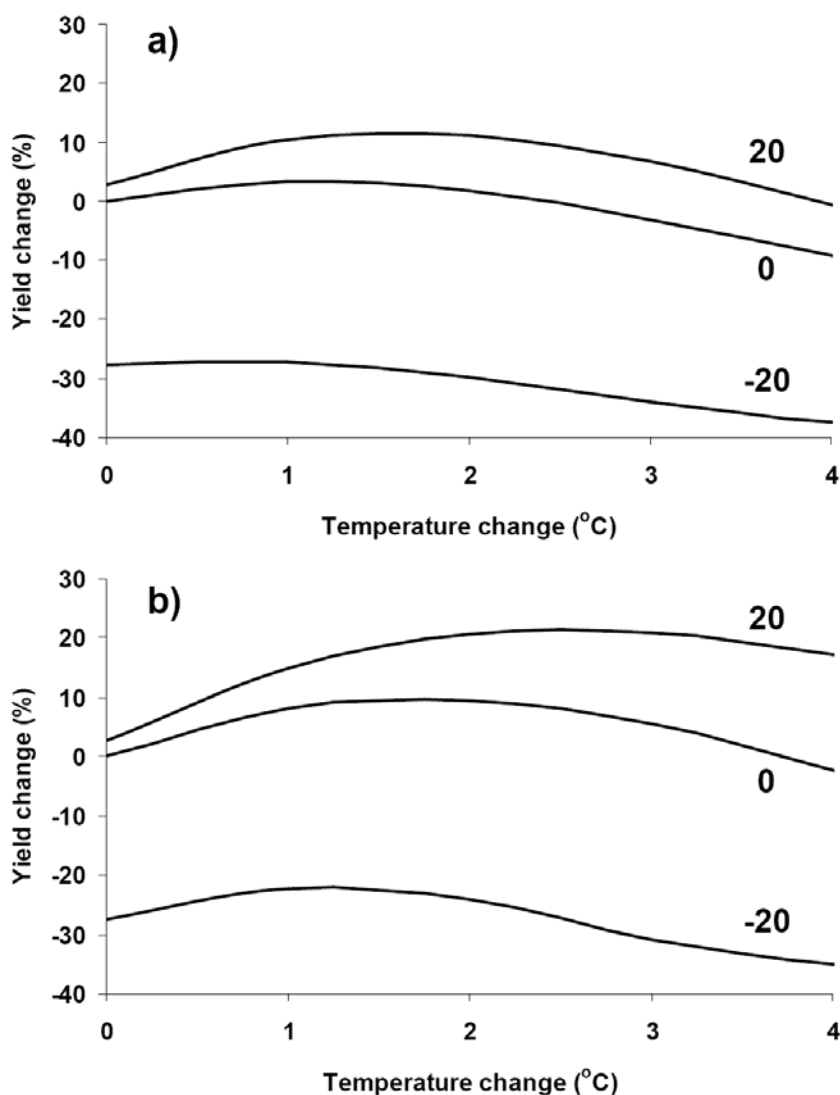


Figure 2: Wheat yield responses (% change from historical baseline) simulated using APSIM for Horsham, Central Victoria, for temperature increases up to 4°C and rainfall changes of +20%, 0 and -20% when a) no adaptation and b) adaptation was simulated (Howden and Crimp 2005).

Conclusions

The analyses above shows that incorporating seasonal climate forecast information to inform management decisions such as planting times, sowing rates, nitrogen application, cover retention and crop type, can result in both production and NRM benefits such as reductions in run-off, drainage and nitrogen leaching. If climate variability increases, the use of seasonal climate information will have even greater potential value. This is because the results of model

simulation suggest that adaptive management improves yields and gross margins more in years with extremely low or high rainfall, which are expected to occur more frequently as climate changes into the future.

The simulation results also suggest that changing crop variety and the planting window in response to warmer and more variable rainfall has potential to improve crop yields, although these benefits were largely limited to scenarios with warmer and wetter conditions. Under warmer and drier conditions (i.e. 1°C increase in temperature and 20% less rainfall), a 28% decline in average yield was simulated for the no adaptation case while a 22% decline was simulated when adaptation was considered. Hence, adaptation to climate change can offset only some of the negative aspects of the climate changes that seem more likely for Northern Victoria.

These results suggest that crop management adaptations have a potentially significant role in maintaining or increasing yields under variable and changing climate conditions. However, relatively unique adaptation options will be required at a range of spatial scales to deal with relatively unique sets of physical and socio-economic conditions at each scale (i.e. climate, soils, production systems etc.).

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