

## Assessing climate risk to improve farm business management

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**Summary.** Climate variability is a significant source of risk for farming businesses. Climate risk management involves assessing the impact of climate variability, applying structural change and making both strategic and tactical decisions to minimise the risk. This management is enhanced by improving the understanding of climatology and the potential application of seasonal climate forecasts to agriculture and natural resources. We argue that the extension of such climatological information plays a primary role in managing climate risk and can be delivered through workshops combined with user-friendly software.

### Introduction

Variability in income is a fact of life for farm businesses, and much of it is directly associated with variability in climate. For example, climate affects the prices of agricultural produce in the local and global market place (Hammer et al. 1987; Stone 1993; White et al. 1999; White 2000). This paper will argue that presenting and discussing weather and climate information in an educational forum is a method that will help to survey and assess climate risk in order to reduce uncertainty and improve farm business management.

### Climate uncertainty and risk in agriculture

Although climate variability affects all the factors influencing farm income, it is the impact on yield (production risk) that is most recognised by farm business managers (see Figure 1). Hardaker et al. (1997) define production risk as the risk that comes from the unpredictable nature of weather and uncertainty about the performance of crops or livestock. The relationship between climate and production risk is well recognised. For example, Hammer et al. (1996), McKeon et al. (2004) and Partridge (2000 and 2001) discuss the influence of rainfall on the yield of crops, the condition of native pastures and the amount of grass produced for livestock consumption. Mavi and Tupper (2004) also recognise that climate variability creates production risk through its impacts on resources, pests and diseases. Malcolm (1992) defines risk as the probability of something happening, while uncertainty covers all things that could happen which the decision-maker would not expect. Figure 1 shows the integration of multiple factors that explain climate in the context of uncertainty.

### Climate risk management and the role of education

Risk management is the systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring risk (Malcolm 1992). Climate risk management therefore assesses the possible impacts of climate variability on farm businesses, rural industries and the options available to mitigate the risk.

Malcolm (1992) and Krause (1994) describe how farming is a risky business, and how managing a risky business is about gathering relevant information, weighing it judiciously and acting accordingly. As improved knowledge about climate and skills in seasonal climate forecasting help in managing uncertainty in farming, the opportunity to learn about them has a pivotal role for all involved in rural production (Banks 2004).

The aim of this paper is to show that climate risk can be reduced through integration of understanding and systematic use of climate analysis into business decisions.

### Climate variability issues relevant to business

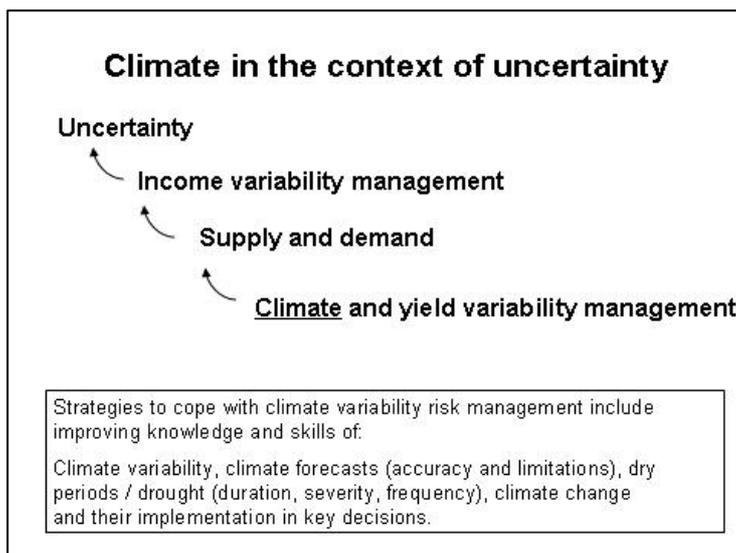
The climate in Australia is never 'normal', and examination of the rainfall of any location would demonstrate the extent of its variability (Lee and Gaffney 1986). The challenge to manage for times of higher or lower than average rainfall is not an easy one. However, analysing historical climatic data helps to provide a better understanding of the following issues:

- the degree of climate variability
- climate forecasts (accuracy and limitations)
- dry periods (duration, severity, frequency, forewarning)
- climate change.

A systematic process covering these aspects and developed from experience with farmer workshops is shown in Table 1. It shows a hierarchical process beginning with a review of historical

rainfall records for the participant's location and working through to critical decision points. It then covers tactical, strategic and structural farm planning aspects (George et al. 2000).

Figure 1. Conceptual map of climate in the context of uncertainty.



### Some tools and process currently available to help manage climate risk

Tools to help manage climate variability through analyses of climatic data such as rainfall, streamflow and temperature include: Rainman Streamflow (Clewett 2002; Clewett et al. 2003), Whopper Cropper (Nelson et al. 2002) which assists in crop management decisions and DroughtPlan (Cobon and Clewett 1999) which assists with pasture and animal management decisions.

Clarkson et al. (2000) alluded to six requirements that are needed by farmers in order to manage climate variability. These include:

- awareness of climate variability
- understanding of climate and the causes of climate variability
- historical records for the location
- analytical tools to describe the variability
- forecasting tools to give advance warning of likely seasonal conditions
- application of forecasts to key decisions.

Many of these elements necessarily require the analysis of historical records. This can be an onerous and difficult task for managers of rural businesses. The ability of software to assist in the process of managing climate risk has been widely recognised (Nelson et al. 2002). A software program that allows analysis of climatic data for the key decision points in an agricultural system is especially valuable (Clewett 2002). White (2000) suggests that models and other decision support systems (DSS) have an important role in identifying those management strategies that are financially viable and exposed to minimum physical and financial risk, particularly in areas exposed to a variable climate. However, limitations of models and forecasts still need to be recognised (Robinson and Butler 2002).

The following key questions that software can help to raise and answer are not exhaustive, but may help to begin discussion about climate variability and better decisions. They include climate information for the key decisions in:

- cropping - what are the chances of getting sufficient rainfall over the next cropping season?
- livestock - when is the wet season likely to break and how much pasture will be produced over the growing season?; what will be the optimal stocking rate?
- irrigation - how many high flows could be expected in the local river this year?; what are the chances of getting heatwave conditions during the crop's flowering period?
- resource management - have heavy rainfall events become more frequent in recent years?; is it getting hotter with climate change at this location?

There is value in looking at the example of the chance of 300 mm of rain falling over the winter cropping season in central NSW (Figure 2). The climatological rainfall probabilities can be grouped according to the state of the Southern Oscillation Index (SOI) to produce separate probability

distributions. Rainfall of 300 mm should deliver a wheat yield of about 2200 kg/ha (assuming average farming conditions, no pests and diseases and yields commensurate with those calculated by the crop model Whopper Cropper (Nelson et al. 2002)). Over all the years, the chance of receiving 300 mm is 44%. However, if the SOI in the previous three months has been below -5, there is only a 26% chance of 300 mm and a median rainfall of 193 mm. This equates to an expected yield of about 1600 kg/ha with a dollar return reduced by almost 30%.

Figure 2. Chance of receiving 300 mm of rainfall from June to November for the winter cropping period, based on March to May SOI, in Dubbo, NSW.

| Chance of rainfall at DUBBO (COOREENA RD)  |              |                 |                 |           |
|--|--------------|-----------------|-----------------|-----------|
| Analysis of historical data (1875 to 2004) using average SOI: Mar to May Leadtime of 0 months  |              |                 |                 |           |
| The average SOI/rainfall relationship for this season is statistically significant because KW test is above 0.9, and Skill Score (14.3) is above 7.6 (p = 0.98). <a href="#">Chance result or real skill? Help</a> |              |                 |                 |           |
| Rainfall period: Jun to Nov  | SOI below -5 | SOI -5 to +5    | SOI above +5    | All years |
| % yrs with at least 478 mm   | 3            | 8               | 3               | 5         |
| 400 mm   | 6            | 19              | 9               | 13        |
| 350 mm   | 16           | 30              | 24              | 25        |
| 300 mm   | 26           | 49              | 50              | 44        |
| 250 mm   | 35           | 66              | 68              | 69        |
| 200 mm   | 48           | 79              | 82              | 73        |
| 138 mm   | 87           | 97              | 100             | 96        |
| % yrs above median 274 mm  | 32           | 54              | 59              | 50        |
| KS/KW probability tests  | KS=0.995     | KS=0.76         | KS=0.63         | KW=0.991  |
| Significance level   | **           | Not significant | Not significant |           |
| Years in historical record   | 31           | 63              | 34              | 128       |
| Highest recorded (mm)  | 584          | 586             | 758             | 758       |
| Lowest recorded (mm)   | 54           | 67              | 153             | 54        |
| Median rainfall (mm)   | 193          | 289             | 299             | 274       |
| Average rainfall (mm)  | 231          | 297             | 299             | 282       |

Source: Rainman software (Clewett et al. 2003)

Management options that could be considered knowing this probability shift arising from different SOI scenarios include: plant a different crop, plant a smaller area of wheat, reduce the seed rate and apply less fertiliser. Thus a better understanding of expected rainfall can be used to amend the crop management decisions, thereby reducing the risk of farming. However, education and training are needed so that the farmer fully understands probabilistic forecasts and their limitations. Details on the 'skilfulness' of forecasts are described in a companion paper (Clewett 2002).

A systematic way of developing knowledge and skills in managing climate variability is now described in terms of weather information, climate information and a theoretical basis to help deliver such information to agriculture.

Factors concerning weather 'contents' are:

- layers of the atmosphere
- differential heating of the earth by the sun
- atmospheric circulation to balance warm and cooler parts of the atmosphere
- behaviour of low and high pressure systems
- Australia's position in relation to the subtropical ridge of high pressure
- Coriolis effect resulting in south-east trade winds
- synoptic charts typical in summer and winter
- local conditions conducive to rain created by:
  - orographic uplift
  - convection
  - convergence
  - cold fronts
- regional effects of phenomena such as the Madden-Julian Oscillation, north-west cloud bands, upper level troughs and cut-off lows.

Up-to-date services and information via the Internet, satellite, radar and new developments such as 4–7-day forecasts can help in planning farm activities. Weather information generates short-term decisions such as those needed in hay-making, harvesting or shearing. Calculating how much hay to sell or store might be more influenced by the longer-term climate outlook.

Factors concerning climate 'contents' are:

- what conditions are needed for a good season?
- what are the chances of getting these conditions?
- what will be done if these conditions are not received?

- how may climate risk be minimised?

In order to answer these questions there should be an examination of the current and future climate and agricultural situation, including:

- identification of problems of climate and agriculture
- consideration of causes of these problems
- description of possible solutions to problems.

Actions to take include:

- identification of key issues and concerns
- examination of climate variability for a specific location
- consideration of effects of climate variability on production and returns
- understanding the forces that drive climate e.g. ocean temperatures, Walker Circulation
- use of forecast tools that explain much of the climate variability (e.g. ENSO, SSTs)
- examination of the current climate position (e.g. rainfall deciles for past 1, 3, 6, 12, and 24 months)
- assessment of the current outlook (for next 1, 3 and 10 days; 1, 3 and 12 months)

These actions, and the answering of other questions that may arise in the course of discussions and in reflection, will help to reduce climate uncertainty in terms of probabilities.

The high variability in Australia's climate is a challenge for agriculturalists (Munro and Lembitt 1997). Management requires better understanding of the causes and impacts of this variability and knowledge of the usefulness and limitations of seasonal forecasts. This flows to better management in soil-plant-animal-water systems. Climate change confounds this issue but makes the understanding of variability imperative (Nicholls 2003). Better understanding of climate variability will help management of climate change, and this will be helped by education and training in applied climatology.

Principles of adult learning relevant to the task of 'surveying climate and enterprise data' include:

- Application of action learning relevant to the ways farmers solve problems (Davey 1987; Kilpatrick 1997, 2000).
- Construction of knowledge, building from actual experiences to abstract concepts (Kolb 1984).
- Use of tables, graphs and animations to enhance different learning styles (Johnson and Johnson 1997).

Applied climate education helps improve knowledge and skills to better manage climate variability (George et al. 2000; Clewett et al 2000b; Sherrick et al. 2000) and ultimately climate change. Methodically surveying and assessing climate risk can reduce uncertainty and improve farm business management. Educational resources that address surveying and assessing climate risk to reduce uncertainty and improve farm business management include:

- introductory materials (Walker 1992; Krause 1994; Clewett et al. 2000a; Buckley 2000, 2002; Buckley and Horsley 2004)
- climate application courses that give elementary climate risk (Bayley and Brouwer 2000)
- courses that highlight climate risk (O'Sullivan and Paull 1994; Truscott and Egan 2002)
- courses that develop climate risk management strategies (George 2004)
- advanced texts also available (Hammer et al. 2000, Mavi and Tupper 2004).

## Conclusion

Farm businesses suffer considerable risk from variability in income, much of which is a direct effect of climate variability. A major challenge for the future of Australian rural industries will be the ability to integrate climate variability, climate change and climate forecasts into the overall decision-making process. However, provision of more climate information does not ensure that it will be assimilated into management of agricultural production or natural resources; this requires more formal educational processes. A sequential way of surveying and assessing weather and climate information in educational forums is suggested as a method that will help to reduce uncertainty and improve farm business management.

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Table 1. A hierarchical theoretical framework for surveying and assessing climate risk for improving farm business management

| Survey and assess climate information  | Reason why important   |
|--|--|
| 1. View recent rainfall record   | The up-to-date climate record is valuable as a learning tool on which to build from recent experience.   |
| 2. Examine the whole historical rainfall record  | This provides a picture of the nature of variability in a location. It demonstrates the degree of variability of the climate as well as recent trends in that climatic record in the context of the whole historical period.   |
| 3. Assess the impact of ENSO and other forecasting tools   | ENSO may be able to explain a considerable amount of variability for much of Australia. It is also helpful to know where and when ENSO is not useful as a forecast tool. ENSO's behaviour is unpredictable around autumn; however, once winter is established, ENSO's pattern will usually be set till the following autumn. Knowing where to look for updated SOI figures, SST's and the thermocline is of critical importance to knowing how and when ENSO establishes and dissipates. |
| 4. Identify climate change trends  | In response to the climate change debate, it is useful to examine if the climate is getting warmer or cooler, wetter or drier at specific locations, and then consider mechanisms driving this trend to help answer why it is so? And how can it be better managed?  |
| 5. Determine where the most accurate and reliable climate information can be accessed and which forecast system has most reliability | Knowing when a forecast is reliable is as valuable as knowing when there is not much reliability. New forecast systems being researched and developed need to be examined for specific locations and tested to see if there is spatial coherence. Current forecast systems used around Australia are SOI, SOI Phases, SST Phases.  |
| 6. Evaluate daily and weekly data  | For planting decisions, or possible disease outbreak in particular, knowing the chances of getting x mm of rain in y days between date 1 and date 2 is useful information for management.  |
| 7. Consider the rainfall along with maximum and minimum temperature  | In agriculture, and horticulture in particular, it is not just rainfall that is important but information such as dates of heat waves and critical frost periods. These may be managed if due warning is available.  |
| 8. Integrate climate data with enterprise information  | Integrating climate information with enterprises is a tool to reduce risk.   |
| 9. Assess the impact of climate on soil – plant – animal – water systems (including pests, diseases, erosion, biota)                 | Climate is significant in agricultural systems; because it is beyond our 'control', it needs to be managed.  |
| 10. Characterise drought duration and frequency for your location  | Dry periods of varying duration, severity and frequency have been a feature of Australia's climate. Characterising drought duration and frequency is recognised as being the most important climate skill required by producers.   |
| 11. Contrast seasonal climate patterns historically and recently   | This issue raises serious questions: What is the recent climate trend and is it expected to persist? Do management practices need to change to allow for extremes of climate variability?  |
| 12. Determine critical periods or key decision points  | Knowing more about climate variability and forecast provides producers with an edge that may help reach the goal of producing the right quality product at the lowest unit cost possible.  |
| 13. Evaluate climatic extremes of drought, flood, heat and cold stress, frost and wind   | Knowing more about drought, flood, heat and cold stress, frost and wind and their forecast provides producers with an edge that may help reach the goal of producing the right quality product at the lowest unit cost possible.   |
| 14. Integrate climate information with business decisions  | Integrating climate information with enterprises is a tool to reduce risk and help produce the right quality product at the lowest unit cost possible.   |
| 15. Manage climatic risk with structural (>5->10 years), strategic (>1-5 years) and tactical (1-10 days or season) decisions         | Weather information is useful for tactical decisions, whereas climate information is useful for strategic and structural decision-making. The two are complementary.   |
| 16. Proceed to update weather and climate information, and decisions as a season unfolds   | Updating data to have the most accurate and reliable climate information available is crucial in data analysis.  |

