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Science
FOR **DECISION MAKERS**

CLIMATE CHANGE

Adaptation in agriculture

Science for Decision Makers is a series published by the Bureau of Rural Sciences. It describes the latest developments in scientific advice, assessments or tools relating to agricultural, fisheries and forestry industries, including their supporting communities.

Its purpose is to make rural science more accessible to those needing to quickly understand the benefits and implications of the most recent research as a basis for decision-making.

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KEY POINTS

- Australia's climate is changing as part of a global trend. Change is expected to continue and perhaps accelerate throughout the 21st century, presenting both challenges and opportunities for Australian agriculture.
- Australian farmers have developed highly adaptive land management systems in response to present climate regimes. However, the cumulative impact of past changes and future climate trends may expose farming systems to conditions not experienced before. This could change the scale and significance of climate risk and appropriate response strategies.
- A risk management approach is an effective way for Australian agriculture to respond to the challenge of a changing climate. It provides a framework for identifying, analysing, evaluating and dealing with the challenges and opportunities associated with climate change.
- This briefing outlines strategies that build on the existing capacity of agriculture to adapt to change and provides steps that can be taken now to prepare for and manage the risks and opportunities presented by a changing climate.

THE CHALLENGE

Australian Agriculture in a Changing World

Australian agriculture operates in a world where change is the norm. Competition in international markets, changing food preferences, reform of institutional and governance structures, a challenging production environment, including saline and relatively infertile soils, and limited access to water are all part of farming in Australia.

At the same time, Australian agriculture faces the most variable climate of any of the world's major agricultural production areas. Australia's farmers have consistently demonstrated a strong capacity to adapt to these challenges, and have become world leaders in using forecasts of seasonal climate variability such as the El Nino Southern Oscillation (ENSO) system to avoid the hazards and seize the opportunities inherent in a variable climate.

Australian agriculture faces the most variable climate of any of the world's major agricultural producers

The Challenge of a Changing Climate

The global climate has changed over the past century. The evidence suggests that climate will continue to change throughout the 21st century, possibly at an accelerating rate. The consensus in the scientific community is that the risk of abrupt change and extreme events will also increase. This means that industries that are particularly affected by climate, such as Australia's agricultural industries, are at greater risk if they rely solely on historical patterns of climate variability and extreme events when making business decisions. The nature and scale of climate risk is changing and decisions that have a significant component of climate risk need to reflect these changes.

Climate will continue to change throughout the 21st century, possibly at an accelerating rate

Several characteristics of climate change are particularly important in designing an effective risk management strategy:

Firstly, there is an inherent level of chaos and uncertainty in the climate system that means that even short-term weather forecasts can only be projected as a probability with significant levels of uncertainty. A background of change in the global processes that drive the climate can only increase these uncertainties, especially in any attempt to predict longer-term climates.

Secondly, although we have a high degree of confidence that average temperatures will increase over time with climate change, we have much less confidence in how rainfall will change and how global climatic trends will translate into seasonal, regional and local changes.

Thirdly, extreme events such as droughts are much harder to predict than changes in average values. It is these extreme events that are typically a greater risk to farmers.

A risk-management approach

As a response to this challenge, this *Science for Decision Makers* briefing considers climate change in a five-stage risk management framework.

Risk management is a process that allows response strategies to be developed now, while we work to reduce the uncertainty surrounding climate change projections over time.

The framework given here is based on a generic risk-management process developed by Standards Australia and has five stages, as outlined below:

STAGE 1 **Establish a set of criteria** for identifying important climate change risks for farmers. The criteria should also reflect the policy and institutional context in which any decisions are to be taken. These criteria could be developed through a consultative process.

STAGE 2 **Identify the risks** that climate change poses to agricultural industries. This stage explores the vulnerability of industries to climate, their capability to adapt to a changing climate, and the thresholds of climate change beyond which adaptation becomes difficult.

STAGE 3 **Analyse the risks** by examining the nature and likelihood of climate change in the future. This is done from an industry perspective.

STAGE 4 **Evaluate the risks** using the information from the risk analysis to make decisions under the risk management criteria.

STAGE 5 **Treat the risk** by developing and implementing risk treatment plans which establish the strategic setting for action.

A risk management assessment process can be repeated every few years to ensure that it is up to date with the contemporary understanding of risk. Regular review will be particularly important for climate change where the science is constantly evolving. Good risk management involves communication to ensure that all stakeholders are aware and involved in the process.

STAGE 1

ESTABLISHING THE CRITERIA FOR IDENTIFYING AND ASSESSING RISK

Determining the nature of the management challenge

Attitudes to risk are grounded in the values, culture and long-term goals of an organisation or individual. For example, a farmer pursuing risk management would develop criteria that reflect the family or company values and business goals of the farm enterprise.

It is beyond the scope of this briefing to develop risk management criteria for specific situations. However, there are some ‘rules-of-thumb’ that are likely to be generally applicable when identifying risks faced by Australian farmers.

The risks will vary with the decision being made. For example, the climate risks relevant to the establishment of long-lived forestry plantations, tree crops and vineyards will differ from those relevant to the sowing of an annual wheat crop. Equally, decisions to invest in large

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> Australian agriculture has learned to deal with a wide range of climatic conditions over the past century…existing climate stresses and pressures will provide a sound underpinning for identifying future risks

scale, long-lived water infrastructure or a new property will involve risks that are very different from those involved in a decision about the disposal of store cattle.

Commonly, the most significant climate change risks requiring attention will be those where the effects of change are expected to happen sooner, rather than relating to some remote future possibility, those where the changes are likely to be widespread in impact (limiting adaptive responses such as importing stock feed from areas not affected by drought), and/or those of significant economic scale (perhaps threatening the very viability of some farming operations).

Government policy can have a role in influencing decisions made by farmers. In particular, drought assistance and policies relating to rural adjustment can have a significant impact on both the perception of, and farm management response to, climate-related risks.

STAGE 2

IDENTIFYING THE RISK

Industry perspectives on vulnerability and adaptability

Australian agriculture has learned to deal with a wide range of climatic conditions over the past century. This experience provides a starting point from which to assess industry's vulnerability and adaptability to potential future climates. Especially important are those aspects of climate (e.g., temperature, rainfall, frost, etc.) that most affect various agricultural sectors and the timescale on which these aspects of climate matter. An analysis on both an industry and regional basis of known, existing climate stresses and pressures will provide a sound underpinning for identifying future risks.

Examining the effects of climatic extremes will also help to identify the risks that the agricultural sector may face with a changing climate. One of the big risks for the future is the pattern of drought and how that will change, particularly the frequency and severity of drought. Coupled with a rise in temperature and the expected rise in evaporation, there is a high probability that Australian farmers will need to operate in a drier climate in the coming decades. Assessing the capability of industry to adapt to a drier environment is therefore a critical element in identifying industry's risk from a changing climate.

Case studies of past successes and failures in dealing with environmental change offer useful insights into future risks. For example, the synthesis of eight major degradation episodes in Australia's rangelands, described in the report 'Pasture Degradation and Recovery in Australia's Rangelands: Learning from History', provides powerful lessons for avoiding the mistakes of the past, particularly with regard to climate risks. Similar studies of the experiences of other industry sectors over the past century could provide additional insights into assessing climate risks for those sectors.

Although the experiences of the past offer important insights into industry vulnerability and adaptability, the past is not a perfect guide to the future, as climate will shift outside the bounds of the variability experienced over the past century. Models based on the understanding of agricultural systems can be used to test their sensitivity and to establish plausible climatic thresholds beyond which existing agricultural practices and technologies may become unviable. Such modelling approaches can provide insights into complex relationships in agricultural systems, such as the interaction between the carbon dioxide 'fertilisation effect' and a changing climate, to build a more realistic picture of the risks to industry from a changing climate (see **Box 1**).

BOX 1

CO_2, CLIMATE CHANGE AND PLANT GROWTH

Increases in carbon dioxide concentration and projected changes in temperature and rainfall will have significant impacts on Australia's agriculture. However, predicting the impacts of these changes is complicated because these environmental changes interact: increased carbon dioxide boosts plant growth and changes water use efficiency, while other changes in climate could offset or even enhance these benefits, depending on the circumstances. There is much that we have yet to learn about how plants will respond to these changes in environmental conditions.

Wheat: Future wheat yields will vary with both the positive effect of increased carbon dioxide levels and the generally negative impacts of projected climate change in the major wheat growing regions. Wheat in Australia is planted in autumn and winter and grows through to spring, so reductions in winter and spring rainfall over southern Australia would increase moisture stress in the growing season. The positive response of wheat to higher carbon dioxide levels may come at the price of lower grain protein contents. To maintain protein content at present levels, farmers may need to add more fertiliser or alternate crop rotations with nitrogen fixing plants.

Fruit: Many fruits are sensitive to frost late in the growing season. A decrease in frost frequency and severity (as projected) will reduce frost damage. However, temperate fruits need winter chilling to ensure normal bud-burst and fruit set. Warmer winters will reduce the accumulated chilling and may lead to lower yields and reduced fruit quality. Adaptation through increased use of chemical treatments is possible, as is selection of varieties that have a less demanding chilling requirement.

High-rainfall pastures: Temperate pastures in high-rainfall regions are largely found in south-eastern Australia. The positive impact of elevated carbon dioxide levels and negative impact of warming could cancel each other out in this pasture zone. However, likely decreases in winter and spring rainfall in southern Australia could greatly reduce plant growth, significantly constraining animal production using current pastures/ farming systems.

STAGE 3

ANALYSING THE RISK

Australia's changing climate

Temperature and rainfall records show that Australia's climate has changed over the past 50–100 years. While the changes are reflected in a general temperature rise across the continent, it is the national average minimum temperature, in particular, that has increased, largely as the result of warmer overnight conditions over this period (**Figure 1**).

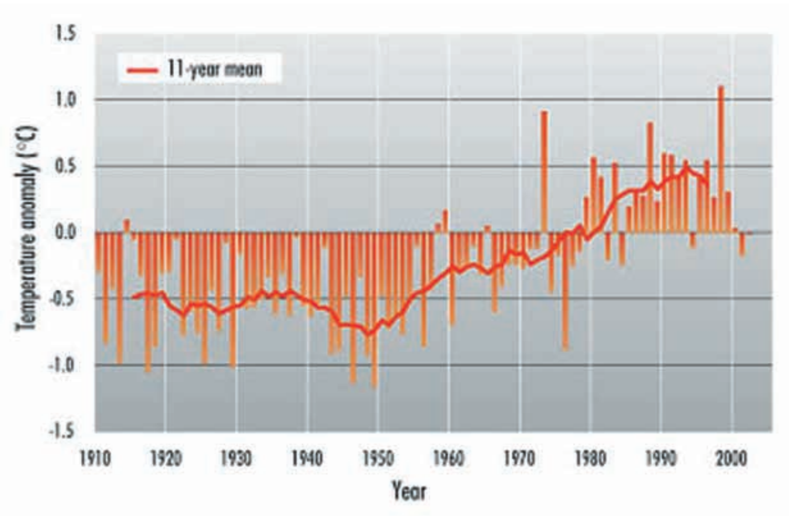
For rainfall during the 20th century, there are wide differences at a regional level, such as a fall in the average amount of rainfall in south-west Western Australia. While there has also been a significant decline in rainfall over large parts of eastern and southern Australia over the past 50 years, this is not as apparent if compared to rainfall around 100 years ago (**Figure 2**).

The 50 year trend may be particularly important, however, as this is the period during which the global climate has moved outside the bounds of experience during the last 1,000 years at least.

Wheat: Future wheat yields will vary with both the positive effect of increased carbon dioxide levels and the generally negative impacts of projected climate change

FIGURE 1

ANNUAL CHANGES IN AVERAGE MINIMUM TEMPERATURE FOR AUSTRALIA (1910–2000). THE VALUES ARE SHOWN AS CHANGES FROM THE LONG-TERM AVERAGE (THE HORIZONTAL LINE AT 0.0)



> Climate change is expected to continue through the 21st century, but there is greater uncertainty about the exact way it will unfold

Climate change is expected to continue through the 21st century, but there is greater uncertainty about the exact way it will unfold. The most feasible scenario is that the pattern of warming observed in recent decades will continue for the foreseeable future. Average annual surface air temperatures are projected to rise by 0.3–1.4˚C by 2030, with this level projected to double by 2070.

The projected changes in rainfall are less certain than the projected changes in temperature. However, the available evidence suggests that much of the Australian continent, including those parts where most farming activities occur, may become more arid and droughts are likely to be more prolonged and intense in the future. There are also likely to be seasonal changes in rainfall distribution, with most projections suggesting an increase in summer rainfall but a decrease in winter rain.

There is an inherent level of chaos and uncertainty in the climate system, which means that, at best, future climatic patterns, especially those related to rainfall and drought, can only be predicted with low levels of certainty. The uncertainty increases when assessing change at the regional to local level.

There is also increasing scientific concern that the climate may change suddenly over a short number of years or that it will become even more variable, with an increase in the severity of floods and drought. Although these possible 'surprises' are even more difficult to predict than gradual changes in climate, they have serious implications for the ability of agriculture to manage impacts. A sudden shift in climate patterns offers farmers little time to prepare risk treatment plans.

STAGE 4

EVALUATING THE RISK OF CLIMATE CHANGE

Exploring management options for minimising risk

Evaluation in risk management involves weighing up the evidence from the risk analysis against the specific risk management criteria. Given the uncertainty, stakeholders, including governments, farmers and communities, face two broad choices to deal with the risk of climate change:

1. Wait for more definite and clear signals on climate change before planning action. This option is based on the view that climate change poses a negligible risk

to agriculture over the next two decades. However, if rapid or extreme climate change were to occur, this response could leave industries and farmers exposed.

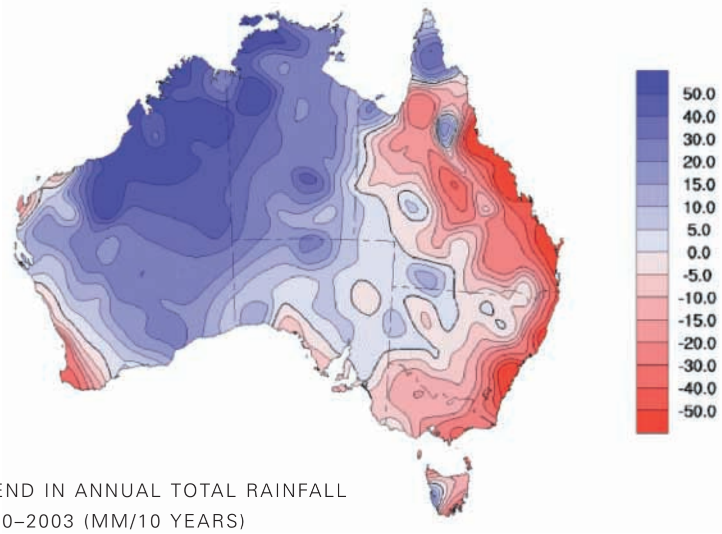
2 Develop early responses to be prepared for the risk of climate change. Industries and individual farmers can work with governments and others to generate the information required to operate their businesses in a changing climate. As with all information gathering, this process has a cost that must be weighed against the benefits to be achieved by being better prepared.

Table 2 shows how farmers might include climate change risks in a decision-making context in some situations. With most if not all of the issues presented in the table, decision makers could be expected to want increased returns from any investments to compensate for the higher levels of risk and uncertainty. Similarly, for many situations selection of a more resilient strain will be an appropriate response to the higher climate risk. Some possible responses, such as increasing water storage capacity, will not be feasible for those parts of Australia where the available water is already over-allocated. Similarly, where water is over-allocated, seeking additional water rights is likely to be expensive and, perhaps, not a feasible option.

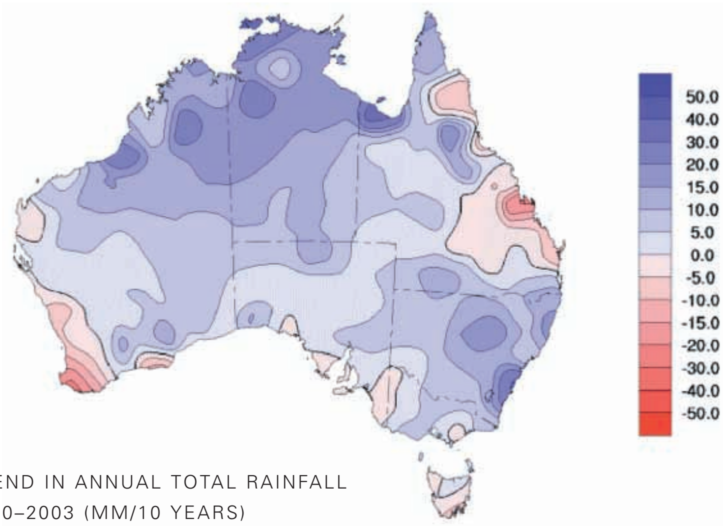
FIGURE 2

TREND IN ANNUAL TOTAL RAINFALL IN MM/10 YEARS FOR THE PAST 50 AND 100 YEARS. BLUE INDICATES AREAS THAT HAVE BECOME WETTER AND RED/PINK INDICATE AREAS THAT HAVE BECOME DRIER.

TREND MAPS OF AUSTRALIAN CLIMATE VARIABILITY AND CHANGE. SOURCE: BUREAU OF METEOROLOGY.



TREND IN ANNUAL TOTAL RAINFALL 1950–2003 (MM/10 YEARS)



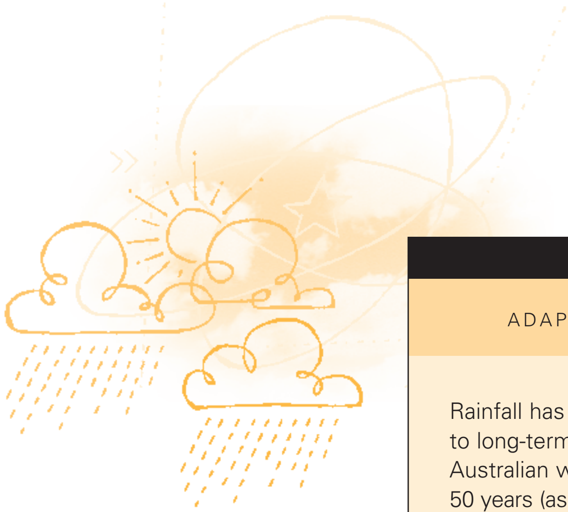
TREND IN ANNUAL TOTAL RAINFALL 1900–2003 (MM/10 YEARS)

There is also increasing scientific concern that the climate may change suddenly over a short number of years

TABLE 1

HOW MIGHT CLIMATE CHANGE EFFECT LAND MANAGEMENT DECISIONS MADE TODAY?

DECISION/ ISSUE	DECISION MAKER	POSSIBLE IMPACT	CERTAINTY OF IMPACT	SOME RISK MANAGEMENT OPTIONS
Property acquisition	Investor/farmer	Varies by region	Nature of climate change highly uncertain at regional levels	Adjust expected return from investment for the higher risk/uncertainty
	Banks (as loan provider)			
Plantations (establishing new plantations)	Farmer	Longer dry periods	High, in traditional growing areas	Adjust site and species selection
		Increased fire risk		Allow for greater losses, or increase insurance
Vine/tree crops	Farmer	Reduced access/higher water cost	High, in most established growing areas	Adjust site and species selection; Seek secure water rights; Water management technologies
		Reduced chill factor		Select/breed appropriate species
Water Infrastructure	Supply authority	Reduced water availability	Variable, but generally high	Increase water use efficiency; Increase storage capacity
	Town planners	More extreme events		More conservative management
	Farmers	More variable supplies		Increase water use efficiency
Annual crop planting decisions	Farmers	More variable seasons Shift in seasonality of rainfall	Variable to high	Increase use of seasonal forecast information (assuming improved reliability of seasonal forecasts)
	Seed suppliers			Plant breeding of adapted varieties
Livestock management	Farmer	More variable water availability/ pasture growth	At farm scale, forecasts are unreliable	Impacts and responses may vary with intensive and extensive (e.g. rangelands) farms
		Changed animal health regime	High levels of confidence at national scale	Increase use of feed/health supplements
				Adjust stocking rates/ grazing regimes
				Change to more resilient species/breeds of pasture and animals



STAGE 5

TREATING THE RISK OF CLIMATE CHANGE

Implementing strategies for maintaining viable agricultural industries

Based on the outcome of the evaluation stage, strategies can be developed to avoid or mitigate risks that are considered to be significant.

Australian agriculture is a complex industry with a proven capacity to adapt to a wide range of environmental and economic changes. The Australian climate has changed over the past 50–100 years and agriculture has demonstrated 'adaptive capacity' under these and other changes (see **Box 2**). This is exhibited in the technological innovation and economic restructuring of our industries and social adjustments in rural communities. Factors that affect capacity to adapt include infrastructure, wealth, education, technology, biodiversity, information and management skills. Australia's performance in managing climate change will depend on the decisions made by individual farming enterprises.

> Australia's performance in managing climate change will depend on the decisions made by individual farming enterprises

BOX 2

ADAPTATION OF WESTERN AUSTRALIAN CROPPING SYSTEMS

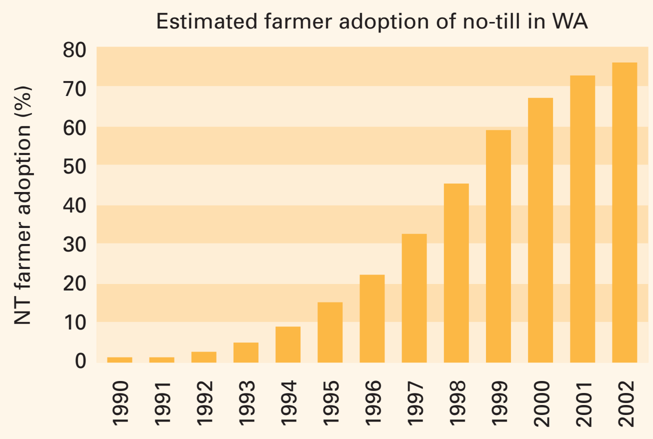
Rainfall has been decreasing relative to long-term averages in the Western Australian wheat belt over the past 50 years (as shown in **Figure 2**). However, wheat yields have increased, with the average yield in some shires increasing from about 2 to 4 kg of wheat per hectare over that period. For example, despite poor rainfall during the wheat-growing seasons in 2001 and 2002, the Western Australian cropping system produced average or better than average crops.

This resilience was achieved by adapting numerous technologies and crop production practices over the past two decades, such as improvement in cultivars and rotation of alternative crops. Another example is the development and uptake of the so called 'no-tillage' technology. This type of tillage conserves soil structure because it reduces disturbance to the fragile top-soil common in the cropping belt. Direct drilling into 'undisturbed' soil allows farmers to successfully sow and grow crops with low rainfall. In 1990, less than 10% of Western Australian farmers were using this technology, but by 2002 that figure had increased to up to 70% (**Figure 3**). Organisations such as the Western Australian Farmers No-Till Association promote this method, and encourage farmers, researchers and extension officers to work closely together.

FIGURE 3

ESTIMATED ADOPTION OF NO-TILLAGE TECHNOLOGIES IN THE WESTERN AUSTRALIAN WHEAT BELT

DATA COURTESY OF THE WEST AUSTRALIAN FARMERS NO-TILLAGE ASSOCIATION



CONCLUSIONS

The climate changes projected to occur during the 21st century are larger than those seen since 1950. As with any 'projection', there is some level of uncertainty. However, the uncertainties are more related to the rate at which the climate will change, and the impacts at the local and regional levels, than to the broad character of climate in the future.

> Australian farmers should be planning for a future climate that is warmer, with even more variable seasonal rainfall and more extreme climate events

Australian farmers should be planning for a future climate that is warmer, with more variable seasonal rainfall and more extreme climate events. Past experience will be an increasingly poor guide to the climate we are likely to experience in the future and the changes that are in prospect will present both threats and opportunities for agriculture.

The ultimate responsibility for managing these changes rests with farmers and other land managers. The role of governments will be to assist in enhancing the resilience and adaptive capacity of agricultural industries and rural communities to the risks and uncertainty inherent in climate change.

> Policy settings that treat droughts and floods, which have been relatively rare in the context of the past 100 years, as a normal part of the agricultural environment will be necessary

There are a number of general measures that will assist the overall preparation of risk planning for climate change by industry sectors or individual farming enterprises. These include:

- Close cooperation between governments, farmers and other land managers, including those at the regional and industry sector levels, to identify information about climate that is most critical to their land management and other business decisions. This could allow better priority setting of ongoing research efforts and ensure that farmers have the information and tools necessary to manage the climate risks.
- Past experience and traditional farming responses to manage climate variability will need to be enhanced to deal with future climate change. Better tools and training for farmers and communities to improve their use of the available climate projection/forecast data in their planning decisions will be important, as exemplified by 'The Managing Climate Variability in Agriculture Program'.
- Developing policy settings that treat droughts and floods as a normal part of the agricultural environment will be necessary. Such events may become more common and dealing with them as 'exceptional' is likely to delay the development and implementation of more resilient and adaptive farming systems.

ACKNOWLEDGEMENTS

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FURTHER INFORMATION

This brief has been based on information and approaches drawn from the following:

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Global Change and the Earth System: A Planet Under Pressure. IGBP Synthesis Volume. Edited by Will Steffen et al. Springer-Verlag, 2004.

Pasture Degradation and Recovery in Australia's Rangelands: Learning from History. Edited by Greg McKeon, Wayne Hall, Beverley Henry, Grant Stone and Ian Watson. Queensland Government Natural Resources, Mines and Energy; Australian Greenhouse Office; and Climate Variability in Agriculture R&D Program, 2004.

http://www.bom.gov.au/info/GreenhouseEffectAndClimateChange.pdf

Other material on climate change:

http://www.greenhouse.gov.au/science/index.html

http://www.bom.gov.au/climate/change/

http://www.cse.csiro.au/research/Program3/ozface.htm

http://www.greenhouse.gov.au/impacts/agriculture.html

CONTACT

FOR MORE INFORMATION CONTACT:

John Sims,
Bureau of Rural Sciences

EMAIL john.sims@brs.gov.au

PHONE (02) 6272 5294

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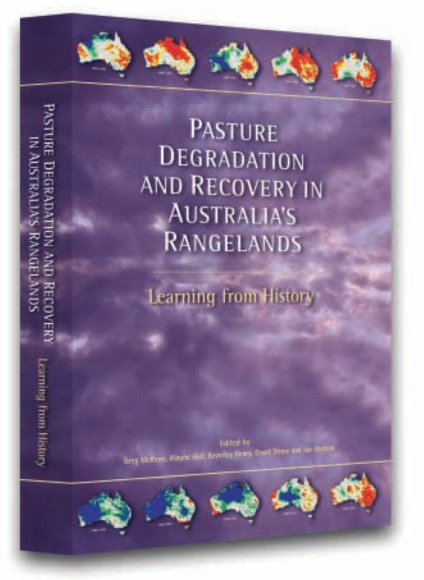

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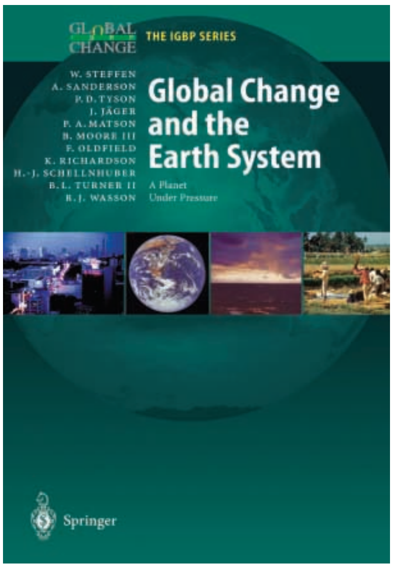

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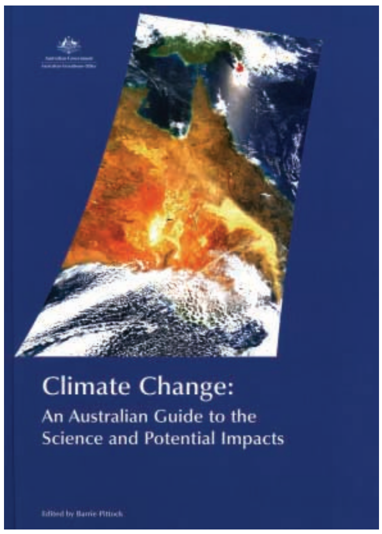

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