FARMING PROFITABLY IN A CHANGING CLIMATE: A RISK MANAGEMENT APPROACH

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Abstract

Climate science has made enormous progress over the last two decades in understanding the nature of earth's climate and the changes that are taking place. Under climate change projections, we can say with some confidence that the Australian climate will continue to become hotter, and temperature-related extreme events are likely to increase in frequency. However, we cannot yet project with any reasonable level of confidence changes to rainfall and the occurrence of drought.

So although there is strong evidence for the reality of climate change, there is still considerable uncertainty associated with projections of precisely how climate change will unfold in the future, particularly at regional and local scales where most farming management decisions are made. Adapting to such an uncertain future demands a flexible approach based on assessing, analysing and responding to the risks posed by a changing climate.

This paper examines a risk management approach to farming in a variable and changing climate, based on experience gained in the insurance industry which is one of the first major industries to be impacted by climate change losses. Governments, businesses and individuals must consider the implications of a variable and changing climate as a normal part of decision-making based on risk, just as they would for other risks, such as market price and fuel price movements, labour costs etc.

The paper also discusses briefly how advances in information technology have enabled information to be accessed and widely distributed, and showcases four best practice spatial IT website tools developed by the BRS to assist farmers and policy makers to manage risk - the National Agricultural Monitoring System (NAMS), the Meat and Livestock Australia (MLA) Rainfall to Pasture Growth Outlook Tool, the Multi-Criteria Analysis Shell (MCAS-S), and the Rainfall Reliability Wizard. There are also several tools under current development in BRS which continue with this theme. These are Water 2010 - National Water Balance and Information for Policy and Planning, the Climate Change Wizard and Climate Change Impacted Data Sets.

Keywords

Climate change, risk management

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1 Introduction

Australia has highly variable and unreliable climate characterised by floods and widespread droughts, which have a significant impact on production both in economic and social terms. Despite this variability, agriculture is an important feature of the Australian landscape, culture and economy.

In Australia, nearly 60% of the total land area is used in agricultural production (Figure 1). In 2000/2001, the number of people employed in agriculture was 435,000 and the number of establishments undertaking agricultural activity exceeded 140,000 (ABARE, 2006). By 2005/2006 employment had fallen to 356,000 largely as a response to drought, although the number of farm establishments (130,000, in 2004/2005) has remained reasonably constant (ABARE, 2006). Agriculture represents a diverse range of enterprises from extensive grazing systems in rangelands to intensive, irrigated horticultural production. Across most sectors, primary producers have adapted to the inherent risks of farming, including drought - something that has long been a feature of the Australian landscape.

Despite extreme climatic variability, Australian farmers remain highly competitive internationally. Indeed, the gross value of farm production in Australia in 2005/2006 was approximately $AUD 38.5 billion ($US 31.8 billion) and the value of Australian farm production that was exported was around $AUD 27.6 billion ($US 22.8 billion) indicating that Australia is a net food and fibre exporter (ABARE, 2007). The main commodities exported are grains; particularly wheat, beef, lamb and wool, sugar; dairy; and, increasingly, wine.

2 Climate variability and drought

Australia covers a wide range of climate regimes including the temperate south with uniform to winter-dominant rainfall, the tropical zone in the north with summer-dominant rainfall and the arid interior (<350mm/year) (Figure 2). Australia's climate is characterised by very high variability and low reliability of rainfall with droughts and widespread flooding (LAUGHLIN, ZUO, WALCOTT and BUGG, 2003). There is a well-established relationship between El Niño events and rainfall in Australia, although not all droughts are strong El Niño events. El Niño events generally occur every 2-7 years and typically, but not always, result in severely reduced rainfall in winter and spring, particularly across eastern Australia where the majority of high-value cropping and livestock husbandry occurs (MCKEON, HALL, HENRY, STONE and WATSON, 2004).

Currently, south-eastern Australia and parts of Western Australia (WA), are experiencing one of the most prolonged and severe droughts on record. The 2001/2007 period has effectively been characterised by a drought that has been intermittently coupled with El Niño conditions (Figure 3). The El Niño dissipated in January/February of 2007, but the BUREAU OF METEOROLOGY (2007b) has warned that severe rainfall deficiencies are likely to remain for some time.

The drought experienced in parts of Australia in 2006/2007 has continued the long term trend of rainfall deficiency for many regions over at least the past five years. This period includes the 2002/2003 drought which affected most of the agriculturally productive regions in the country (Figure 4). Not only did the 2002/2003 drought significantly reduce farm production, but cumulative effects continue to be felt by Australia’s irrigation industry, with many reservoirs not returning to pre 2002/2003 drought levels prior to the current drought.

Severe drought conditions in 2006/2007 have been manifested in well below average rainfall over much of the south eastern region as well as western WA (Figure 5), with some key agricultural areas of southern Australia experiencing their driest year on record (BUREAU OF METEOROLOGY, 2007a). It has also been a relatively warm year for parts of the south east, notably from August to December, with some areas recording maximum temperatures 3°C higher than the long term average (BUREAU OF METEOROLOGY, 2007a).

The drought has had a significant impact on agricultural production, and for the 2006/2007 period there have been large falls in farm production, exports and incomes (ABARE, 2007). The winter cropping sector has been significantly affected; with winter crop production in 2006-07 estimated to have reduced by around 60 per cent relative to the previous year (Figure 6). The forecasted impact on summer crops is similar and the livestock sector has been significantly affected through increased feed costs, higher slaughter rates and natural deaths, and lower wool production (ABARE, 2007).

Key areas affected by the current drought are catchment areas which feed the Murray Darling Basin (MDB), Australia’s largest river system and most productive agricultural region, accounting for 51 per cent of the gross value of Australia’s agricultural crop production in 2000/2001 (MURRAY DARLING BASIN COMMISSION, 2005). Inflows into the Murray system for the 2006 water year were 550 GL, significantly less than any other inflow experienced in the last 115 years of records (MURRAY DARLING BASIN COMMISSION, 2006). As a result, current storage levels in the MDB are 11 per cent of total capacity, noting that approximately 5% represents “dead water” which is below the dam outflow portal (Figure 7), an unprecedented low level. This situation prompted a recent announcement by Australia’s Prime Minister (THE HON JOHN HOWARD MP, 2007) that there is unlikely to be any water allocation for irrigation purposes sourced from the MDB at the commencement of the new water year in spring and summer 2007/2008. The Prime Minister cautioned that this will have a “…potentially devastating impact on horticultural crops like grapes and stone fruits and other primary industries that rely on irrigation such as the dairy industry.” (THE HON JOHN HOWARD MP, 2007).

3 Climate change

Since about 1950, there has been a steady increase in Australia's mean temperature (Figure 8) and in 2005 Australia officially recorded its warmest year on record with an annual mean temperature 1.09°C above the1961-90 average (BUREAU OF METEOROLOGY, 2006a). Temperature rise is now above natural variability and is accepted as a clear signal of climate change (BUREAU OF METEOROLOGY, 2006b).

Climate science has made enormous progress over the last two decades in understanding the nature of Earth's climate and the changes that are taking place. We can now say with some confidence that the Australian climate will continue to become hotter, and temperature-related extreme events will increase in frequency (PITTOCK, 2003; STEFFEN, 2006). However, changes in rainfall and in the pattern of droughts, which so significantly affect Australia's agricultural industries, are much harder than temperature to attribute to climate change and to predict for the future. Therefore, although there is strong evidence for climate change, there is still considerable uncertainty associated with projections of precisely how climate change will unfold in the future, particularly at regional and local scales where many management decisions, including farming management, are made (STEFFEN, 2006).

These uncertainties will likely remain for some time despite improvements in our understanding of climate change. Adapting to such an uncertain future demands a flexible approach based on assessing, analysing and responding to the risks posed by a changing climate.

4 Lessons learnt from the insurance industry

The insurance industry, which was one of the first major industries to be impacted by climate change, has adopted a risk management approach to deal with the increasing risk of losses from extreme weather events (UNEP FI, 2002). Application of the risk management approach by the insurance industry provides insights into how the approach can be applied to other sectors, such as agriculture.

Two aspects of the insurance industry's approach to risk management are central to its success. First, the industry treats the risks posed by climate change in the context of other risks to the business — political, economic, social, technological, environmental and legislative — rather than as a new and separate phenomenon that is dealt with in isolation from other risks. Second, there is a strong emphasis on review and monitoring on a regular basis, as information on climate risk changes and as other risks to the industry evolve. Thus, risk management is an ongoing process, not a one-off remedial treatment.

Scientific information is central to the insurance industry's treatment of climate risk. Probabilistic modelling of cyclone tracks, for example, helps to determine regions of Australia most exposed to changing climate risk. 'Catastrophe modelling' is used to simulate worst-case scenarios and determine the exposure of the industry to low probability-high impact events. Such scientific information is a key part of analysing the changing risk of extreme climatic events, which in turn is essential in setting premiums at levels that maintain the viability of the industry (STEFFEN, SIMS and WALCOTT, 2006).

5 Dealing with uncertainty

To date, a common approach to the issue of adapting agriculture to climate change has been to analyse how climate change scenarios could impact on a particular crop or industry, with additional scenarios for resulting socio-economic effects (e.g. HERRON, DAVIS and JONES, 2002; HOWDEN, MCKEON, WALKER, CARTER, CONROY, DAY, HALL, ASH and GHANNOUM, 1999; LUO, JONES, WILLIAMS, BRYAN and BERLOTTI, 2005; REYENGA, HOWDEN, MEINKE and MCKEON, 1999).

However, for an adaptation strategy to be effective, it must consider climate risk as a normal part of decision-making, allowing governments, businesses and individuals to reflect their risk preferences just as they would for other risk assessments. Adaptation strategies will fail if climate is considered separately from other dimensions of strategic planning and risk management. To reach this point, however, is going to require a period of awareness raising, development of the science, and development of techniques for applying scientific information in practical situations.

6 Risk management approach

The generic risk management framework has been developed jointly by Standards Australia and Standards New Zealand to deal with a significant, but highly uncertain risk (SA/SN, 1999) and can be adapted to Australia's agricultural sector (CLARKE, BARRATT, MUNRO, SIMS, LAUGHLIN AND POULTER, 2006; STEFFEN, SIMS and WALCOTT, 2006). There are five stages associated with applying this framework:

1. Establishing context – determine the nature of the management challenge;
2. Identifying the risk – gain industry perspectives on sensitivity and adaptability;
3. Analysing the risk – analyse climate change with respect to vulnerability;
4. Evaluating the risk – explore management options for mitigating impacts and exploiting opportunities; and
5. Treating the risk – implement strategies for maintaining viable agricultural industries.

6.1 Determining the nature of the management challenge

The perceptions of climate risk, and how it might change in future, vary widely across agricultural industries, depending on the characteristics of the industry and the climate of the regions in which these industries operate. For example, changes in temperature and in pests and diseases are important in monsoonal tropical and sub-tropical, northern Australia, while water availability is of overriding importance in the Mediterranean temperate south. The first step in the risk management approach is to determine the implications of evolving climate-related risks — their nature and severity — for management strategies.

The perspective of the agricultural sector towards changing climate risks will be based strongly on its experience in dealing with climate variability. The relatively effective adaptation capability of most Australian agriculture producers to deal with current climate variability means that climate change will become an issue only if it occurs faster than producers can adapt, and/or if it changes the reliability of climatic patterns in ways that are difficult to foresee.

In general, Australian producers already have a well developed capacity to manage for changes in climate. A fundamental principle is that the entire process of managing for climate risk needs to be producer-driven rather than imposed by outside organisations, including governments.

6.2. Gaining industry perspectives on sensitivity and adaptability

Producers have already learnt much about maintaining profitability in a variable climate, and this knowledge will be directly useful in dealing with longer term trend change in climate.

In December 2004, the Australian Bureau of Rural Sciences (BRS) hosted a workshop to provide guidance for the development of science-based tools to support the risk management approach to climate change. The workshop explored the sensitivity of agricultural industries to climate — the ways in which climate enters the decision-making processes in these industries, and the capacity of an industry to adapt to future climate change.

The findings from this workshop indicated that although climate risk is industry specific, there are some general features of climate to which most Australian rural industries are sensitive. Most of these features are related to the hydrological cycle. Moisture availability, and particularly its timing through a growing season, was identified at the workshop as an overriding, critical issue across most agricultural industries. Two major time scales of interest were also identified — the within-season climate/weather variability and the multi-decadal climate change planning horizon (STEFFEN, SIMS and WALCOTT, 2006).

6.3 Analysing climate change with respect to vulnerability

Vulnerability to climate change is a function of exposure to changing climate factors, sensitivity to change and the current capacity to adapt to that change. Systems that are highly exposed, sensitive and less able to adapt, are vulnerable.

Vulnerability analyses can be built around layers of data estimating the level of exposure from a changing climate, the sensitivity of a region or sector to climate risks, and the current adaptive capacity of a region or sector (i.e. its ability to cope with climate risks). Data that could contribute to a national level vulnerability analysis in Australia include:

- Rainfall and temperature reliability — indicators of sensitivity to climate;
- Shifts in rainfall reliability — analyses of the historical record;
- Economic indicators — profitability, return on investment, export earnings;
- Diversity of industries within a region — flexibility in livelihood & employment; and
- Social indicators of adaptive capacity — educational level, social networks.

6.4 Exploring management options for minimising the risk

Ultimately, it is resilience that will determine whether or not the agricultural sector can deal successfully with climate change risk. An important overall adaptation strategy in agriculture is to increase the range of options to which farmers have access: for example, the number of crop and cattle varieties (continual change in crop varieties is a normal part of farming business, as is breeding for preferred traits in animal stock) and the types of management practices and technological changes, such as modification of micro-climates through minimal till practices. For animal based industries, for example, a shift to Bos Indicus cattle and to non-merino breeds of sheep, better adapted to hot, dry conditions, represent viable management options for a changing climate. Another strategy is associated with a social decision to increase off-farm income.

6.5 Implementing strategies for maintaining viable agricultural industries

The final stage of the risk management approach is to implement the decisions made following the evaluation stage. It is important to remember, however, that a risk management approach is iterative and ongoing, not a once-off remedial treatment. It is evident from the assessment of the insurance industry that there is a strong emphasis on review and monitoring on a regular basis, as new information on climate risk and other risks to business or industry becomes available.

7 Bureau of Rural Sciences tools

Decision-support tools are also important in helping producers deal with a changing climate, particularly change within the current season. BRS has developed a range of tools to help farmers and planners analyse climate risks particular to their industry and region. In general terms, each system accesses data from a wide variety of sources, assimilates data into a database, makes data publicly available on the web, and provides tools for interrogating and visualising these data, such as interactive mapping and reporting. Four of the BRS tools are profiled below:

- National Agricultural Monitoring System: http://www.nams.gov.au/
- Meat and Livestock Australia (MLA) Rainfall to Pasture Growth Outlook Tool: http://www.mla.com.au/rainfalloutlook/
- MCAS-S - Multi-Criteria Analysis Shell http://www.brs.gov.au/rainfall/
- Rainfall Reliability Wizard http://www.brs.gov.au/rainfall/

National Agricultural Monitoring System

The National Agricultural Monitoring System (NAMS) is a real-time monitoring system that makes climate and agricultural data available to farmers and government decision-makers. The system provides current and historical information on climate variability; contextual factors such as land use and soil type; the impact of climatic variability on agricultural production; and economic information on farm performance (LEEDMAN, BRUCE, AND SIMS, 2006). A range of tools are available for graphing, mapping and reporting so that users can interrogate the data.

Although NAMS was primarily designed to streamline the Australian Government program for drought assistance, it can also assist farmers in management decisions by improving their ability to judge and assess the climate risks to production systems. NAMS allows farmers to consider their current situation in a historical context or to compare their region with other parts of Australia. This type of information can be important for both tactical (growing season) and strategic (multiyear or decadal) decisions. For example, a shift in agricultural production to areas with high intra-seasonal rainfall reliability is a reasonable adaptive response to climate change and information about rainfall reliability from NAMS can underpin these decisions.

Meat and Livestock Australia (MLA) Rainfall to Pasture Growth Outlook Tool

The MLA tool was developed by the Bureau of Rural Sciences on behalf of Meat and Livestock Australia (MLA) (BUREAU OF RURAL SCIENCES, 2005). The tool assists farmers in making better pasture and grazing management decisions by estimating pasture growth in relation to rainfall, soil moisture and other climatic factors (MEAT AND LIVESTOCK AUSTRALIA and BUREAU OF RURAL SCIENCES, 2007). It does this by providing an outlook for rainfall and pasture growth for three months, for over 3,300 locations across southern Australia (MEAT AND LIVESTOCK AUSTRALIA and BUREAU OF RURAL SCIENCES, 2007). The MLA Tool has direct application to the following farm management activities:

- Strategic direction — to better design and set longer term directions for grazing enterprises influenced by variation in rainfall,
- Tactical stock control — the three month outlook can be used to assist in tactical control of the stocking rate,
- Pasture growth — to optimise pasture growth across land classes,
- Pasture utilisation — as a guide in making daily operational decisions used to plan and control pasture utilisation (MEAT AND LIVESTOCK AUSTRALIA AND BUREAU OF RURAL SCIENCES, 2007).

MCAS-S – Multi-Criteria Analysis Shell

Government policy-makers, local authorities and land managers often need to access and analyse large amounts of environmental, social and economic information (BUREAU OF RURAL SCIENCES, 2006). The treatment of this information and the use of value judgments incorporating public opinion and policy and management goals can be achieved using multi-criteria analysis (MCA) (BUREAU OF RURAL SCIENCES, 2006).

The Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) is a software tool developed by the Bureau of Rural Sciences that brings the MCA process into the decision-makers' realm. It is an easy-to-use, flexible tool that promotes:

- insightful desktop combination and study of different types of mapped information
- understanding of the relationships between the decision-making process and the available spatial data
- interactive 'live-update' and mapping of alternative project/management scenarios (BUREAU OF RURAL SCIENCES, 2007a).

MCAS-S is currently being used at the national, regional and catchment scale for:

- assessment of Australia's rangelands: analysing natural resources, patterns of use and commodity assets,
- assessment of land cover change and ecosystem services using the Vegetation Assets, States and Transitions (VAST) framework,
- assessing the contribution to ecologically sustainable development of regional areas for the National Land and Water Resources Audit (BUREAU OF RURAL SCIENCES, 2007a).

Rainfall Reliability Wizard

Rainfall reliability is a particularly useful metric for agricultural producers because it links directly to the management of seasonal conditions (LAUGHLIN and NELSON, 2007). Rainfall reliability allows patterns of rainfall that are useful for agricultural production to be described and compared (LAUGHLIN and NELSON, 2007). The Rainfall Reliability Wizard is a tool used to provide robust analyses of rainfall reliability, based on monthly rainfall data since 1900 (LAUGHLIN, ZUO, WALCOTT, BUGG, 2003). The Wizard is able to rapidly evaluate rainfall events and to characterise rainfall risk/reliability across broad geographic areas (BUREAU OF RURALSCIENCES, 2007b).

8 Bureau of Rural Science tools under development

The BRS is also in the process of developing some new tools and data to help planners and farmers analyse climatic risk. These include:

- Water 2010 - National Water Balance Information for Policy and Planning
- The Climate Change Wizard, and,
- Climate Change Impacted Data Sets

These tools and data are profiled below.

Water 2010 - National Water Balance information for Policy and Planning

At present, Australia has no comprehensive and consistent source of information on the spatial and temporal relationships between rainfall, evaporation, transpiration, drainage to ground and surface water, and runoff to rivers and storages. Resolving this fundamental knowledge gap in a nationally consistent fashion is a primary focus of Water 2010.

A national water balance model and prototype on-line tool have been developed for reporting annual water balances by Australian river basins under the Water 2010 initiative. This includes estimates by land-use type of rainfall, total evaporation, runoff, deep drainage, and irrigation demand. A Water Resource Reliability Tool has also been developed that allows analysis of the historical reliability of stream flows based on modelled runoff and stream gauge records from around the country.

Data and web-tools compiled under the Water 2010 project are designed for longer-term strategic planning and scenario building. River basin-scale information on water availability and use allows government policy formulators and decision-makers to consider the policy and planning options available to them given the availability of water. The future challenges for Water 2010 are to deliver a fully operational on-line system that provides national water flux estimates and river basin water resource status reports in near-real-time (weekly to monthly) and, to test scenarios of change in climate, land use and population growth, to enable the implications of these changes on the water balance to be explored.

Climate Change Wizard

The objective of this tool is to build on the Rainfall Reliability Wizard and to allow producers to identify changes in rainfall reliability in the rainfall record (LAUGHLIN and NELSON, 2007). Changes in rainfall reliability are a particularly important impact of climate change, as decreases in the frequency and/or volume of within season rainfall reduces water availability (LAUGHLIN and NELSON, 2007). The Climate change Wizard will provide producers with some insight into the impacts of climate change (LAUGHLIN and NELSON, 2007). This insight may help producers to adapt to climate change and be better positioned to manage climate risk (LAUGHLIN and NELSON, 2007).

Climate Change Impacted Data Sets

These are data sets which link current and emerging climate with projections arising out of the Global Circulation Models (GCMs). These data sets will allow the impact of climate change to be integrated into other tools (LAUGHLIN[†], pers.comm).

[†] Greg Laughlin is a Senior Principal Scientist in the Bureau of Rural Sciences

9 Conclusions

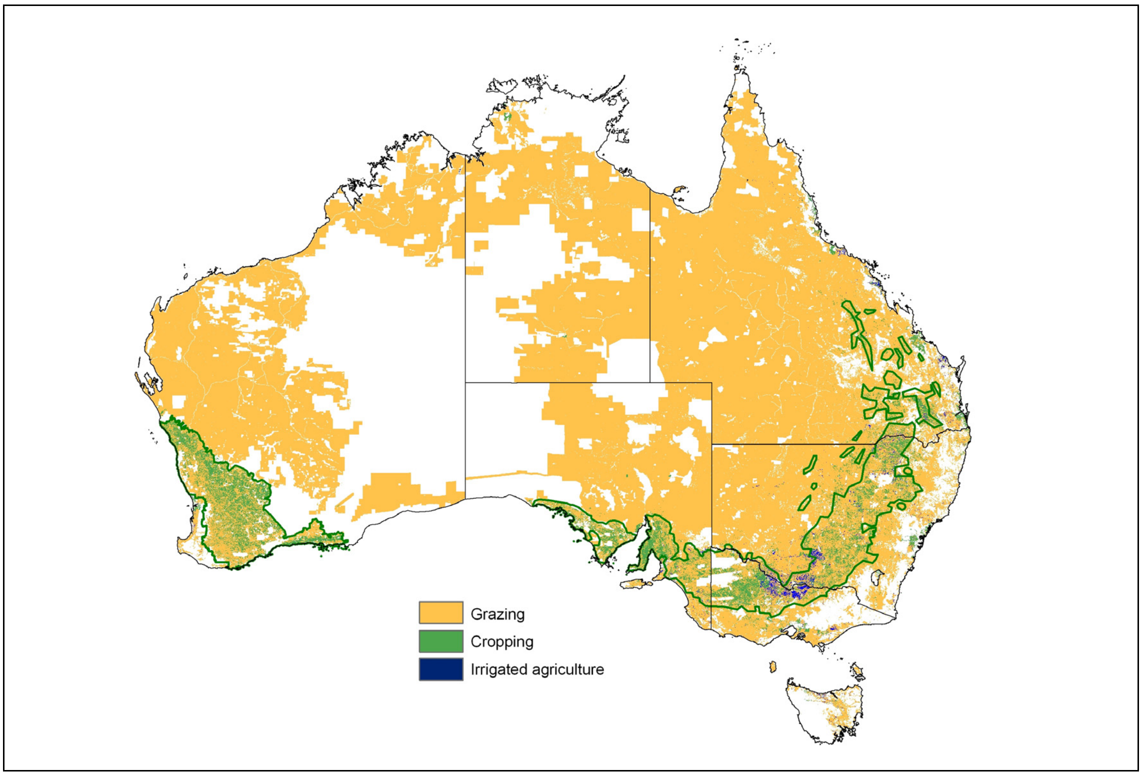
To conclude, the Australian climate is highly variable and unreliable. Despite this, agriculture is an important feature of the Australian landscape and economy, accounting for approximately 3% of GDP, and although droughts have a significant impact on agriculture both in social and economic terms, productivity has grown at a relatively constant rate of approximately 2.8% annually for the past 30 years (PRODUCTIVITY COMMISSION, 2005).

Climate change has added further complexity to farming in Australia. Recent high temperature anomalies in Australia have been recognised as climate change. Projections suggest that Australia's climate will become hotter and extreme temperature events will become more frequent. Changes to rainfall and extreme events are, however, still difficult to predict, particularly at the local scale.

Dealing with climate variability and change by way of a risk management approach that treats the risks posed by such features in the context of other risks to business is seen as the most appropriate way to manage farming into the future. It appropriately places a strong emphasis on review and monitoring on a regular basis, provides a sound framework for identifying, analysing, evaluating and dealing with the challenges and opportunities associated with climate change. This approach allows individuals to manage the risks posed by climate change rather than having change imposed by government, and government assuming the risk of an inability to manage risk.

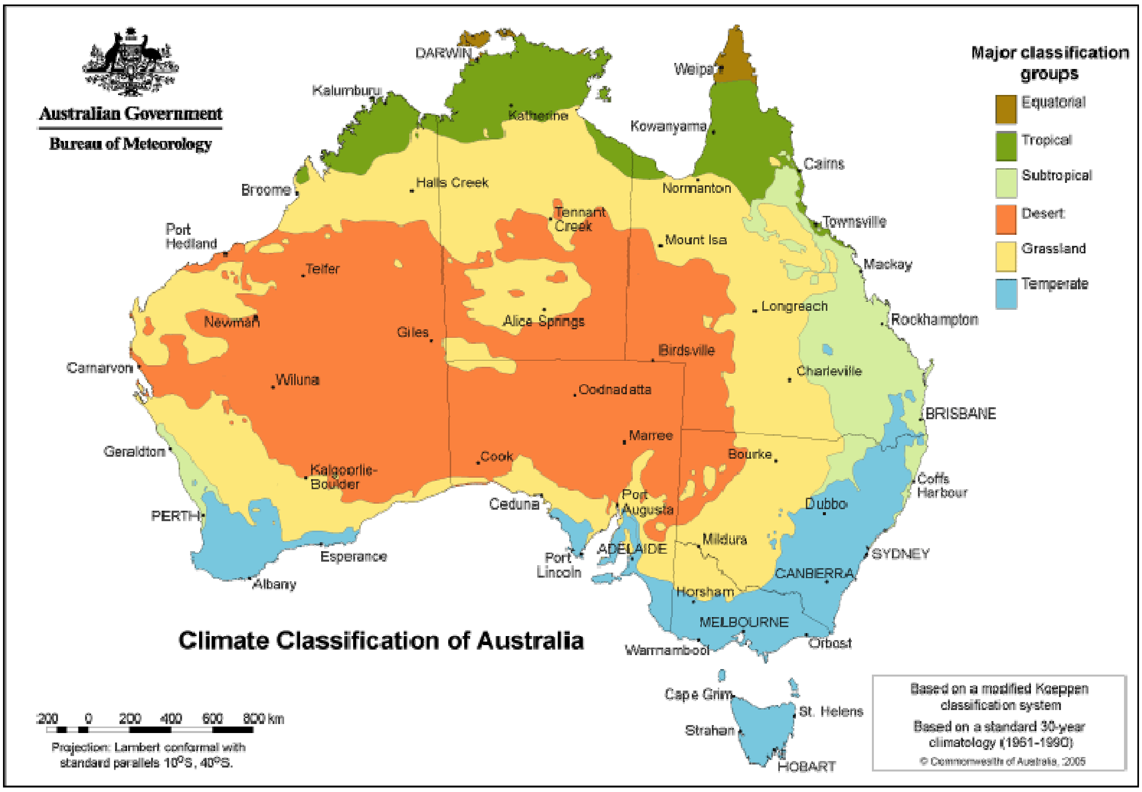
The Bureau of Rural Sciences has developed a range of on-line tools to support the risk management approach to managing climate variability and change including the National Agricultural Monitoring System (NAMS), the Meat and Livestock Australia (MLA) Rainfall to Pasture Growth Outlook Tool, the Multi-Criteria Analysis Shell (MCAS-S), and the Rainfall Reliability Wizard. There are also several tools under current development in BRS which continue with this theme. These are Water 2010 - National Water Balance and Information for Policy and Planning, the Climate Change Wizard and Climate Change Impacted Data Sets.

Figure 1: Extent of agricultural production (grazing, cropping and irrigated agriculture) in Australia



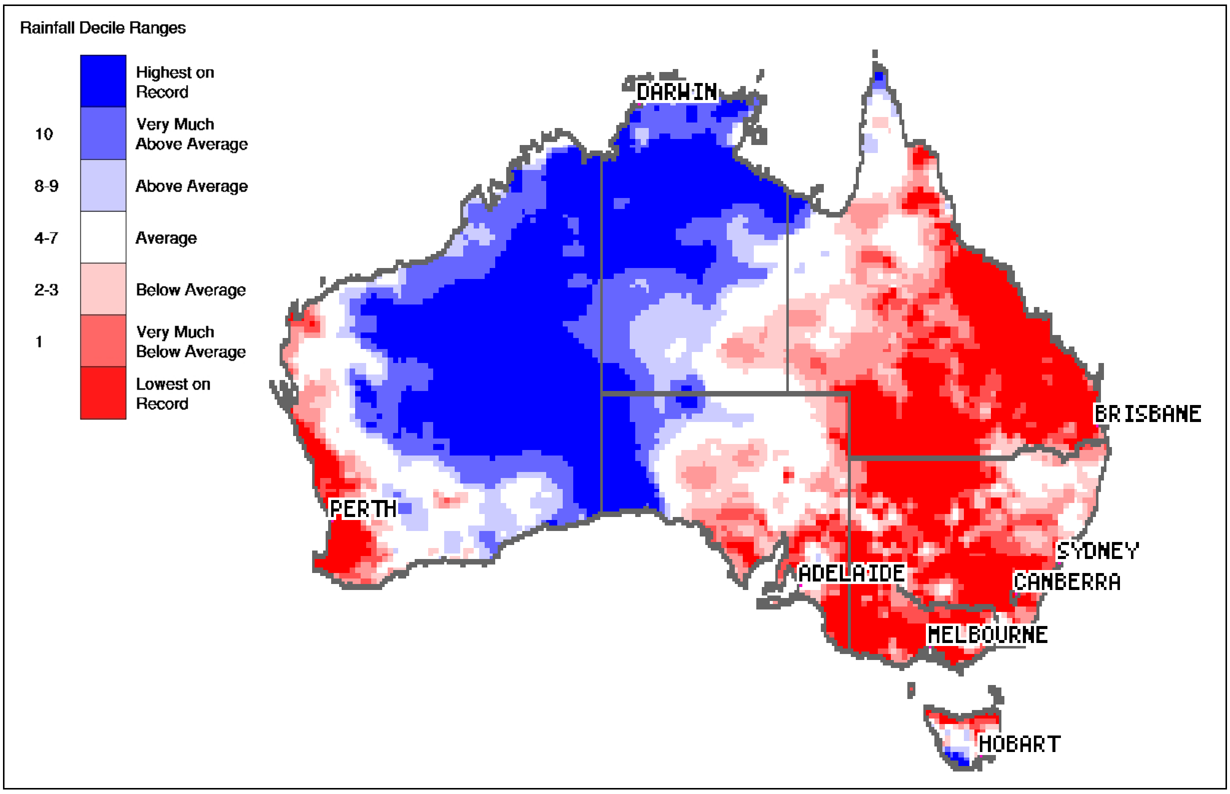
Source: Bureau of Rural Sciences

Figure 2: Climate classification of Australia



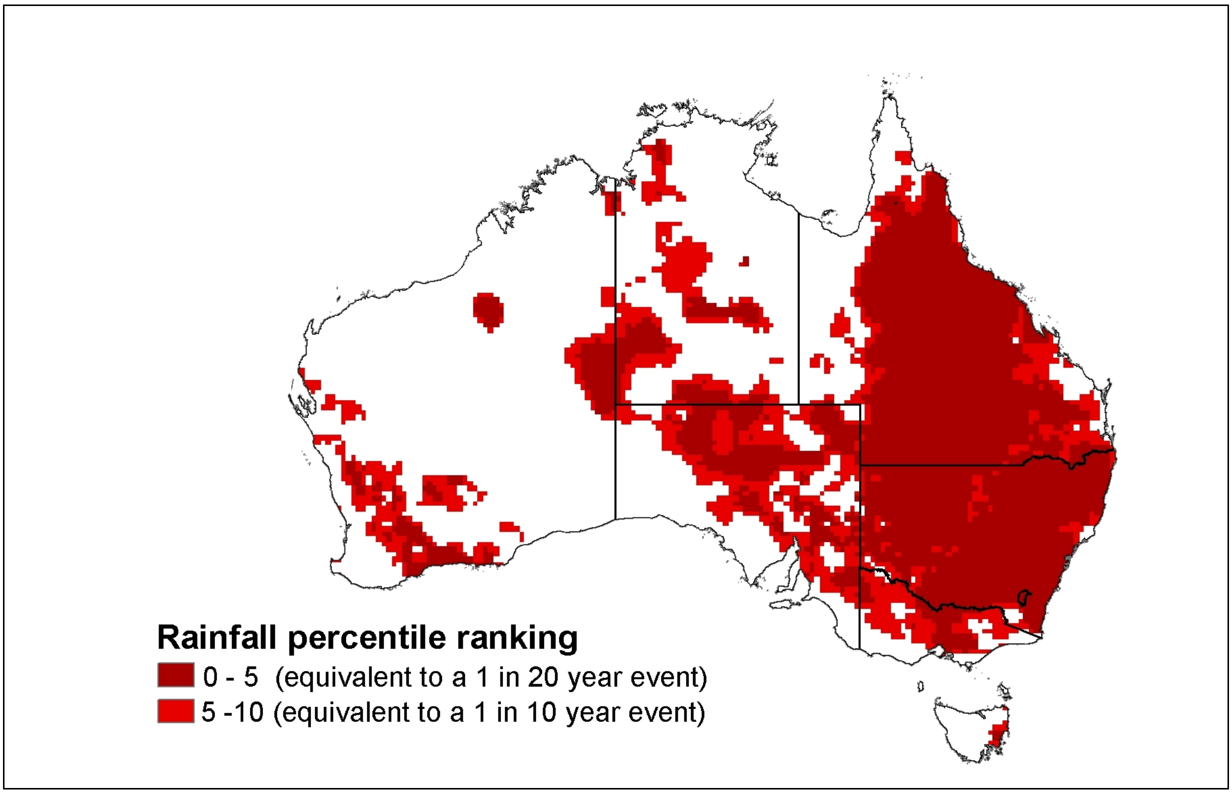
Source: BUREAU OF METEOROLOGY, 2006

Figure 3: Rainfall percentiles January 2001 to December 2006



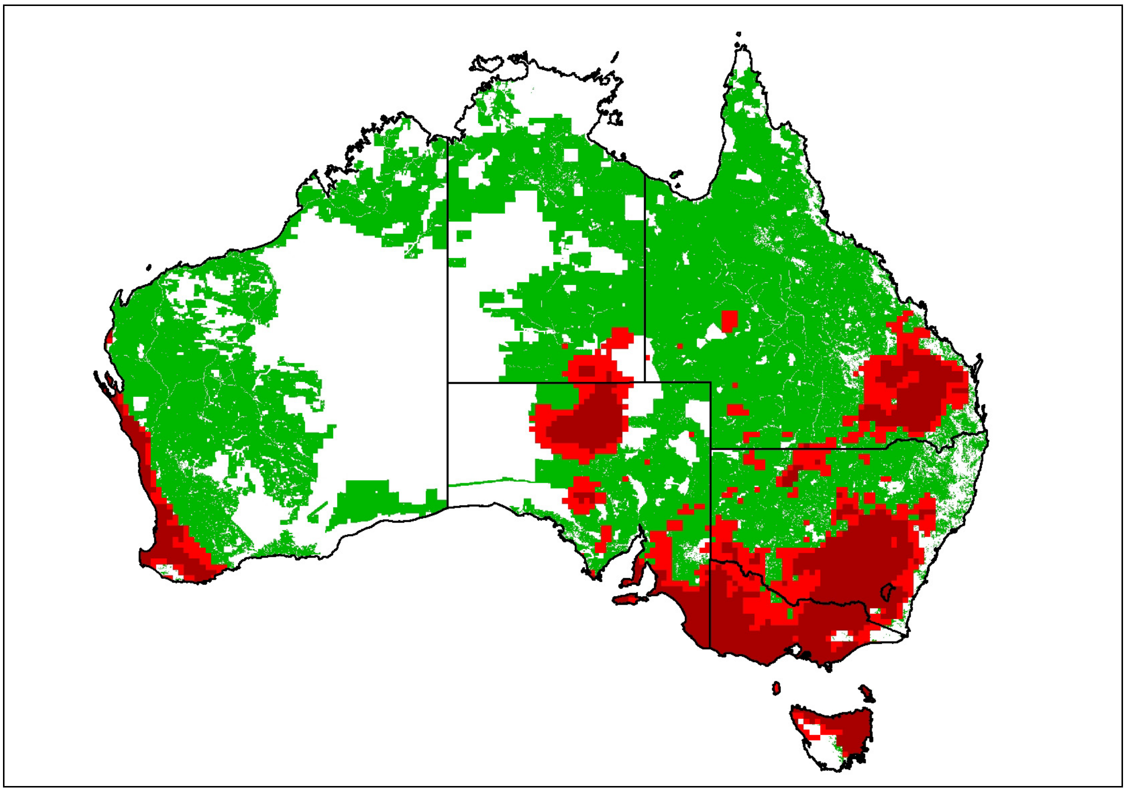
Source: Bureau of Rural Sciences

Figure 4: Extent of the 2002/03 drought (rainfall deficit below the 5th and 10th percentiles between March 2002 and January 2003) in Australia.



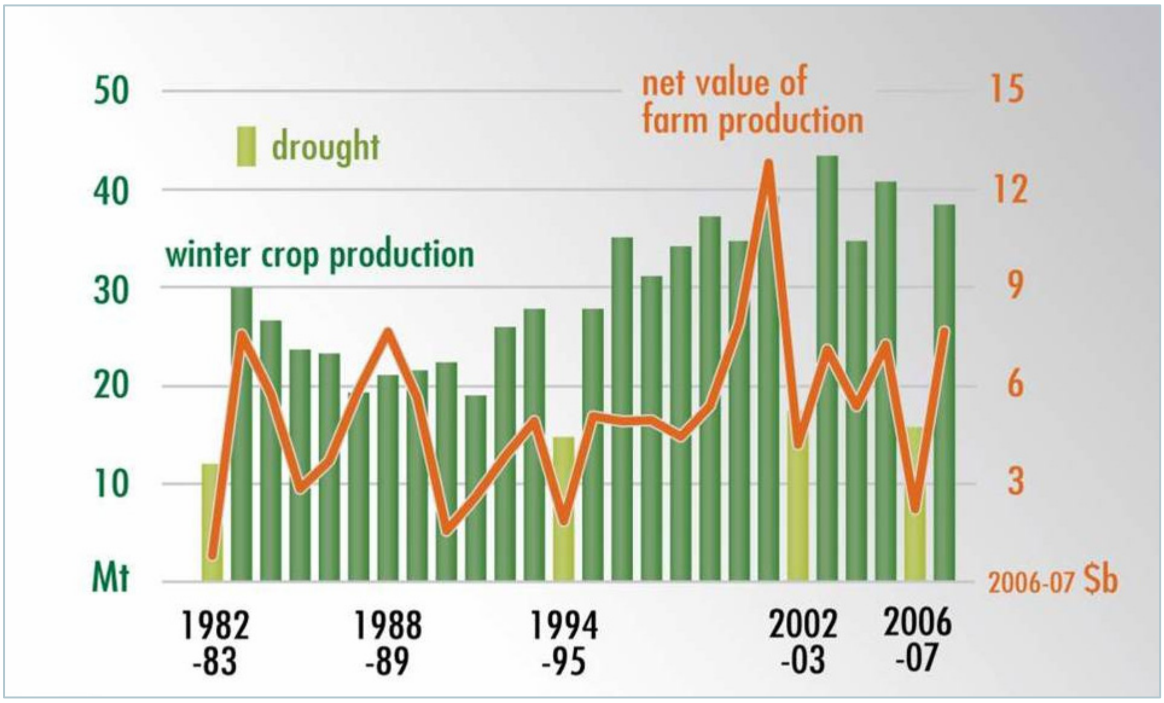
Source: Bureau of Rural Sciences

Figure 5: Extent of the 2006/2007 drought (rainfall deficit below the 5th and 10th percentiles between January 2006 and January 2007) in Australia.



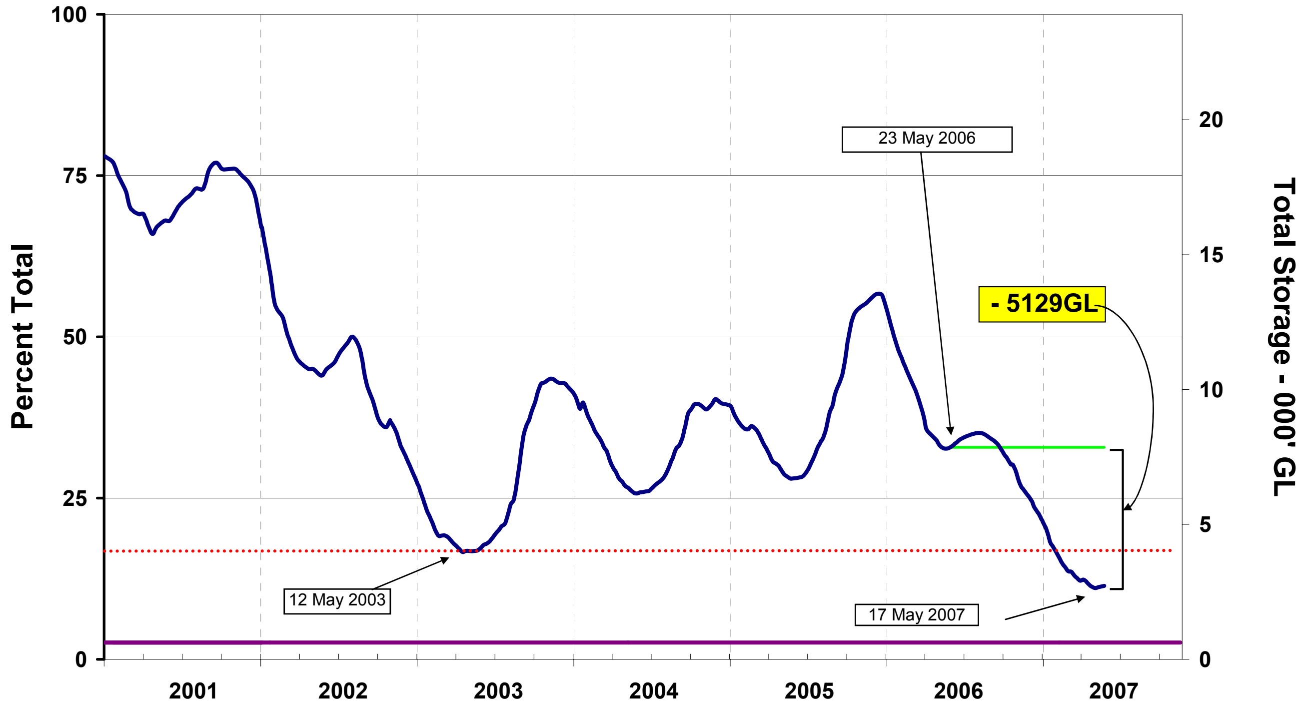
Source: Bureau of Rural Sciences

Figure 6: Long-term trends in the net value of farm production in Australia. The downturn in production in 1982/83, 1994/95, 1994/1995, 2002/03 and 2006/07 was associated with severe droughts.



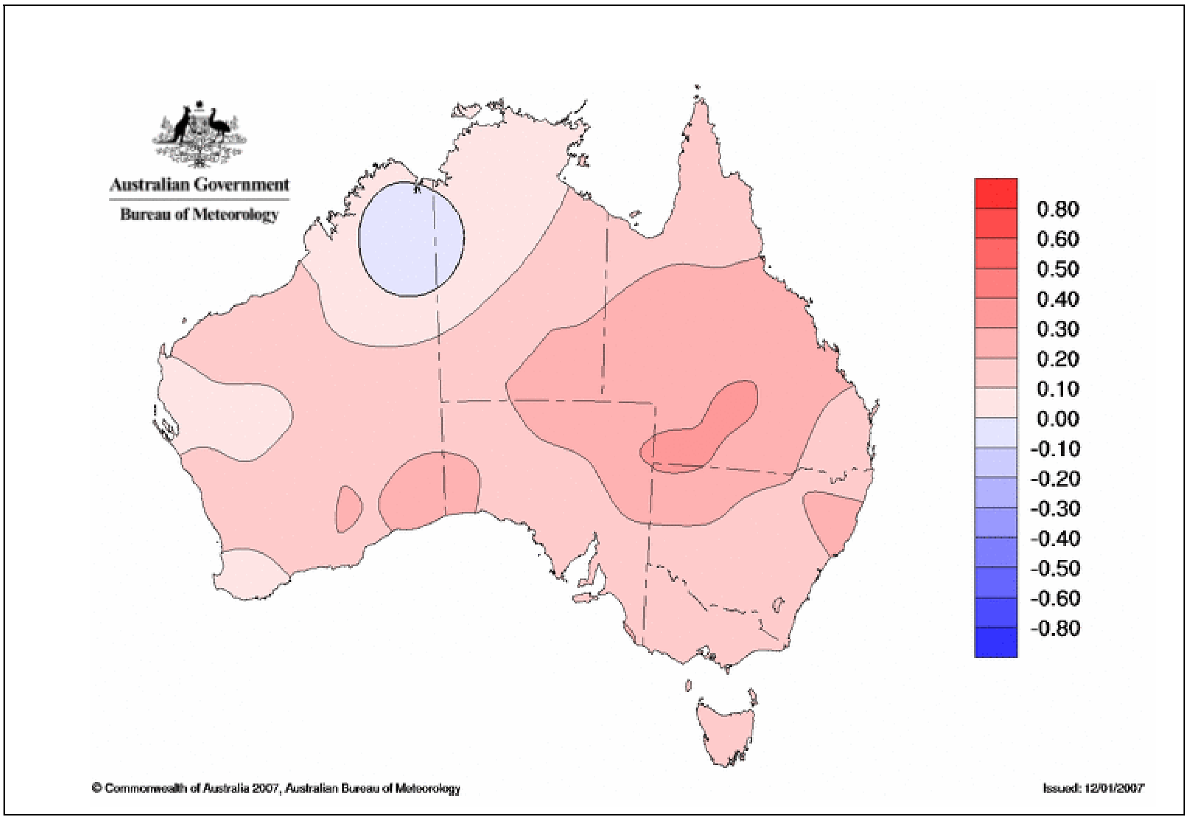
Source: ABARE, 2007

Figure 7: Water storage for the Murray Darling Basin (New South Wales and Victoria)



Source: Bureau of Rural Sciences

Figure 8: Trend in mean temperature from 1950 to 2006 (°C/10 years).



Source: Bureau of Meteorology, 2007

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