



Australian Government

Land & Water Australia



A National Climate Change Research Strategy for Primary Industries: Phase I Report



July 2008

A joint initiative of the Rural Research and Development Corporations;
Federal, State and Territory Governments; and the CSIRO,
managed by Land & Water Australia

www.lwa.gov.au/ccrspi

A National Climate Change Research Strategy for Primary Industries: Phase I Report

Published by Land & Water Australia
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Citation

Land and Water Australia 2008.

A National Climate Change Research Strategy for Primary Industries: Phase I Report

Product code PN21393
Print ISBN 978-1-921544-00-2
Design by Mariana Rollgejser
Printed by Union Offset

Contents

Foreword	I
Executive Summary	2
Context for the Development of a Research Strategy	4
Developing the Research Strategy	6
Implications of Climate Change for Australia	8
Greenhouse gas management	8
Impacts on Primary Industries	9
Agriculture	9
Marine Fisheries and Aquaculture	10
Forestry	11
Table I: Projected Impacts of Climate Change in Australia	12
A Strategic Approach to Research	14
Research Themes	16
Figure I: The Six Collaborative Research Priorities for Primary Industries	17
Understanding Future Climates (projected climate change)	18
Understanding Future Climates (seasonal climate)	20
Managing Emissions	22
Preparing Industries	24
Accessing Information	26
Facilitating Change	28
Linking Decision Makers	30
Conclusions	32
References	34

The National Climate Change Research Strategy for Primary Industries has six appendices which can be downloaded from the Land & Water Australia website at www.lwa.gov.au/ccrspi

- **Appendix A**
Part 1: State of Knowledge and Identification of Research Gaps
- **Appendix A**
Part 2: List of Research Projects on Primary Industries and Climate Change
- **Appendix B:**
Summary of the CCRSPI Reference Group Discussions
- **Appendix C**
Key Findings from Primary Industry Consultations
- **Appendix D:**
Key Findings from Public Consultations
- **Appendix E**
An Overview of Climate Change Adaptation in Australian Primary Industries – Impacts, Options and Priorities by the CSIRO Climate Adaptation Flagship
- **Appendix F**
Knowledge Gaps and Opportunities for Research to Inform and Position Australian Primary Industries to Respond to a Future National Greenhouse Emissions Trading Scheme by the Australian Farm Institute



Foreword

Changes to Australia's already variable climate will present great challenges and opportunities to its primary industries. As a nation we must be prepared for these to ensure the long-term economic, environmental and social sustainability of rural and regional Australia.

Our preparedness and decision-making must be based on good research and its adoption. It is with this knowledge that Australia's primary industries research community has come together in an unprecedented national effort to lead the development of this first phase of a national Climate Change Research Strategy for Primary Industries. The results contained in this long-term strategy reflect rural and regional Australia's eagerness to understand, engage with and respond to climate change issues.

It also demonstrates that collaboration can lead to vastly improved research planning that ensures the delivery of much-needed knowledge which helps primary industries in the face of climate change. In this case, collaboration has included the federal and all state and territory governments, a wide range of investors in research, research providers, primary producers and industry leaders.

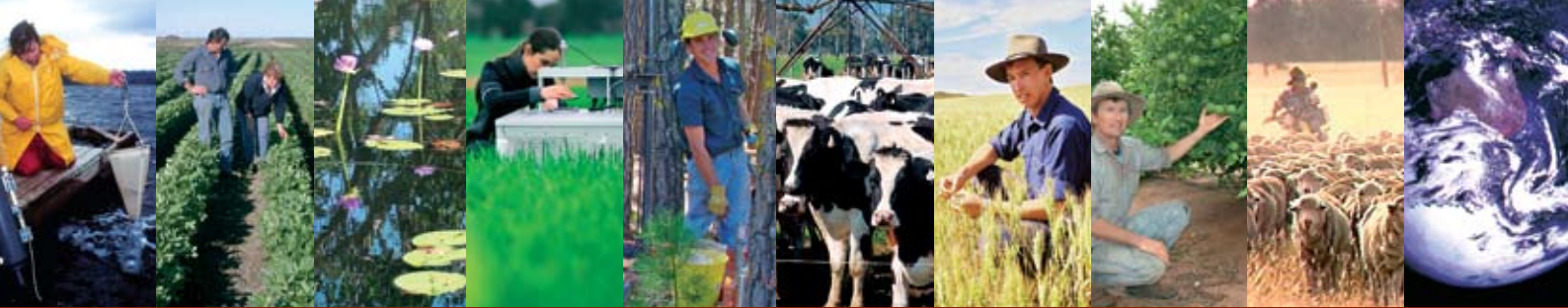
Through intensive consultation and analysis we have identified the major needs for national collaborative research and adoption, the existing areas of research activity, and the major gaps in our knowledge. From this, the National Climate Change Research Strategy for Primary Industries has set a course for efficient, coordinated and collaborative research and its adoption. This is just the first step of several which will be required so that good science and its adoption will underpin the long-term economic, environmental and social sustainability of our primary industries.

Dr Michael Robinson

Chairman

Joint Strategy Team

National Climate Change Research Strategy for Primary Industries



Executive Summary

Australia's primary industries are projected to be significantly affected by climate change. The changes in climate over the next few decades will be substantial, but the effects will vary across the country. Some regions will experience average warming of up to 1.8°C by 2030; in other areas average rainfall will decrease as much as 40 per cent by 2070 (compared to 1990). These impacts must be understood to minimise risk and maximise opportunities.

Australian and international policies, programs and market expectations in response to climate change will also affect primary industries. For example, primary industries contribute an estimated 22 per cent of Australia's total greenhouse gas emissions and will need to reduce these emissions or provide valuable offsets in response to both government policy and market demands. However, the primary industries have a strong history of adaptation and change to overcome threats and take advantage of new opportunities.

The development of this strategy has been funded by all 15 rural Research and Development Corporations (RDCs) (through the Council of Chairs), CSIRO, all state and territory governments and the Commonwealth Government (through the Primary Industries Standing Committee Research and Development Subcommittee). The research strategy identifies areas for industry and government collaboration, and will be used as a guide for developing more specific research and development plans by a number of Australian government, research and industry stakeholders.

The parties to this initiative recognise that Australia's collective capacity in climate change research needs to be harnessed in a nationally coordinated effort if the nation's primary industries are to be adequately and rapidly equipped to reduce greenhouse gas emissions and adapt to climate change. Land & Water Australia has managed the development of this strategy for the partners, consulting widely with expert reference groups, the public (through submissions), relevant agencies and research providers. It has commissioned specific reports on climate change impacts and adaptation and emissions trading, and assessed existing research activity across the nation. The level of input and support for the process has exceeded expectations, demonstrating the interest in this important subject and the need for such a strategy and its subsequent implementation.

This research strategy establishes a foundation upon which sector specific and cross-sector research programs can be developed. It recognises the considerable amount of existing research and the gaps in knowledge, identifies the importance of predicting climate change and its impacts, and highlights opportunities for primary producers to adapt to a changing climate and reduce greenhouse gas emissions. The strategy also recognises the need to link with and build upon related research and program activity already in place.

This strategy identifies areas for collaborative research, development and extension across industry sectors and governments under six key themes.



Underpinning research

- 1 **Understanding Future Climates:** Primary producers need better information about future climate and climate variability at seasonal timescales.
- 2 **Managing Emissions:** A full understanding of primary production life-cycles and processes is essential to reduce and offset emissions.
- 3 **Preparing Industries – Adaptation:** Primary producers are able to adapt and respond to climate change to maintain productive, profitable and sustainable systems.

Enabling research

- 4 **Accessing Information:** Primary producers need access to clear, relevant and factual information that is nationally consistent, but regionally and sectorally specific.
- 5 **Facilitating Change:** Changes are inevitable and must be facilitated through capacity and capability development.
- 6 **Linking Decision Makers:** It is essential that dialogue exists between researchers, policy makers and primary producers to align research priorities, policy development and industry responses.

Primary industries as a whole and across the different sectors need to act quickly to understand the implications of climate change and greenhouse gas management.

There is a strong desire to act as a nation, supported by good, coordinated research, clear consistent communication and the best available information. It is only in this way that primary industries and primary producers can be assisted through any required transitions to minimise impacts and maximise opportunities.

This strategy is a major and critical first step to nationally coordinated research, development and extension that will lead to sustainable, competitive and profitable Australian primary industries in the face of climate change. Primary producers and their industry groups, regional communities, policy makers and researchers demonstrated great enthusiasm in developing this strategy to respond to climate change and it is essential they continue to support its implementation.



Context for the Development of a Research Strategy

Australia is projected to be one of the countries most adversely affected by changes in climate, leading to reductions in agricultural production and exports (ABARE 2007).

Changes in temperature, rainfall, atmospheric carbon dioxide levels, ocean currents and chemistry, winds, nutrient supply and extreme weather conditions will impact on Australian agriculture, fisheries and forestry. Exports of Australia's key agricultural commodities are projected to decline 11-63 per cent by 2030 and 15-79 per cent by 2050 (ABARE 2007). The distribution, growth, recruitment and catch of marine fisheries is also forecast to be affected (Hobday and Poloczanska in Stokes and Howden 2008). However, for some regions and industries there may be benefits from climate change, with increased carbon dioxide concentrations positively affecting plant growth.

Australian primary producers realise they are vulnerable to adverse effects of climate change. Potential impacts are becoming better understood, however, and research is underway to provide knowledge that will assist primary producers, governments and communities to make decisions and plan strategies. These strategies include preparing primary industries to take advantage of opportunities that may arise as a result of climate change.

Although individual industries, industry sectors and regions require information and direction to take account of their particular features, much climate change information and research is broadly relevant and there is scope for substantial collaboration. Information should be shared to inform industry and regional understanding of the impacts on different production systems, and consistent information formats should be developed to assist in analysing potential impacts and opportunities.

A national collaborative approach by rural RDCs, the state and territory governments, the Australian Department of Agriculture, Fisheries and Forestry (DAFF), CSIRO and others has led to the development of this Climate Change Research Strategy for Primary Industries (CCRSPI). It applies to agriculture, fisheries and forestry and the sectors within these industries (which include the commercial, recreational and indigenous sectors of the fishing industry) and covers climate change impacts, adaptation, and management of greenhouse gas emissions. Direct effects of changes in climate and the indirect flow-on impacts of changes to markets, policies and government programs are considered.

The research strategy is set within the context of a range of policy, program and research activities being undertaken to address climate change issues. It aligns with Australian Government policy, particularly the reduction of greenhouse gas emissions, and partnerships between research and industry with a focus on productivity and innovation. It directly addresses the Australian Government National Research Priority "*An Environmentally Sustainable Australia*", specifically the goal to respond to climate change and variability. It also directly addresses the Australian Rural Research and Development Priority "*To build resilience to climate variability and adapt to and mitigate the effects of climate change*".



Consistent with the *National Agriculture & Climate Change Action Plan 2006-2009* (National Resource Management Ministerial Council 2006), the research agenda focuses on adaptation and mitigation and integrates research, development, communication and extension under these goals. It is also consistent with the recommendations of the *Creating Our Future* report (Agriculture and Food Policy Reference Group 2006) that:

“Governments and industry must work in a coordinated way to support increased research into:

- Climate change and its impacts on Australia and the agriculture and food sector, including economic and social impacts;*
- Strengthening adaptive capacity, including through developing easily accessible farm and regional level management and decision tools, and providing related training; and*
- Better understanding of whole of farm emission profiles, and of the potential for emission reductions and carbon sequestration in agriculture.”*

The importance of the challenges posed by climate change has been affirmed by the Commonwealth, state and territory governments.

Dealing with climate change has been recognised by the Prime Minister as one of the core risks facing Australian agriculture, affecting the long-term productivity and profitability of the agriculture and food sector (Rudd 2008). A successful approach to tackling climate change will require primary industries to seize new market opportunities, including opportunities from the management of carbon through actions such as soil management. There is a strategic need to recognise the links between climate change, drought and water management as part of the national response, as well as undertake specific research on issues such as climate modelling, seasonal forecasting, and the management of pests, disease and weeds.

Commonwealth, state and territory governments have agreed to coordinate adaptation, mitigation and research and development policies and programs to support industry productivity growth under the challenge of a changing climate (Burke 2008). This will require increased cross-jurisdictional work on strategic research and development priorities, and a national collaborative approach.

The value of this research strategy is that it is an industry-driven approach to climate change. As such, it focuses on how climate change will impact on primary industries, the policy makers who will contribute to shaping their future, and the regional communities within which they are located. The research strategy seeks to meet the needs of primary industries, while at the same time complementing existing activities, policy and programs that are undertaken by government and research institutions.

Developing the Research Strategy

The development of this research strategy is a joint initiative of all the rural Research and Development Corporations (RDCs), the state and territory governments, the Australian Department of Agriculture, Fisheries and Forestry, and CSIRO. Representatives of these organisations as well as universities gathered at a workshop in June 2007 and identified the opportunity for a collaborative and coordinated strategy to address climate change for primary industries.

The 15 RDCs are:

- Australian Egg Corporation Ltd
- Australian Pork Ltd
- Australian Wool Innovation Ltd
- Cotton Research and Development Corporation
- Dairy Australia
- Fisheries Research and Development Corporation
- Forest and Wood Products Australia
- Grains Research and Development Corporation
- Grape and Wine Research and Development Corporation
- Horticulture Australia Ltd
- Land & Water Australia
- LiveCorp
- Meat and Livestock Australia
- Rural Industries Research and Development Corporation
- Sugar Research and Development Corporation

A team was formed to scope and coordinate the development of a research strategy. Both the Research and Development Subcommittee of the Primary Industries Standing Committee (PISC R&D Subcommittee) and the Council of Rural Research and Development Corporations Chairs supported the development of the National Climate Change Research Strategy for Primary Industries (CCRSPI).

The joint strategy team members established by the PISC R&D Subcommittee comprised:

- Dr Michael Robinson (Land & Water Australia, Chair)
- Mr Peter Reading (Grains RDC, PISC R&D Subcommittee)
- Mr Ian Thompson (DAFF, PISC R&D Subcommittee)
- Dr Andrew Ash (CSIRO, Director Adaptation Flagship)
- Mr Rob Delane (Department of Agriculture & Food WA, PISC R&D Subcommittee)
- Prof. Snow Barlow (University of Melbourne, Australian Council of Deans of Agriculture).

Land & Water Australia provided the secretariat to develop the research strategy with the support of the Department of Agriculture, Fisheries and Forestry.

The initial scoping of the strategy formed the business case for developing a strategy, which was unanimously supported by the Rural RDC Council of Chairs and the PISC R&D Subcommittee.

The subsequent major phases in developing the strategy included:

- Scoping the research needs of primary industries in response to climate change;
- Auditing current and developing research activity and analysis of investment gaps;
- Assessing research priorities, especially those deemed urgent and important; and
- Assessing collaboration and coordination opportunities for existing, developing and new investments.

The process included the following activities:

- A report compiling current knowledge and projects, and identifying research gaps;
- Establishment of an expert reference group (40 experts covering industry, research and policy), which met over three workshops and through email consultation;
- Face-to-face interviews (35) conducted with industry organisations, state government representatives and rural RDCs;
- Compilation of submissions from primary industry and others (63) in response to a broadly promoted 'invitation to comment';
- Commissioning of CSIRO to report on *An overview of climate change adaptation in the Australian Primary Industries - Impacts, Options and Priorities*; and
- Commissioning of the Australian Farm Institute to report on *Knowledge gaps and opportunities for research to inform and position Australian primary industries to respond to a future national greenhouse emissions trading scheme*.

To address the long-term nature of climate change, a range of timeframes was considered in developing the strategy: short-term (5 years), medium-term (10 years) and long-term (20+ years). All aspects of biophysical, social, institutional and economic impacts, risks and opportunities were considered.





Implications of Climate Change for Australia

By 2030, the temperature is projected to warm by about 1°C over Australia for the mid-range emissions scenario (relative to 1990). Inland areas are likely to experience stronger warming of up to 1.8°C. By 2070, average Australian temperatures are projected to increase around 1.8°C in a low emissions scenario, with a range of 1.0°C – 2.5°C across the country. In a high emissions case the projected average temperature increase is around 3.4°C, with a range of 2.2°C – 5.0°C, relative to 1990. Mean warming in winter is expected to be less than in other seasons.

In south-eastern Australia, El Niño events may tend to become drier and La Niña events may become wetter (CSIRO and Bureau of Meteorology 2007). For 2030, rainfall is projected to decrease by 2-5 per cent on average, and by about 7.5 per cent by 2070 (compared to 1990). The exception is far northern Australia where little rainfall change is projected. However, changes in rainfall are expected to vary widely across regions and seasons. For example, rainfall in south-western Australia is projected to decline by as much as 40 per cent by 2070 (compared to 1990).

Across Australia, the decreases in rainfall are projected to be greatest in winter and spring. The climate models also show an increase in daily rainfall intensity (rain per rainy day) and in the number of dry days. Due to the projected changes in rainfall and predicted increases in evaporation, soil moisture is likely to decline over much of southern Australia (CSIRO and Bureau of Meteorology 2007).

Greenhouse Gas Management

In 2005 the agriculture, fisheries and forestry sector of Australia's economy was the second-highest emitting sector after the electricity, gas and water sector (emissions disaggregated by Australia-New Zealand Standard Industry Classifications, including emissions from fuel use (Australian Greenhouse Office 2007)). In 2005 Australia's net greenhouse gas emissions were 559.1 million tonnes carbon dioxide equivalent (Mt CO₂-e) and the agriculture, fisheries and forestry sector accounted for 22.9 per cent (128.2 Mt CO₂-e) of Australia's total net emissions. The agriculture, fisheries and forestry sector has achieved a 41.7 per cent net reduction in greenhouse gas emissions between 1990 and 2005 (220.1 Mt CO₂-e to 128.2 Mt CO₂-e). This was largely attributed to reductions in clearing, a component of land use change (128.9 Mt CO₂-e in 1990 to 53.3 Mt CO₂-e in 2005).

Direct emissions from the primary industries, and in particular agriculture, come from a range of sources. In 2005, two-thirds of the direct emissions (i.e. not including fuel and energy use) from Australian agriculture were from livestock digestion, 19.1 per cent from soils management (including rice production) and fertiliser use, 10.2 per cent from burning (prescribed burning of savannas and burning of field wastes) and 3.9 per cent from intensive livestock manure.



About 77 per cent (67.1 Mt CO₂-e) of these agricultural emissions were methane and 23 per cent nitrous oxide (20.7 Mt CO₂-e). Energy use (fuel and electricity) also contributes to the 'carbon footprint' of Australia's primary industries.

Changes in the emissions from the primary industries sector during the period 1990 to 2005 were mainly the result of reductions in broad-scale clearing and it is unlikely that reductions on this scale will be achieved in the future. Further decreases in emissions are most likely to be achieved through changes in management practices and advanced technological solutions. Improved energy efficiency and actions in the land sector (including forestry, farm forestry and the management of soil carbon) will also provide opportunities for reducing and offsetting emissions.

Primary industries will be faced with a number of challenges that will drive them to better manage and reduce greenhouse gas emissions. Domestic and international markets (including international retailers) are beginning to demand information on emissions generated in food production, particularly in premium markets. The discussion surrounding the development of a national emissions trading system is also generating questions about what the impacts may be for the primary industries. The challenges and opportunities that will arise from trade and policy impacts of greenhouse gas management, nationally and internationally, will have significant implications for businesses in the primary industries in the short to medium-term. The development of technologies and skills to measure greenhouse gas emissions will also provide opportunities for greater production efficiency, with potential gains through increased efficiency of nitrogen fertiliser use (reducing nitrous oxide emissions) and improved feed conversion efficiency (reducing methane emissions from enteric fermentation).

In the agriculture and land management sectors, however, there appears to be a limited understanding of emissions trading, the costs of abatement, and the economic opportunities from engaging in emissions management. There is uncertainty about the potential impact for industries and regions. Primary industries will need access to sound analytical capability and information to understand these issues and make the most of the opportunities that exist. Information about the cycling of greenhouse gases through different production systems, options for mitigation and abatement of emissions and possible ways to modify enterprises is inadequate, making it difficult for primary industries to improve emissions management.

Impacts on Primary Industries

AGRICULTURE

Australian agriculture is particularly vulnerable to climate changes, with potential negative impacts on the amount of produce, quality of produce, reliability of production, and the natural resource base on which agriculture depends (IPCC Fourth Assessment report, Hennessy et al. 2007 in Stokes and Howden 2008). Table 1 provides an overview of the key predicted impacts on these factors due to climate change.

Agriculture contributes about two per cent of Australia's gross domestic product (GDP). About two-thirds of agricultural products are exported (DAFF 2007), and exports of agricultural products account for about 18 per cent of total Australian merchandise exports. The Australian Bureau of Resource Economics estimates future climate change is projected to lead to a decline in Australian production of wheat, beef, sheepmeat, dairy and sugar production by 8.5-10 per cent by 2030 and 13-19 per cent by 2050. Australian agricultural exports of key commodities are projected to decline by 11-63 per cent by 2030 and by 15-79 per cent by 2050, relative to the reference case (ABARE 2007). Under some scenarios, future climate change is projected to lower agricultural productivity in Australia by 27 per cent without carbon fertilisation, and by 16 per cent with carbon fertilisation by 2080 (Cline in ABARE 2007).

Changes in international production and therefore competition will also have implications for Australia's agricultural sectors, and will be complicated by changes in consumer demands (for example, projected shifts from crop-based to livestock-based diets). It is expected that changes in the frequency and severity of extreme climate events will have significant consequences for food production and food security, which will have broad consequences for international markets and trade. (Easterling et al. 2007).

MARINE FISHERIES AND AQUACULTURE

Changes in temperature, ocean currents and chemistry, winds, nutrient supply, rainfall and extreme weather conditions are projected to generate impacts on Australian fisheries and aquaculture.

Marine fisheries and aquaculture are important industries in Australia, with a gross value of production of \$A2.12 billion in 2005/06, of which about 35 per cent is from the aquaculture industry (Hobday and Poloczanska in Stokes and Howden 2008).

Rock lobster, prawns, abalone and tuna are the most valuable wild marine fisheries, accounting for 55 per cent of Australia's gross value of fisheries production in 2005/06 (ABARE 2007). Salmon and trout, southern bluefin tuna, pearl oysters, edible oysters and prawns are the most valuable aquaculture species accounting for 86 per cent of the industry gross value, with barramundi and abalone aquaculture rapidly expanding.

The combination of ocean warming around Australia, and strengthening of the East Australia Current is predicted to change the distribution, growth, recruitment, and wild catch of species, and the location of some aquaculture. The greatest warming of marine waters in the southern hemisphere is projected in the Tasman Sea, and is expected to have adverse impacts on Tasmania's valuable salmon aquaculture industry. The recent above average water temperatures in southern Tasmania have already increased mortality (Pittcock in Stokes and Howden 2008).

Also of concern is the potential impact of climate change on the supply of aquaculture-feed ingredients. Feeds used in aquaculture often contain a high proportion of wild-harvest fish. As soybean meal and plant protein are increasingly used as an alternative to fish meal and fish oil, the climate change impacts on crop plant industries will become increasingly important to aquaculture (Preston and Poloczanska in Stokes and Howden 2008).

Changes in ocean temperatures and conditions may also bring benefits. For example, increased temperatures in northern fisheries may enhance recruitment and growth in some species, such as prawn.

The recreational and traditional fishing sectors will also feel the impacts of changes to the marine environment. A survey of indigenous fishing effort in northern Australia identified more than 37,000 indigenous Australians, representing 91.7 per cent of the indigenous population, participating in fishing during the survey period (Henry and Lyle 2003).

Recreational fishing is an important activity for about 3.4 million Australians who fish each year and contribute an estimated \$1.8 billion to the economy through this activity (Henry and Lyle 2003). The impacts of climate change on recreational and traditional fishing sectors will flow through to communities and other industries relying on these sectors, including tourism, with likely social and economic implications.

The commercial wild-catch fisheries and aquaculture industries are relatively low emitters of greenhouse gases. Little research has been conducted into opportunities for these industries to generate emissions offsets, which limits their participation in the national emissions trading scheme. However, the wild-catch fishing sector relies heavily on fuel inputs, and increases in fuel costs arising from an emissions trading scheme will present a challenge.

FORESTRY

Climate change is likely to have both positive and negative impacts on forestry. About 164 million hectares of Australia is covered by forest. About seven per cent of that area is native forest managed for timber production, and about one per cent is plantation forest. There are about 1.8 million hectares of commercial plantations. Farm forestry accounts for about 20 per cent of plantations and is growing in importance, with 33 per cent of farm forest plantations planted since 1995.

The impacts on plantation productivity are uncertain. Rising levels of atmospheric carbon dioxide may increase productivity, but warmer temperatures combined with declining rainfall may reduce productivity. Any reduction in rainfall, coupled with increased water requirements as a result of a warmer climate, is of concern for plantations in the future (Booth, Kirschbaum and Battaglia in Stokes and Howden 2008).

Australia's native forests include more than 2000 tree species, many of which are highly vulnerable to climate change because of their limited climatic ranges. There are also potential problems from increased pest and disease risks and increased bushfire frequency and severity.

The forestry industry can provide greenhouse gas emissions offsets, and has been researching opportunities for a number of years. In 2005 it was estimated that reforestation activities and the sequestration of carbon dioxide in plantations established since 1990 had removed 19.6Mt of carbon dioxide, which represented a 3.5 per cent offset of the total net national emissions (Australian Greenhouse Office 2007).



Table 1 Projected Impacts of Climate Change in Australia

FACTOR	CLIMATE CHANGE IMPACT
Temperature Rise	<ul style="list-style-type: none"> ■ By 2030, the temperature is projected to warm by about 1°C annually over Australia for the mid-range emissions scenario (relative to 1990). Inland areas are likely to experience stronger warming of up to 1.8°C, with coastal areas warming a little less. ■ By 2070, the annual warming is about 1.8°C (range of 1.0°C – 2.5°C) for the low emissions case and about 3.4°C (range of 2.2°C – 5.0°C) for the high emissions case, relative to 1990. Mean warming in winter is expected to be less than in other seasons. ■ In south-eastern Australia, El Niño events may tend to become drier and La Niña events may become wetter (CSIRO and Bureau of Meteorology 2007).
Rainfall	<ul style="list-style-type: none"> ■ For 2030, rainfall is projected to decrease by two to five per cent across Australia, except for far northern Australia where little rainfall change is projected. ■ By 2070, annual rainfall is estimated to decrease by about 7.5 per cent across Australia, except in the far north where little rainfall change is projected. ■ Changes in rainfall are expected to vary widely across regions and seasons in Australia. Although northern Australia is projected to experience little change in rainfall levels over the next 60 years, south-western Australia is projected to experience declines of as much as 40 per cent by 2070. ■ Across Australia the decreases in rainfall are projected to be greatest in winter and spring. The models also show an increase in daily rainfall intensity (rain per rainy day) and in the number of dry days. ■ Due to the projected changes in rainfall and increases in evaporation, soil moisture is likely to decline over much of southern Australia (CSIRO and Bureau of Meteorology 2007).
Pests and Diseases	<ul style="list-style-type: none"> ■ Changes in temperature, rainfall and humidity are likely to alter the distribution, occurrence and frequency of pests and diseases. For example, the Queensland fruit fly is expected to spread southwards whereas the range of the light brown apple moth is expected to contract (Preston and Jones in ABARE 2007).
Rising Atmospheric Carbon Dioxide	<ul style="list-style-type: none"> ■ Atmospheric carbon dioxide concentration (CO₂) has increased steadily from about 350 parts per million (ppm) in 1990, to the current atmospheric CO₂ levels of about 380ppm. World CO₂ emissions are expected to increase by 1.9 per cent annually between 2001 and 2025. By 2030, atmospheric CO₂ levels are expected to be about 430–455 ppm, and 525–705 ppm by 2070 (CSIRO and Bureau of Meteorology 2007). ■ The steadily increasing concentration of CO₂ in the atmosphere directly affects productivity, product quality and resource use efficiency of plants and vegetation. Higher atmospheric CO₂ concentration increases the efficiency of use of light, water and nitrogen and possibly the uptake of other minerals such as soil phosphorus (Stokes and Howden 2007). Increases in CO₂ concentration could have positive carbon fertilisation effects by increasing the rate of photosynthesis in some plants. (Steffen and Canadell 2005). However, higher concentrations of CO₂ could also reduce crop quality by lowering the content of protein and trace elements (European Environment Agency in ABARE 2007).

FACTOR	CLIMATE CHANGE IMPACT
Extreme Events	<ul style="list-style-type: none"> ■ Extreme events such as flooding and droughts are projected to increase in frequency and severity as the global climate changes. Such events are likely to reduce agricultural productivity and production by decreasing crop yields and increasing stock losses (CSIRO and Bureau of Meteorology 2007). ■ An increase in fire-weather risk is likely with warmer and drier conditions. It is likely that the fire season will lengthen, shifting periods suitable for prescribed burning toward winter.
Sea Level Rise	<ul style="list-style-type: none"> ■ Global sea levels rose by about 17cm during the 20th century, and by about 10cm from 1920-2000 at the Australian coastal sites monitored. ■ By 2100, a global average rise of 18-59cm is projected, with a possible addition from ice sheets of 10-20cm. However, further ice sheet contributions may substantially increase the extent of sea level rise (CSIRO and Bureau of Meteorology 2007).
Other Marine Changes	<ul style="list-style-type: none"> ■ General ocean warming around Australia, changes in ocean chemistry and circulation patterns are projected (Stokes and Howden 2007). Substantial warming has occurred in the three oceans surrounding Australia. For example, the sea surface temperature around Maria Island, Tasmania, has warmed by approximately 1.5°C since the 1950s. ■ By 2030, the sea surface temperature is projected to warm by 1-2°C around Australia with the greatest warming off south-eastern Australia (2°C). ■ By 2070, the sea surface temperature is projected to warm by 2-3°C around Australia with the greatest warming off south-eastern Australia (3°C). ■ Warming ocean temperatures, in particular on the east coast, are expected to threaten coral reefs with more frequent bleaching events, causing fish species to migrate towards the poles and threaten kelp forests. ■ Ocean acidity is projected to increase as levels of CO₂ in oceans increase, reducing the availability of calcium carbonate which is required by many creatures with calcium carbonate shells. ■ The East Australia Current is likely to strengthen, resulting in warmer waters extending further southward. ■ Estuaries are likely to be affected by rising sea levels and changes in flows of freshwater from rivers (CSIRO and Bureau of Meteorology 2007).



A Strategic Approach to Research

Australia's primary industries need to be sustainable, competitive and profitable now and in the future. Although each industry sector has specific issues, there are many cross-sector issues that require collaborative effort. In recognition of this, the research strategy's desired outcome is that:

Primary industries are equipped to make the best possible decisions to manage for climate change.

This outcome has been developed recognising that climate change will lead to changes in the biophysical environment, government policies, regulations, prices, consumer demands and international markets, with increasing requirements for better emissions management.

These changes will affect Australia's primary industries and the impacts will flow through into the regional communities that support primary industries, as well as industry value-chains. This means that research must take account of socio-cultural as well as economic and productivity impacts.

In achieving the research strategy outcome, Australia's primary industries will have to understand existing, emerging and new issues, and respond by optimising their adaptation and mitigation decisions. In managing for climate change, primary producers will need to take into account the inter-relationships between practices to manage impacts of climate change and practices to reduce greenhouse gas emissions. These are distinct, yet inter-dependent areas for action and investment. In recognition of this, two objectives have been developed to assist the development of research in these areas, and to focus investment on outcomes for primary industries.

ADAPTATION: Primary industries are able to make the best possible decisions to manage change due to climate change.

MITIGATION: Primary industries are able to manage greenhouse gases in response to policy and market expectations.

The adaptation goal focuses on the need for primary producers to adapt their management and production systems to account for changes in climate, and consequent changes in their production systems and/or businesses flowing from changes in climate. The long-term nature of climate change means that primary producers will experience an ongoing process of change and adaptation. Management strategies will need to change over time as new information becomes available.

Mitigation goals focus on greenhouse gases generated by primary industries, the sequestration opportunities that may arise, and opportunities for improved production efficiency. Options will be influenced by national and international policies and markets. Research is required to



quantify emissions, and to identify and support reduction measures and options, such as emissions abatement, prevention or offsets for different regions and sectors.

These objectives reflect the current priorities of primary industries. Through stakeholder consultations, four questions emerged to focus research investment on delivering outcomes to primary industries, and specifically producers. These questions can be used as a 'filter' to ensure that research links directly to the needs of primary producers and regional communities, be it biophysical, social, economic or institutional research.

OUTCOMES FILTER

1 How will climate change influence the future for primary industries?

Primary producers and regional communities need to understand climate change and its potential impacts, greenhouse gas emissions and their management, as well as potential impacts on international competitors and markets.

2 What does climate change mean for primary industries, their businesses and their regions?

Primary producers and regional communities need a detailed understanding of the potential future climate change impacts and emissions management for their region and enterprise.

3 What can primary producers do about climate change?

Primary producers and regional communities need to be able to make informed decisions and choices about the trade-offs and benefits from adopting alternative practices and management strategies.

4 How can primary industries prepare for climate change?

Primary industries need to build their understanding of climate change impacts and emissions management into existing research programs, develop alternative production and management systems to meet future challenges and opportunities, and understand and monitor changes in climate as they occur.

These four questions are broadly aligned with the risk-management approach to climate change advocated by the Australian Greenhouse Office (Allen Consulting Group 2005) and the Bureau of Rural Sciences (2004). The premise behind the four questions is that decision makers for, and within, primary industries need to understand and identify the climate change issues they face, and develop strategies and mechanisms to deal with them. This base of understanding can then be used to identify and implement responses that are appropriate for their industry and region.

Some sectors within the primary industries have already developed research strategies and investment plans to address climate change (for example, the Sugar Research and Development Corporation and Dairy Australia); however, these issues have not been dealt with consistently across primary industries or regions.

Research Themes

Six collaborative themes have been identified for research activity to assist primary industries to make the best decisions to manage for climate change in both the short and long-term. These themes identify opportunities for primary industries to collaborate and coordinate research activity and investments, or where groupings of different sectors could collaborate and coordinate to maximise outcomes from research investments.

1 Understanding Future Climates (projected climate and seasonal climate)

Primary producers need better information about Australia's potential future climate as it is central to decision-making for individual enterprises and for policy planning. Understanding climate variability at seasonal timescales and having relevant seasonal forecasting tools remain two of the best risk management strategies at an enterprise level for many sectors.

2 Managing Emissions

Research is required to understand emissions (including life-cycle assessments), and manage emissions from all sectors in response to market and policy demands. Information and guidance is needed for formal reporting processes, to aid good policy development, and to assist individual enterprises to reduce emissions or provide offsets.

3 Preparing Industries - Adaptation

Understanding climate change, the implications of climate change on production systems and regions, and the implications of policy, program, market and behavioural responses, is essential for primary producers and authorities responsible for natural resources. The development of management practices and technologies appropriate for changes in climate also has advantages for managing risk from climate variability, including drought.

4 Accessing Information

Primary producers need access to clear, relevant and factual information to understand the implications of climate change and emissions management for their production systems. Good quality information that is nationally consistent and regionally relevant allows for consideration of options to respond and helps avoid mal-adaptations.

5 Facilitating Change

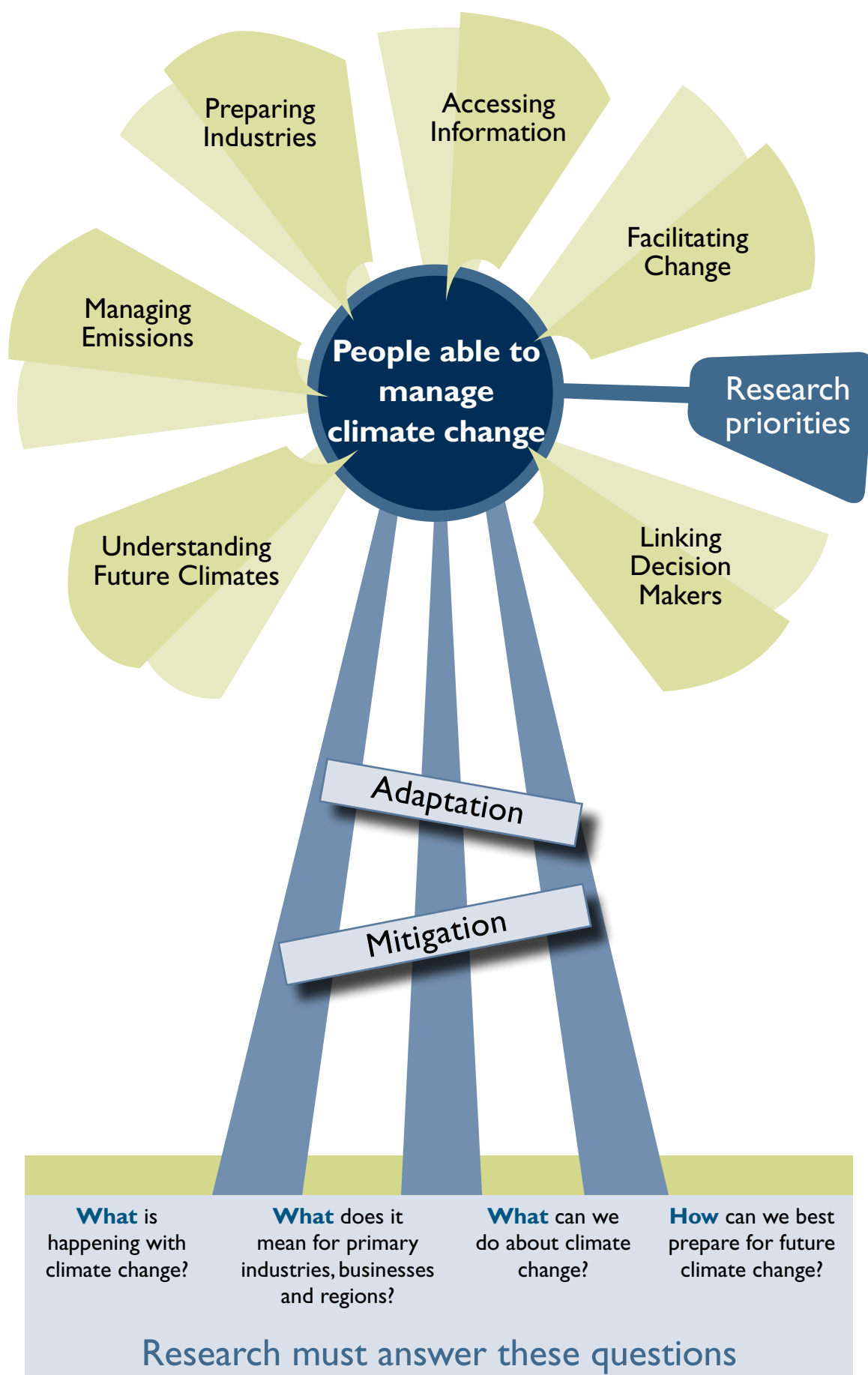
Change, and the management of change, has long been an integral part of Australia's primary industries and a competitive strength. Governments, industries and individual enterprises need the capacity and capability to manage and facilitate change to maximise opportunities and minimise risks, supported by knowledge, tools and extension programs.

6 Linking Decision Makers

It is essential that dialogue exists between researchers, policy makers, primary producers and other agribusiness stakeholders (including industry groups) so that decisions by each party address the challenges and opportunities of climate change, but do so within a practical industry context.

These six themes are discussed in detail in the following pages. Figure 1 shows how the elements of the research strategy work together to deliver outcomes and outputs for primary industries.

Figure I The Six Collaborative Research Priorities for Primary Industries



Understanding Future Climates (projected climate change)

Statement of need

Understanding and having access to information about Australia's future climate is central to developing an understanding of how climate change will influence the future of Australia's primary industries. This information underpins regional and industry planning to identify opportunities and manage risks to production, as well as informing the research programs that deliver industry preparedness and adaptation for future climates.

Rationale for collaboration

The development of climate models such as the Global Circulation Models (GCM) is a significant long-term financial commitment that requires ongoing funding and currently receives support through the Australian Climate Change Science Program. The information primary industries demand from climate change projections can differ from the GCM outputs and there needs to be basic, or 'discovery', research to underpin the development of projections and appropriate model outputs. Information from these models, especially if tailored to particular sectors or regions and made widely available, would be of benefit to primary industries generally.

Anecdotal evidence suggests that demand for climate change projection information has led to duplicated investment by regions and industries, and difficulties in accessing consistent, high quality information in a timely manner. In particular, there has been a strong demand for regional climate change projections to better understand the implications on future production and regional viability. Several research providers are now undertaking work in this area, and there has been discussion on the need for consistency in the way GCMs are treated, and how outputs are used (for example, which models are the most appropriate to use to generate rainfall information) and communicated (for example, 'if' and 'how' primary producers should respond to uncertainty in projections). These issues have implications across all primary industries. Collaboration and agreement on projections and the treatment and communication of GCM outputs will help prevent confusion and provide opportunities to negotiate better mechanisms for accessing this fundamental information.

Existing investment activities

The Australian Climate Change Science Program supports the development of GCMs to underpin climate projections from CSIRO and the Bureau of Meteorology. There are a number of research centres that have specific skills in developing and applying downscaled climate change projections including the recently established Centre for Australian Weather and Climate Research partnership between CSIRO and the Bureau of Meteorology, the Queensland Centre for Climate Change Excellence and a number of universities. Some work is being undertaken to model the impacts of climate change scenarios on primary production, but little or no investment has been made to improve the accessibility or relevance of this information for primary industries, particularly at a sector or regional level. This is a critical and widely recognised knowledge gap. There is also a clear need for information on climate change projections to be readily accessible and relevant, i.e. information that reflects factors important to each sector (such as rainfall, ocean conditions, and climate change in northern Australia) and that are valid at regional scales.

Areas for further investment

Work is required to communicate climate change projection information that is relevant and useful for primary producers. Research is required to produce better downscaled information and climate information with specific relevance to primary production. It is also important to understand what the limits to resolution and interpretation in downscaled climate projections may be. The significant international effort underway to develop GCMs may also provide opportunities and advances for Australian primary industries. Ongoing evaluation and review of this research effort is required.

Outcomes sought through research include:

- Climate change projections with information on factors of relevance to primary industries (such as rainfall, ocean conditions, water availability, plant growth and regional climate change).
- Credible and easy-to-understand climate change scenarios (such as scenarios of mild, moderate and severe climate change) to facilitate broader understanding of climate change science and impacts.
- Research to identify risks to primary production that may be affected by climate change to enable focussed GCM model development.
- Consistency in the way different GCMs are treated, and how GCM outputs are used and presented.
- Collaborative research between industry, modellers and climate scientists to research and develop scenarios of future primary production.
- Research to validate downscaled projections developed for primary industries.
- Ongoing research and monitoring to investigate the effects of climate change on different primary industries and regions.
- Research to underpin improved communication of concepts and information about probabilities and uncertainty, and how to deal with irreducible uncertainty in climate change projections.

Consultation with stakeholders consistently identified the need for more accessible, easy-to-understand, relevant information on climate change projections at regional scales as a high priority.



Understanding Future Climates (seasonal climate)

Statement of need

Managing for climate variability within seasons is an important aspect of risk management decision making for many primary producers and is required to address both current and future climate conditions. Management of climate variability is a fundamental tool for supporting adaptation and preparedness to future climate change. Understanding seasonal climate and forecasts also has application in understanding the language used to communicate climate change projections, and the implications of climate change projections for their enterprise and region.

Rationale for collaboration

There are significant benefits from collaborative investment in research to better understand and manage climate variability. Significant further investment in this area is needed to improve forecasts of climate variability at seasonal timescales from dynamic climate models (given that current statistical tools for developing seasonal forecasts will be less effective under climate change) and to better understand how seasonal climate may change under future climates. The link between the management of current climate variability and preparedness to manage future climates suggests that there is a strong argument for greater investment in this area of research. The development of better communication tools and improved understanding of within-season climate variability could have broad benefits, and be applied across a number of sectors.

Existing investment activities

There has been ongoing collaborative investment in research under the Managing Climate Variability (MCV) program to improve communication and understanding of seasonal climate information among primary producers. The MCV program has invested in research over the past decade across a range of industries and regions to better understand and manage the impacts of climate variability, and has supported a range of research to understand the climate drivers that produce climate variability at seasonal timescales. Its focus has been on statistical methods for developing seasonal forecasting tools.

The development of the National Agricultural Monitoring System, coordinated by the Bureau of Rural Sciences, has been a significant collaboration between the Commonwealth, state and territory governments. The project has allowed information on climate variability and related research to be applied to policy questions such as drought management.

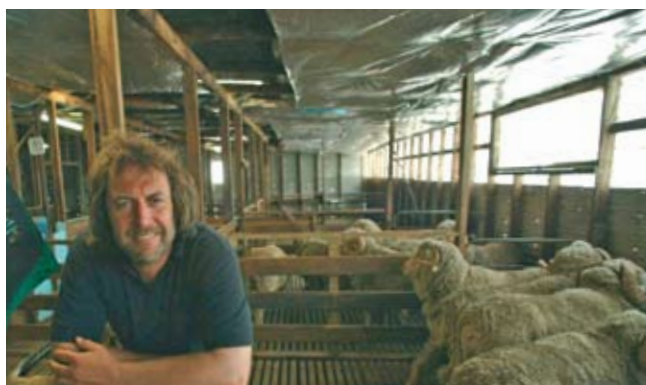
Areas for further investment

An increased emphasis on research to support better management and understanding of climate variability at seasonal timescales is required. The focus must also shift towards dynamic forecasting methods as statistical methods become less relevant under a changed climate. Substantial new research investment is required if, within the next decade, dynamic models are to provide seasonal climate information with meaningful confidence levels for end users.

Areas for research include:

- Research to support the communication and greater uptake of seasonal climate forecasts in primary industries.
- Research and development to better underpin seasonal forecasts in a changing climate, including the further development of dynamic seasonal forecasts.
- Research and development to link seasonal forecasts to other variables (for example, market information, production system models and real time information on conditions such as water availability) to develop decision support tools and increase the usefulness and uptake of forecasts.

Stakeholders involved in the research strategy consultation process consistently identified the need for better seasonal forecasts to assist in the management of within-season climate variability and to prepare industries for future climates.



Managing Emissions

Statement of need

In 2005 the agriculture, fisheries and forestry industries accounted for 22.9 per cent of Australian national emissions. The management of greenhouse gas emissions is a significant challenge for primary industries and is currently the subject of many unanswered questions. Questions range from how consumer demand and policy settings may influence international and domestic markets and trade, to basic questions about greenhouse gas emissions and cycling within primary production systems. Primary producers need answers to these questions and access to tools to understand their liabilities and the opportunities. Research and development is required to produce information packages, economic information and decision support tools to manage and reduce emissions, and to support the development of highly productive, sustainable, primary production systems and technologies with low emissions. There are also opportunities to understand and capture the benefits of improved production efficiencies.

Rationale for collaboration

Although primary industries may have specific issues and priorities that relate to the way they operate and their emission profile, a number of common interests exist, including the development of measurement and reporting standards. Groups of primary industries face similar research issues in developing technologies and management systems to deal with emissions from livestock and plant-based production systems (including crops and pastures).

A number of primary industries also have shared interests in understanding the opportunities from offsets, biofuels and reduced energy use. These common interests provide the rationale for collaboration around a range of emission management issues, and work in this area could lead to significant spill-over benefits for other industries.

Existing investment activities

Although a range of research is underway to understand emissions and to develop systems and technologies that will reduce emissions, a great deal more work needs to be done.

The Australian Government, through programs such as the Greenhouse Action in Regional Australia program, has catalysed investment in a range of work to look at emissions in primary industries. This has helped deepen the understanding of Australia's national greenhouse gas inventory and led to the development of tools that include the National Carbon Accounting System. The now closed Cooperative Research Centre for Greenhouse Accounting made a significant contribution to the development of the national greenhouse gas inventory as well as industry-specific tools to understand emissions. A number of state governments have also recognised the role of primary industries in their greenhouse strategies and have been active in helping primary industries to understand and address emissions management.

Primary industries have recognised the challenge of emissions management and have begun to develop their knowledge on emissions from production systems through to the development of life-cycle assessment tools and systems. Work on life-cycle approaches has been done, or is currently being undertaken, for maize, canola, lupin, wheat, cotton and the beef and sheepmeat industries. The wine industry has embarked on work to examine emissions from its industry, in part to meet consumer demand for information on this premium product. The forestry industry has been undertaking work in this area for considerable time, including the application of International Standards Organisation (ISO) rules and United States protocols in developing life-cycle inventories.

A significant challenge still lies in the development of consistent protocols and reporting so that industries can share and compare information (for example, ensuring information on life-cycle assessment for feed grains is compatible and complementary with the intensive livestock industry).

Research being undertaken on an industry by industry basis includes work on methane emissions from lagoons, methane emissions from enteric fermentation, nitrous oxides from animal wastes, nitrous oxides from fertilisers, soil carbon, pyrolysis products from bioenergy production (including bio-char) and forestry sequestration. There are several projects looking at emissions and life-cycle assessments across the primary industries, and a small number of projects, such as the cotton industry's energy use calculation project, that can potentially be applied across a range of sectors.

Although work is being undertaken to develop management practices and technologies to reduce emissions, this research tends to be industry focussed. Collaborative cross-industry research could better realise the value from investment and share the information and technologies developed.

Areas for further investment

The research priorities of industries and regions relating to greenhouse gas emissions will vary depending on the risks and opportunities they face. Areas of research to be considered and addressed include:

- Collaborative research and consultation to develop baseline data, appropriate methodologies and standards for consistent emissions reporting (including life-cycle assessments) across industries, including the development of reliable, simple and agreed methods for modelling and verifying on-farm emissions.
- The development of collaborative research arrangements between industries to research common interests on understanding emissions and support emissions management and reduction (including: soil carbon, fuel and energy use, nitrous oxides from fertilisers, nitrous oxides from animal wastes, methane emissions from enteric fermentation, methane emissions from lagoons, methane emissions from anaerobic soils, pyrolysis products from bio-energy production and forestry sequestration).
- Research to underpin the development of best management practices on emissions management for primary production systems.
- Research into technologies and management to support low input, high production primary production systems, with collaborative arrangements between industries to research common interests (including improved nitrogen use efficiency in crops and pastures, improved fuel and energy use efficiency).
- Research (including economic research) and development of tools to support decision-making and understanding of the risks and opportunities from the management of greenhouse gas emissions.
- Research (including social and economic modelling) to identify the most appropriate policy instruments to reduce net emissions from the primary industries.
- Research on the implications for biodiversity and hydrology of managing agricultural lands for carbon sequestration at landscape and catchment scale.
- International collaborative research programs to ensure rapid transfer of knowledge and to avoid duplication of research.

Stakeholders identified the need to better understand emissions and develop consistent reporting to underpin life-cycle assessments as fundamental to informing emissions management in the primary industries, and to prepare industries for the introduction of the national emissions trading scheme.

Preparing Industries

Statement of need

Primary producers need to understand the implications of climate change on production systems (for example, quality and quantity of production) and regions, and determine how to respond. To do this, primary producers will need tools, technologies and alternative management systems and information about the appropriateness of practices and technologies under climate change scenarios.

Rationale for collaboration

Although management practices and technologies may be specific to particular industries, there are researchable topics with shared interests across industries. Research programs that will require ongoing attention and support under climate change include:

- breeding and selection programs (including the application of biotechnologies),
- management systems development,
- production system modelling,
- pest, disease and weed risk assessment and management,
- nutrient management,
- water use efficiency (including irrigation management), and
- salinity management.

Although the detail of these programs may be specific to industries there is an opportunity to share information on approaches, particularly if they operate in the same or similar regions. A number of collaborative research programs have been undertaken with co-investment in farming system related research (for example, Land, Water & Wool, Grain & Graze) and these collaborative investments may be models for future work to address climate change.

Existing investment activities

Primary industries have made a significant investment in the development of practices and technologies to help manage climate variability, and have undertaken research that directly and indirectly relates to climate change adaptability. Breeding and selection programs to increase drought tolerance, improved water use efficiency in crops and irrigation systems, and decision support systems to better manage drought are examples of research to manage climate variability that has relevance to climate change. Research investment to better manage variability and climate extremes is an appropriate strategy for addressing climate change, particularly given that regional Australia will experience climate change through extremes in variability as climate conditions shift.

Research has been undertaken to understand the implications of raised carbon dioxide concentrations on production systems, including the responses of wheat, forestry and pasture systems. Modelling has also been used to examine the implications of climate change on different industries, such as changes in production and distribution of the sheep industry and marine systems, and understanding fire risks. The dairy industry is researching how to increase its resilience to external shocks, as well as strategic options to respond to climate change and to understand climate risks. However, limited research investment has been undertaken to examine the direct impacts of climate change on production systems and increase preparedness of primary producers for change.

Areas for further investment

The risks and opportunities from climate change will vary from industry to industry and alter their research priorities. Climate change will influence primary production systems in a number of ways, including changes to carbon dioxide concentrations, temperature, moisture and seasonal conditions. Research will be required to understand these impacts and account for them, which should be built into existing research programs, where possible, to underpin the future productivity and profitability of primary industries. In addition to research already highlighted, areas of research to be considered and addressed include:

- Research and development to produce climate projections that are agreed at regional and industry level for use in communication and to underpin the negotiation and development of breeding and selection programs, biosecurity and production system research.
- Research (including economic and social research) and development to underpin tools to help primary producers understand the implications of climate change for different production systems and regions.
- Research (including economic and social research) and development to underpin the development of tools and communication packages to help primary producers make choices on adaptation strategies, including transitions to new production systems and industries, to underpin adaptation and build resilience.
- Ongoing research to support the development of production systems and management strategies for future climates.
- Collaborative research where production systems have similarities or use similar technologies including: biosecurity and pest, disease and weed management, nutrient management, water use efficiency (including irrigation management) and salinity management.

Stakeholders consistently identified the need for information to better understand the timeframe and implications of climate change at regional and industry levels to inform their response and the development of adaptation strategies.



Accessing Information

Statement of need

Primary producers need access to the best science available to be informed about the implications of climate change and emissions management in their enterprises and local communities. They need to understand the potential impact of climate change on production systems and be able to consider scenarios to which they may have to respond as well as know how to avoid mal-adaptations. There is a need to bring together available information and interpret and deliver it in ways that make it relevant and easy to access. This information should be nationally consistent, but tailored to sectors and regions as appropriate.

Rationale for collaboration

Without access to the credible and accurate information on climate change and the management of emissions, it is likely there will be delayed action, and increasing potential for confusion, misunderstanding and mal-adaptation. Many of the concepts underlying climate change and emissions management are similar for different industries. Information about soil carbon, farm forestry, bio-fuels and climate projections are some of the knowledge gaps identified by primary producers in different sectors. A number of stakeholders have recognised that these could be addressed through a collaborative communication program, delivering periodic updates on the current state of scientific knowledge. Encouraging awareness and discussion of these issues at sectoral and regional levels would help to drive the development of appropriate research questions, priorities and investment.

There is also a need for greater sharing of information on research underway. Without this information, it is difficult to determine what the current state of knowledge is, where further research investment might be required and if research is being duplicated.

Existing investment activities

The Australian Departments of Climate Change and Agriculture, Fisheries and Forestry carry some information on their websites regarding the impacts and management of climate change, and there are communication programs run by a number of state governments. Examples of state-based communication programs include regional workshops to discuss climate change projections, the implications for regional production systems undertaken by the New South Wales Department of Primary Industries, and the Government of South Australia's *Guide to Climate Change and Adaptation in Agriculture in South Australia*.

Apart from the communication activities described above, there are few easily identifiable and comprehensive sources of information on climate change for primary producers. The information that is available is fragmented and managed by researchers or the organisation that made the research investment. There are few consolidated lists of projects or reports available. The project information that can be accessed is highly variable, research is inconsistently described and, in a number of cases, relevant research was either over-emphasised or hidden within a broader research project.

Areas for further investment

- Establishment of an information hub (and/or hubs) to raise awareness about climate change issues, improve access to current research and existing communication material and facilitate interaction between primary industries.
- Review and publish research updates (including fact sheets) on the current state of knowledge regarding high profile issues (for example, soil carbon sequestration, carbon sequestration in forestry, climate change scenarios) and coordinate distribution amongst primary industries and general public.
- Research and review existing information to provide credible and accurate reports (including web-enabled information) about climate change and the management of emissions for different industries and regions.
- Invest in modernisation of databases such as Australian Agriculture and Natural Resources Online (AANRO) to provide easier access to information on climate change and emissions management related research.
- Develop and apply consistent meta-data to assist research investors and end users identify and report on research relevant to climate change and emissions management.
- Facilitate workshops and forums where climate change issues can be discussed within different primary industry sectors and regional communities.
- Invest in advocates and champions to raise awareness about climate change issues and facilitate primary producer involvement in decision-making processes.

Stakeholders involved in the research strategy consultation process strongly supported the establishment of information 'hubs' to provide credible and easy-to-find information relating to climate change and the management of emissions.



Facilitating Change

Statement of need

Change has always been an integral part of Australia's primary industries, and climate change impacts and the need to manage greenhouse gas emissions will be two drivers for continuing change within these sectors. To generate efficient change within primary industries, producers need the capacity to identify and assess the magnitude of potential vulnerabilities and opportunities, and access the tools and capability to make appropriate decisions.

Rationale for collaboration

There is a specific need to invest in research to understand and promote adoption of new and improved practices in primary industries. Changes in climate, and the drive to manage emissions, require increased rates of change and adoption of new practices and technologies. The traditional focus on win-win solutions to promote practice change by delivering production and environmental gains has been effective in the past but may not be as effective if efficiency gains are small or producer understanding of the issues is poor. These experiences and issues are common across primary industries.

Significant opportunities exist to learn from the successes of current programs in different sectors and industries. Opportunities also exist for investment in social, economic and policy research to assist in the development of tools and information packages that can empower primary producers and improve decision-making. There is scope to improve on current approaches and encourage research adoption through a collaborative program of social research to understand how practice change occurs in the primary industries. This has the potential to provide broad benefits across primary industries and improve adoption of research, encouraging flexibility within industries beyond the issue of climate change.

Existing investment activities

Traditionally, primary industries have relied on the extension and communication networks that have evolved over time. The development of industry groups and research programs to promote producer participation in research has also been encouraged. This has assisted the distribution of information and promoted the adoption of best practice to facilitate change in industries. State and territory governments, peak industry bodies and private consultants play key roles in this area, and have been effective in translating emerging science into knowledge and practices relevant to primary producers.

Some investments are being made to understand the needs of primary producers to adapt to climate change with specific work being undertaken by the Victorian Department of Primary Industries (in relation to both emissions trading and climate change) and the Bureau of Rural Sciences, which is examining social dimensions of farmer drought preparedness. State and federal governments are undertaking some research to underpin vulnerability assessments at regional and industry level.

The Australian Bureau of Agriculture and Resource Economics (ABARE) has ongoing programs of work looking at economic performance of the primary industries, and the federal and state governments have embarked on a range of investments to examine the vulnerability of regions to climate change. This type of research has the potential to provide information on regions or industries at particular risk that may need support to facilitate adaptation and change.

Areas for further investment

Work in this area could broadly benefit primary industries, as well as improving the adoption of research and encouraging flexibility within industries beyond the issue of climate change and the management of greenhouse gas emissions. Areas for research include:

- Research to explore the implications of different policy options, including market-based instruments, incentive programs and social programs.
- Research to understand the social and economic drivers of adaptation and practice change.
- Research and review into the effectiveness of existing extension programs to underpin their improvement, including work to identify and promote effective adaptation practices that have already been adopted on-farm.
- Collaborative research and consultation between industries and governments on vulnerability assessments.
- Research and monitoring to track and benchmark changes in practice that reduce emissions or have benefits for adaptation.
- Practices that have been developed and adopted by industries, independent of research investment by governments, that reduce emissions or have benefits for adaptation also need to be identified and encouraged.

Lack of information about how best to encourage industry understanding and drive practice change was identified by a number of stakeholders as a missing element to delivering efficient adaptation responses in primary industries.



Linking Decision Makers

Statement of need

It is essential that dialogue exists between researchers, policy makers and primary producers so that decisions by each party are aligned and address the challenges and opportunities of climate change, and do so within a practical industry context.

Rationale for collaboration

The absence of strong and coherent links between policy makers, industry and scientists is a substantial weakness in the current environment. Stakeholders have commented that without an understanding of the policy debate, timeframes and directions (particularly in the area of emissions trading) it is difficult for industries to develop and align their research priorities and drive significant research investment.

Linkages and discussion between policy makers, industry and scientists can assist the development of practical solutions to climate change and emissions management issues, as well as inform the development of research priorities, reduce duplication of research and inform debate at a broader level. Improved linkages can be built upon traditional science-policy connections through contracted research, and industry-science links through the rural RDCs and industry groups (e.g. Birchip Cropping Group, Kondinin Group).

Effective industry-science-policy links could be used to develop better informed and practical outcomes for both industry and policy. A key example of this is the complex and rapidly developing area of emissions management and emissions trading in which partnerships could be used to develop a more informed understanding of the issues and focus on the delivery of practical solutions to better manage greenhouse gas emissions.

Existing investment activities

Analysis of existing research shows that governments have invested in research to better understand the issues related to climate change. In some cases research to understand these issues has been undertaken in partnership by government and industries (for example, the Department of Climate Change's Greenhouse Action in Regional Agriculture program). State agencies are undertaking research to understand the implications of climate change for regional communities and industries (for example, the Victorian Department of Primary Industries' work examining the implications for climate change at regional and community levels, and work to inform institutional arrangements).

The National Climate Change Adaptation Research Facility being established at Griffith University will include industry aligned research networks (including agriculture and water resources) and will provide an opportunity to promote linkages between industry, researchers and policy makers.

Some industries are investing in research to inform policy (for example the Fisheries Research and Development Corporation is investing in research to examine alternative fisheries management strategies with the Australian Fisheries Management Authority), however, this type of joint industry and policy research partnership and investment is not widespread.

Areas for further investment

The significant challenges and opportunities faced collectively by decision makers in the primary industries means that there will be significant benefit from greater collaborative research investment and work. There are opportunities to develop and use forums, including conferences and workshops, to exchange information, encourage debate and clarify research questions and objectives. There are also opportunities to develop collaborative research investments in non-traditional areas for industry investment, such as economic, social and policy research, to better inform policy development and industry options.

The main issues for collaborative work between policy, researcher and industry stakeholders at regional and national levels include:

- Research on emissions management and trading (including legal frameworks to underpin trading systems and the treatment of offsets) and other policy instruments.
- Research to understand international and domestic trade implications from climate change and emissions management, particularly the implications of domestic and international policy decisions as well as direct and indirect trade impacts.
- Research to support policy to facilitate industry adaptation and adjustment.
- Examples of other areas where collaboration could occur include: water management, land use and change, drought policy, future labour requirements and environmental services.

Stakeholders involved in the research strategy consultation process consistently identified a need for partnerships between policy, industry and researchers to better align research and develop both informed policy and appropriate industry responses.





Conclusions

Climate change presents opportunities and challenges for primary industries and their regional communities. The National Climate Change Research Strategy for Primary Industries (CCRSPI) developed in response to these challenges highlights the opportunities for primary industries, research agencies and other stakeholders to work together on common issues, share available knowledge, and build capacity among their stakeholders to make the best possible decisions.

Primary industries and their component sectors have different knowledge gaps and research priorities. However, there are significant opportunities for industries to work together to reduce duplication of research and increase coordination of research investment. There are also opportunities to share knowledge and experiences across industries on climate change issues and build on the work that has already been done in Australia and internationally. Where there is relevance to Australian operating conditions there will be an ongoing need to develop and promote international linkages, particularly with the international climate research community.

In managing for climate change, it is important that primary producers take into account the inter-relationships between practices to manage the impacts of climate change, and those designed to manage greenhouse gas emissions. Adaptation to climate change and the mitigation of greenhouse gases are distinct, yet inter-dependent areas for action and investment. This inter-dependency is reflected in the six areas of investment presented in the research strategy.

The six areas are:

- 1 Understanding Future Climates (projected climate and seasonal climate)
- 2 Managing Emissions
- 3 Preparing Industries for Climate Change
- 4 Accessing Information
- 5 Facilitating Change
- 6 Linking Decision Makers

These six areas provide a significant opportunity for collaborative work between the rural RDCs, CSIRO, Bureau of Meteorology, Commonwealth and state government agencies, universities and others to address issues where there are significant common interests, particularly in regard to emissions research and management, linking decision makers and providing stakeholders with access to authoritative hubs for information and guidance.

The CCRSPI development process has established relationships and built momentum among primary industries, regions and research organisations to work together in addressing climate change. These relationships need to be maintained and developed so that information and lessons from the research strategy can be shared and joint research undertaken to address knowledge gaps.



Climate change is impacting on Australia's primary industries now. Organisations with responsibilities and interests in the success of Australia's primary industries need to act on this research strategy to ensure that their stakeholders are best equipped to deal with the opportunities and challenges that climate change presents.





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