REPORT TO
THE DEPARTMENT OF JOBS, PRECINCTS AND REGIONS
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SUPPORTING AGRICULTURE TO ADAPT TO CLIMATE CHANGE

STREAM 2: OPPORTUNITIES AND RISKS

FINAL REPORT

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EXECUTIVE SUMMARY

In April 2018, the Agriculture Ministers' Forum (AGMIN) agreed on the importance of ongoing cooperation between governments to support adaptation to climate change and managing emissions in agriculture. Ministers agreed to develop proposed actions and a work program to inform the development of a coordinated national approach to adaptation to climate change and managing emissions in the agricultural sector.

Ministers requested the preparation of advice providing an overview of climate scenarios and potential impacts; a stocktake of the current work being undertaken by jurisdictions on adaptation and managing emissions in agriculture; and the identification of risks and opportunities of climate change in agriculture. This work will provide input to jurisdictions in considering actions and a work program to support a coordinated national approach.

Stream 1 provided an overview of potential climate change scenarios and impacts; a description of current work on managing emissions; and a stocktake of approaches to adaptation across jurisdictions.

This paper is the second step in the process and provides an analysis of the opportunities and risks for agricultural industries arising from climate change. Subsequent work will propose options for actions (in response to the opportunities and risks) which could be considered as part of a work program for a coordinated national approach to support the agricultural sector adapt to climate change.

Consultation

A stakeholder consultation process was undertaken to ensure stakeholders' views on opportunities and risks were captured. Stakeholders were identified in collaboration with all jurisdictions. Stakeholder input was sought through workshops, interviews and written input. The considerable effort of stakeholders to provide input into the process was much appreciated, particularly in view of the tight timeframes for the project and the period over which consultations were held. The views gathered through the consultation process are a primary input into the analysis of the opportunities and risks.

Methodology

A wide array of cross-cutting issues were identified from engagement with stakeholders and jurisdictions. All are important and warrant consideration in the analysis of opportunities and risks. The first step of the analysis involved using a PESTLE framework as an initial classification for each issue from the consultations.[1]

[1] PESTLE stands for political, economic, social, technological, legal and environmental.

Opportunities and Risks

Table ES 1 shows the outcomes of the qualitative assessment of issues, grouping them into high level themes, incorporating both opportunity and risks elements into each. The assessment process considered:

— the extent to which the opportunity or risk was relevant and applied across geographic regions; and

— the extent to which the opportunity or risk was relevant and applied across a range of agricultural commodities.

Some themes have both significant opportunities and risks, while others are predominantly one or the other.

TABLE ES 1 KEY THEMES

Theme
Coordination, collaboration and governance of climate change responses
Driving productivity and profitability of agricultural production through research and innovation (R&I)
Climate policy certainty
Value-adding along the supply chain
Financial instruments and tax incentives to address climate change
Social cohesion of rural communities and individuals
Land use planning, competition and management
Climate change impact on water policy
Leadership and coordination in the provision of climate data
Biosecurity
Infrastructure planning and investment

SOURCE: ACIL ALLEN CONSULTING

Each theme (and its opportunity and risk elements) was analysed in terms of its relevance to the concepts of resilience, adaptation and mitigation; linkages to broader policy considerations; and responsibilities and timeframes for actions to address the issues raised.

Coordination and collaboration: A coordinated and enduring regulatory and policy framework that is farmer focused, is essential to manage the risks inherent to the sector (including risks stemming from climate change and extreme weather). Such an approach would need to recognise the diversity in agricultural systems across Australia, the considerable differences between regions and commodities, and ensure that farmers, commodity sectors and communities are able to take advantage of the opportunities to adjust and adapt.

Stakeholders also made it clear that such coordination meant a drawing together and integration of otherwise discrete policies and programs. From a farmer's perspective, long-term stability in the settings for energy policy; water availability and security; drought policy; biodiversity and biosecurity programs; agricultural R&I coupled with deployment initiatives; effective water and carbon markets; and emissions reduction commitments, are fundamental to the sector's willingness and ability to make long-term investments in adaptation and emissions management.

Adaptive responses that deliver incremental adjustment, such as changing crop variety between seasons, are relatively low cost but unlikely to deliver the quantum of adaptation necessary in the long-term. More substantive and transformative responses such as consolidating enterprises; moving to other commodities or markets; shifting the enterprise to a different climatic location; or diversifying into other businesses, require significant capital investment and longer lead times.

R&I: The long-term viability of components of the agricultural sector are at risk in the absence of adaptation responses that deliver a step change in the levels of productivity. Innovative, new research activity focused on transformational changes, is required. Consideration of the overall R&I system indicates the scope to provide greater coherence in direction, stability of ongoing funding, and a

stronger focus on delivery at the regional and farm level. Improved coordination between the institutions, companies and scientific communities engaged in agricultural climate adaptation research, development and innovation programs would deliver better outcomes.

Stakeholders consider that farmers' needs are not adequately targeted and highlighted the importance of their engagement in the development of R&I policy and programs addressing climate change.

Climate policy certainty: The lack of a consistent long-term policy on climate change has created a stop-start approach to measures to manage emissions and the impacts of climate change. Stakeholders perceive that the uncertainty that pervades policy in this area has hampered longer term thinking and action by the sector. This has reduced the willingness of industry, markets and governments to make investments in long lived infrastructure or land use changes to help mitigate climate change due to the uncertainty around whether policies will remain in place long enough to deliver a positive return on investment (ROI).

A long-term, stable policy on climate change would provide the agricultural sector with greater confidence to invest in developing and implementing measures to both manage emissions and adapt to the impacts of climate change. It would also provide a stable framework for programs that provide support to the sector to make those investments.

Supply chains: Stakeholders saw an opportunity to build on Australia's reputation for clean, green products. If agricultural emissions are curbed, coupled with appropriate marketing, Australian agricultural products would be well positioned to obtain a premium in the marketplace. Stakeholders identified that action is required to facilitate this opportunity and to also address possible disruptions to the supply chain arising from climate change.

Financial instruments: A lack of financial instruments and tax incentives were seen as hampering investments to adapt to the impacts of climate change and manage emissions and risk. Many forms of adaptation require farmers to make significant upfront, long-term capital investments that have greater than normal periods for a ROI. Tax measures and other incentives can encourage capital investment in infrastructure and resources (e.g. fodder reserves) which can be called upon in times of stress (e.g. drought). Transformational adaptation or recovery from extreme weather events may not be possible under current settings owing to the significant upfront capital investments required.

It was seen that in order to drive decisions and investments by farmers on emissions mitigation, clearer signals on carbon price, offsets and sequestration were required, together with clarity around emissions policy and impacts on agriculture. A clearer market signal on carbon price could be facilitated by governments articulating a set of specific goals for adaptation and emissions management. This could be complemented by establishing mechanisms for trading in carbon credits by the not-for-profit or private sector as well as governments.

Social cohesion: Stakeholders noted that the movement of agricultural production to more suitable climatic zones, enterprise consolidation, and the increased frequency of local and regional extreme weather events, will impact on rural and regional communities and individual farmers. There were expected to be economic and social effects and impacts on the viability of a number of rural townships and regional centres (especially those which are solely or primarily reliant on agriculture as the key economic driver). Stakeholders observed that this could occur incrementally or rapidly, particularly if a locality experiences several extreme weather events over a short period leaving little time to adjust or recover. The long-term impacts could be profound and include significant social and economic costs.

Land use: Stakeholders observed that agricultural producers may expand their areas of operation to allow for the possibility that the region(s) they are currently operating in may become less productive or suitable for their agricultural activities over time. This could lead to land use conflicts. A reduction in the land available for agricultural uses could reduce the ability of farmers to adapt to the impacts of climate change.

Water policy: The agricultural sector needs to plan for and manage periods where there is not reliable access to a known quality of water. For non-irrigated enterprises, on-farm water resource management (e.g. better farm management practices to improve the water holding capacity of the land and investment in efficient irrigation practices) is key, and water quality and the availability of 'safe' water resources for livestock is vital.

Stakeholders observed that there is likely to be increasing competition for scarce and highly variable water supplies between agricultural commodities and communities, which could lead to an increased price for water, structural adjustment and dislocation of communities.

Climate data: Access to a robust, reliable, consistent, single source of climate modelling and projections at a national, regional and local scale, that are regularly updated and further developed, was seen as necessary to underpin actions. Quality projections would facilitate emissions management at the farm level. Improved projections data may also inform decisions about on-farm mitigation measures and investment, while its absence may lead to ill-advised decisions.

This information was seen as essential to underpin research, development, innovation and deployment of adaptive responses in the agricultural sector and elsewhere, and for mitigation. This capability in climate systems and forecasting could be drawn together and provided through national leadership. The private sector would then be able to develop the tools and provide the commercial application systems and services that are needed by the agricultural sector.

Biosecurity: Stakeholders identified that increases in the prevalence of pests and diseases could lead to reduced yields and/or reduced income for agricultural producers. Pests and diseases were also seen as having the potential to destroy much of the asset value related to carbon offsets. While biosecurity threats arising from climate change include incursions from overseas, the main threat was seen as species migration from neighbouring regions within Australia.

Infrastructure: Stakeholders raised increased planning for, and investment in, infrastructure would help to reduce the potential disruption caused by the impacts of climate change. Additional infrastructure may be needed to ensure that emergency services have the capacity to respond in a timely fashion to increasingly frequent extreme weather events. A failure to plan for, and invest in, infrastructure will increase the risk of agricultural activities being disrupted, resulting in reduced earnings for farmers and a loss of resilience. Key areas for infrastructure investment need to be identified.

Next steps

The analysis will feed into Stream 3. Stream 1 and Stream 2 have served to identify the underlying issues and explore the opportunities and risks that climate change presents to the agricultural sector. Stream 3 will consider options to take advantage of the opportunities and to address the risks. These could form the basis of a work program for a coordinated national approach to support the agricultural sector adapt to climate change and manage emissions.

GLOSSARY OF TERMS

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AGMIN	Agriculture Ministers' Forum
AGSOC	The Agriculture Senior Officials' Committee (AGSOC) comprising department heads and CEOs of Australian/State/Territory and New Zealand Government agencies responsible for primary industries policy issues
AgVet	agricultural and veterinary (AgVet) chemicals
BoM	Bureau of Meteorology
CH_4	methane
CMA	Catchment Management Authority
COAG	Council of Australian Governments
CO_2	carbon dioxide
CRSPI	Climate Research Strategy for Primary Industries (formerly the Climate Change Research Strategy for Primary Industries (CCRSPI))
CSF	Climate Solutions Fund (formerly the Emissions Reduction Fund (ERF))
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ERF	Emissions Reduction Fund
GHG	greenhouse gases
GPS guidance	Global Positioning Satellite (GPS) guidance
IPCC	Intergovernmental Panel on Climate Change
KPIs	key performance indicators
MLA	Meat and Livestock Australia
MDB	Murray-Darling Basin

NCCARF	National Climate Change Adaptation Research Facility
NH_4	ammonium
NOx	nitrous oxides
NRM	Natural Resource Management (NRM) regions
NSWFA	New South Wales Farmers' Association
N_2O	nitrogen dioxide
Paris Agreement	The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change, dealing with greenhouse gas emissions mitigation, adaptation, and finance, signed in 2016
PESTLE framework	PESTLE analysis/framework is an analytical tool for strategic business planning. PESTLE categorises the 'Political, Economic, Social, Technological, Legal and Environmental' environments to be considered
ROI	return on investment
Rural RDC(s)	Rural Research and Development Corporation(s)
R&D	research and development
R&I	research and innovation
tCO_2-e	tonnes of carbon dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States dollar

1 INTRODUCTION

This chapter provides a brief introduction to the overall project, outlining its context and broad goals and its three component parts. It provides a brief summary of the Stream 1 outcomes and outlines the objectives and structure of the Stream 2 work and its role in the total project.

1.1 Background

On 27 April 2018, the Agriculture Ministers' Forum (AGMIN) meeting agreed on the importance of ongoing cooperation between the Australian, state and territory governments to support adaptation to climate change and in managing agricultural emissions.

The project focuses on the necessary work to support officials in their preparation of a paper for consideration by AGMIN. The work is divided into three work streams as shown in Figure 1.1.

- **Stream 1**: Understanding climate scenarios and a stocktake of current approaches.
- **Stream 2**: Analysis of opportunities and risks of climate change for agricultural industries.
- **Stream 3**: Identification of options for consideration in preparing advice on actions and a work program that could inform the development of a national strategy for adaptation to climate change and emissions management in agriculture.

FIGURE 1.1 WORK STREAMS RESPONDING TO AGMIN'S REQUEST

SOURCE: ACIL ALLEN CONSULTING

Ministers have requested the development of proposed actions and a work program for a coordinated national approach to support the agricultural sector adapt to climate change. These actions and work program could form the basis of a national strategy. The work will identify options for actions to implement to achieve the desired outcomes.

1.2 Summary of Stream 1

Stream 1 provided an overview of potential climate change scenarios and impacts over time, and a stocktake of approaches and work on adaptation and managing emissions in the agricultural sector across jurisdictions.

Agriculture continues to be a vital component of the social and economic structure of jurisdictions across Australia. It is the major economic driver of regional and rural communities. Australia is a world leading producer and exporter of many agricultural commodities, with agricultural exports showing a continuing growth trend over the past five years.

The Bureau of Meteorology (BoM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) have developed detailed climate projections for Australia as a whole and regionally. Projections are provided for modelled climate variables (e.g. temperature, rainfall, wind) and derived variables (e.g. indices of climatic extremes, fire weather, soil moisture). In the short-term the impact from extreme weather events and fluctuations in climatic conditions (e.g. severe/prolonged drought), rather than the underlying climate signal (increases in temperature and declines in rainfall), will generate the most impact for the majority of commodities.

The modelling provides insights as to potential climatic conditions out to 2090, but beyond 2030 the scenario pathways diverge quite strongly and there is considerably greater uncertainty. Stream 1 examined the impacts of climate change on nine key agricultural commodities. By 2030, the potential impact on most of the sectors examined is significant, as the analysis points to a significant decline in productivity. Beyond 2030, the impacts (in the absence of concerted action) are likely to be more severe, with an acceleration in productivity and economic losses being the norm for most commodities.

The combination of potential production and yield declines, coupled with rising production costs (as inputs such as water become scarce and more expensive), results in a range of outcomes (some positive, others negative) spread across both commodities and jurisdictions. Economic impacts are likely to become more marked beyond 2030.

The work also included a stocktake of current work and approaches to adaptation and managing emissions in agriculture, which considers recently completed, current and planned work in each jurisdiction.

1.3 Drivers and objectives of Stream 2

Climate change presents both opportunities and risks to the agricultural sector. Stream 2 considers these within the broader context of the many factors influencing decision making. While the work is focused 'on-farm', Stream 2 also identifies opportunities beyond the farm gate.

The Stream 1 analysis identified a wide range of issues and learnings which formed the starting point for the Stream 2 work. A thorough analysis of the relevant literature, strategies and programs was conducted to identify opportunities and risks. Commentary from jurisdictions on the Stream 1 analysis served to both verify and build consensus around key issues and to identify matters for further consideration in Stream 2. The issues identified as part of the Stream 1 work are listed in Appendix A.

The Stream 2 analysis of opportunities and risks will inform the identification of options for potential actions and a possible work program to be developed as part of the Stream 3.

2 DEFINITIONS AND METHODOLOGY

This chapter identifies the key parameters used for the analysis in Stream 2 and describes the analytical approach adopted. It summarises the findings of that analysis and introduces the discussion that follows in Chapter 3.

2.1 Stakeholder consultation

To ensure stakeholders' views on opportunities and risks were properly captured, a stakeholder consultation process was undertaken with the following objectives:

- to build ownership of, and support for, the project and to inform AGMIN's deliberations regarding development of a coordinated national approach
- to source the necessary information and views from stakeholders required to complete the project, and in particular, to capture their views in relation to opportunities and risks
- to review and test the findings of the analysis with jurisdictions and stakeholders to ensure that the outcomes are valid and supported.

Stakeholders were identified in collaboration with all jurisdictions. Stakeholder input was sought through three main channels - workshops, interviews and written input. The considerable effort of stakeholders to provide input into the process was much appreciated, particularly in view of the tight timeframes for the project and the period over which consultations were held.

The views on opportunities and risks gathered through the consultation process (at Appendix A) are the basis of the analysis below.

2.2 Framework and definitions

The breadth of issues raised during stakeholder consultations, in discussions with each jurisdiction and through desktop research, highlights a number of factors that will affect adaptation and emissions management by the agricultural sector. These include factors such as environmental change, economic development, science and technology, regulation, competition, international treaties, individual commodities and political/agro-ecological geographic units. Each is important and needs to be considered in a way that effectively articulates both the national interest and public benefits, to ensure that AGMIN is well placed to make informed decisions as to the elements which might best contribute to a national approach.

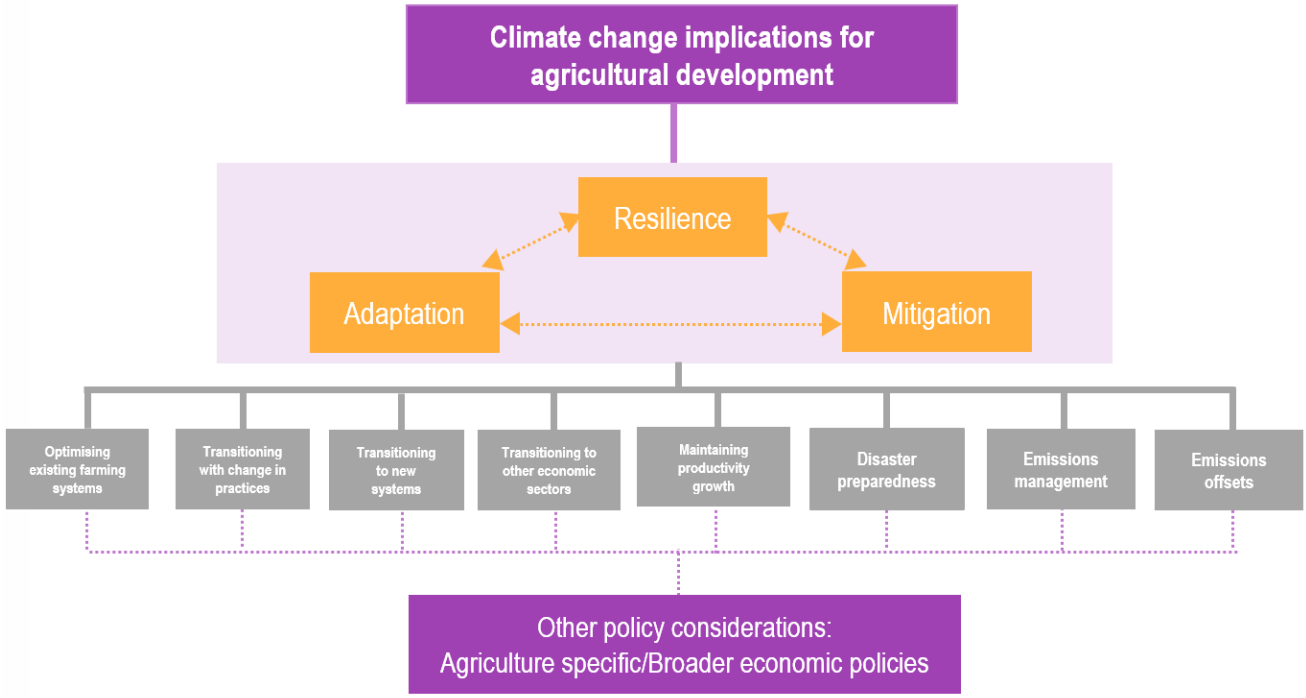
2.2.1 Framework for integrating climate change and agriculture

Three overarching concepts have been used to help frame the analysis, namely resilience, adaptation and mitigation. While there are strong interlinkages between the three, each warrants individual consideration. Figure 2.1 looks to capture these interdependencies, in addition to the linkages with

broader policy settings. While resilience is in part a unifying concept between adaptation and mitigation as well as other agricultural trends and policies, it also embraces issues which go beyond the definitions of adaptation and mitigation (e.g. leadership, governance, responding to extreme events, etc.). There are a number of issues which apply to all three concepts (e.g. R&I). The three concepts and their definitions are explored further in Section 2.2.2.

The key advantage of the framework (illustrated in Figure 2.1) is that it provides sufficient granularity to break down opportunities and risks to a meaningful level, while creating a structure that integrates the available evidence, consistent with both climate change and agricultural development principles.

FIGURE 2.1 STREAM 2 FRAMEWORK



SOURCE: ACIL ALLEN CONSULTING

Wider policy considerations

The framework shows the interrelationships between the central tenet of this work (climate change implications for the agricultural sector) within the broader policy framework. These connections run in both directions. For example:

— Policy settings not directly related to agriculture, such as employment, energy, immigration, community development and social security, are all likely to impact in some way on agriculture's ability to adapt to climate change. For instance, social security policy will be relevant to the agricultural community in times of natural disaster.

— Policy considerations/settings developed in relation to agriculture will inform the broader policy stance in a range of areas. For instance, changes in casual or seasonal labour requirements for agriculture arising from climate change may inform immigration policy; and changes in water use by agriculture may influence broader water policy considerations.

While the linkages with broader policy settings are considered, the work focuses on the opportunities and risks arising from climate change that directly affect the sector. Nevertheless, actions by industry and government to address climate change could have linkages to a range of policy measures in other areas, such as:

— broader agriculture policy

- broader climate policy settings particularly policies relating to offsets; economy wide emissions targets approaches to modelling the impact of climate change; and carbon farming
- drought, natural disasters and emergency preparedness and response policies/mechanisms for dealing with extreme events
- policies in support of research and development (R&D) generally, and in particular, rural R&I
- water policy and competition between different economic sectors
- national biosecurity strategies and programs
- broader environmental policy settings, including policies on ecosystems services
- land use and land clearing policies
- energy, transport and infrastructure development policies
- economic, taxation and fiscal policy; investment policies; and the banking and finance industry
- foreign affairs and trade policies
- social security policy and welfare safety net provisions; and health policy.

While these interrelationships generate challenges and complexity, they also provide an opportunity to facilitate the implementation of measures to support productivity and profitability as they allow for the creation of broader benefits. However, inaction in addressing the risks to the agricultural sector posed by climate change could have deleterious impacts on all these policy areas.

When designing actions and a work program for a national strategy for adaptation to climate change and emissions management in agriculture, it will be vital to acknowledge these linkages.

Linkages to Intergovernmental Agreements

There are a number of detailed commitments of the Council of Australian Governments (COAG) set out in various intergovernmental agreements or statements of cooperation which closely relate to climate change and agriculture.[2] These include the:

- Intergovernmental Agreement on Biosecurity - 3 January 2019
- National Drought Agreement - 12 December 2018
- Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin - 28 April 2017
- COAG Select Council on Climate Change, Agreement on Roles and Responsibilities for Climate Change Adaptation in Australia - 4 May 2012
- Intergovernmental Agreement on the Environment - May 1992.

2.2.2 Definitions

Opportunities and risks

Opportunities and risks can be simply defined as:

- **Opportunities**: - Opportunities encompass both circumstances and actions where the agricultural sector can improve its position (in economic and/or social terms), compared to the current position, through actions to offset the deleterious impact of climate change.
- **Risk**: - The exposure of someone or something valued to danger, harm, or loss. For the purposes of the Stream 2 work, risk focuses on the loss or threat of loss arising from climate change and covers both economic and social losses.

While simple definitions are attractive, the reality is far more complex. What actually constitutes an opportunity or risk is highly contingent on one's point of view, and there is considerable interplay between the two. In many cases they can be inter-changeable depending upon a stakeholder's perspective. For example, in marginal cropping lands the drying effect may result in some farms becoming uneconomic - those farmers will perceive this as a significant risk. However, others may see

[2] COAG level agreements make clear that the outcomes have head of government support and have greater currency and force than ministerial reports and communiqué text which may not always contain detailed policy and/or operational matters.

it as an opportunity to maintain their viability through consolidating land holdings to enable them to reap the benefits of operating at a scale appropriate to the new rainfall/soil moisture regimes.

Furthermore, realising some opportunities may also bring or exacerbate risks. For example, the sale of water rights (which may increase in value as water availability declines) could lead to land use changes, declining investment in irrigation asset maintenance and ultimately a loss of scale/viability for the remaining farmers. This may well impact regional commodity viability and lead to changes in growing areas (with possible land use competition).

Resilience, adaptation and mitigation

Table 2.1 sets out the definitions adopted for various terms used in this report.

TABLE 2.1 DEFINITIONS: RESILIENCE; ADAPTATION; MITIGATION

Term	Definition	How it differs from the other terms	How it interplays with the other terms
Resilience	Ability of a system to anticipate, absorb, accommodate, or recover from one off or ongoing events.	Describes existing capacity of a system or entity to manage changes in circumstances.	Greater resilience will enable agriculture to adapt more readily to the impacts of climate change and minimise the impact of emissions management actions.
Adaptation	The process of adjustment to climate change effects by moderating the negative impacts and/or enhancing the positive impacts of climate change.	Describes how changes to the existing conditions of a system or entity can be made to prepare for, or respond to, an external influence.	Adaptation actions may offset or complement emissions management and make the sector more resilient to climate change impacts.
Mitigation	Actions that reduce emissions associated with climate change.	Describes how changing the impact of a component of a system or entity affects the whole system/entity.	Mitigation may make it easier for the sector to adapt to climate change, which can in turn boost resilience.

SOURCE: ACIL ALLEN CONSULTING, S. FANKHAUSER, 2017, ADAPTATION TO CLIMATE CHANGE, ANNUAL REVIEW OF RESOURCE ECONOMICS 9: 209-30, INTERGOVERNMENTAL PANEL OF CLIMATE CHANGE (IPCC)

Resilience, together with market failure, underpins policy relating to natural hazards and agriculture across Australia. That is, resilience embraces both the ability to deal with the impacts of change (e.g. reduce negative impacts of climate change on agricultural economic growth), as well as the capacity to recover quickly from external pressures (e.g. preparedness for, and recovery from, extreme weather events and natural hazards).

2.3 Methodology

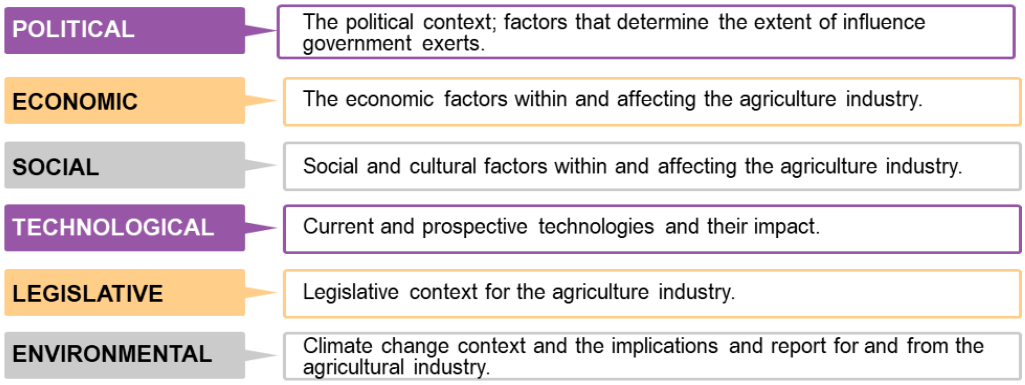
Stakeholder workshop consultations, one on one interviews, written submissions and issues identified from the Stream 1 work, comprise the inputs used to assess opportunities and risks. A staged approach was adopted in which the overarching objective was to identify and detail key cross-cutting themes that encompassed the opportunities and risks identified.

The format of the consultations facilitated this composition. Whilst each jurisdictional workshop had its own context and 'starting points', cross-cutting themes could be consolidated without losing the individual components. The process was iterative, and themes were not identified pre-emptively, but rather discovered as the input was explored and analysed. The process of distillation and refinement meant that elements were not missed, as there were no pre-defined outcomes.

2.3.1 PESTLE framework

The acronym PESTLE stands for 'Political, Economic, Social, Technological, Legal and Environmental'. The approach (PESTLE analysis) is generally used as an analytical tool for strategic planning purposes. The PESTLE framework enables a better understanding of the impact of external influences on a business (e.g. the impact of climate change on the agricultural sector). By understanding the external environment organisations can maximise the opportunities and minimise the threats to the sector. The framework is outlined in Figure 2.2.

FIGURE 2.2 PESTLE FRAMEWORK



SOURCE: ACIL ALLEN CONSULTING

2.3.2 Qualitative assessment

The PESTLE framework was initially used to classify issues raised during consultations. While this provided the initial delineation, issues could apply to several classifications. The framework was used to fracture the information from its original jurisdictional split but did not impose other constraints.

Based on a qualitative assessment, the issues identified were grouped into eleven high level themes which incorporated both opportunity and risk elements. The assessment process considered:

— the extent to which the theme and its inherent opportunities and risks was relevant and applied across geographic regions (e.g. was it applicable across both multiple jurisdictions and ecological zones); and

— the extent to which the theme was relevant and applied across a range of agricultural commodities (e.g. all commodities will face biosecurity risks of one form or another, whereas irrigation water shortages will only impact on those agricultural commodities reliant on irrigation).

The identification of the opportunities and risks involved understanding the comments raised and consideration of regional/commodity distinctions. For example, the change in weather patterns may increase the area of arid land in South Australia, whereas in New South Wales it may result in land use competition between commodities. Both of these issues relate to the 'Land use competition and planning' theme. Table 2.2 shows the outcomes of the qualitative assessment. Some themes present as affording both significant opportunities and risks, while others are predominantly one or the other.

TABLE 2.2 KEY THEMES

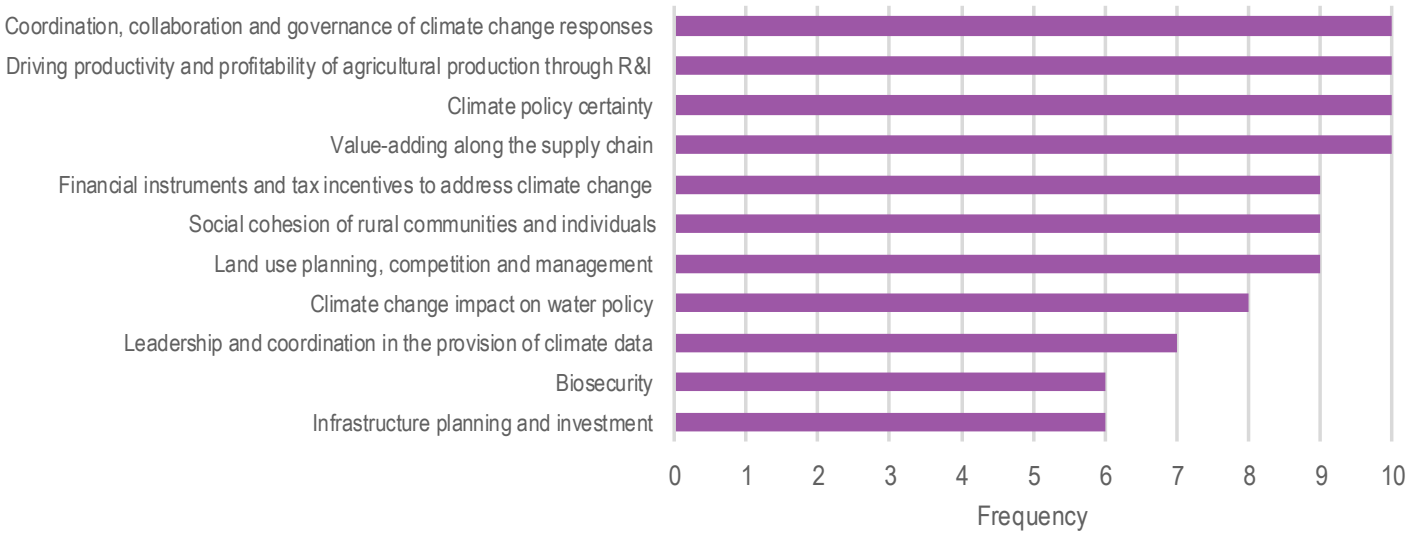
Theme
Coordination, collaboration and governance of climate change responses
Driving productivity and profitability of agricultural production through R&I
Climate policy certainty
Value-adding along the supply chain
Financial instruments and tax incentives to address climate change
Social cohesion of rural communities and individuals
Land use planning, competition and management
Climate change impact on water policy
Leadership and coordination in the provision of climate data
Biosecurity
Infrastructure planning and investment

SOURCE: ACIL ALLEN CONSULTING

2.3.3 Theme ordering

The themes are ordered according to the frequency of identification through the jurisdictional workshops, interviews and research (which provides a score out of ten) as shown at Figure 2.3. All themes carry both an opportunity and a risk, albeit to differing degrees.

FIGURE 2.3 FREQUENCY OF STAKEHOLDER RESPONSES



SOURCE: ACIL ALLEN CONSULTING

As shown in the figure, the results are quite clustered, meaning that many themes were mentioned across most jurisdictional workshops, interviews and research. However, even the themes mentioned less frequently are significant.

The above order dictates the sequence in which each theme is elaborated upon in Chapter 3.

2.3.4 Public benefits

The final component of the analysis is the application of a public/private benefits test which is applied to the themes discussed in Chapter 3. This is used to differentiate between the themes and their opportunities and risks with regard to those:

- where government might lead (and fund) action
- where there is joint responsibility
- which clearly fall to industry to lead and fund (or co-fund).

Doing this test sequentially highlights the areas where industry can play an integral or leadership role. It also shows the linkages and potential partnership opportunities across government, industry and others to collectively address climate challenge.

3 CROSS-CUTTING THEMES

Chapter 3 provides a short synopsis and qualitative analysis on each theme addressing both the opportunity and risk aspects embodied in each. While it explores responsibilities and possible timeframes for action, these are only indicative and will need to be informed more accurately through the development of detailed actions and work plans, and interjurisdictional discussion and agreement.

3.1 Overview of themes

Table 3.1 shows the outcomes of the qualitative analysis. Some themes present as affording both significant opportunities and risks, while others are predominantly one or the other. The analysis involved the rolling up of a number of like issues under a common theme. For example, a significant number of like opportunities and risks were identified in relation to policy certainty – these are 'bundled' under the single 'Climate change policy certainty' theme shown in Table 3.1 below.

TABLE 3.1 OVERVIEW OF KEY THEMES

Theme	Description	PESTLE category
Coordination, collaboration and governance of climate change responses between industry and government	The Australian, state and territory governments, agricultural industries and research organisations are engaged in activities to support adaptation to the impacts of climate change and in managing emissions. However, these parties often have different goals, objectives and priorities and there is a lack of coordination of the efforts being made. This may reflect industry, regional or climatic differences. However, it increases the potential for significant duplication and fragmentation of responses and may limit each jurisdictions' ability to agree on, and/or meet, common climate adaptation or mitigation objectives. An opportunity exists to improve coordination and collaboration. For example, through improved governance arrangements between jurisdictions in relation to offset mechanisms; climate projections and data; rural research, development and deployment, and responses to extreme weather events.	**Political** Technological Legislative
Driving productivity and profitability of agricultural production through R&I	Climate change impacts, particularly increased temperatures and reduced rainfall, will increase scarcity and probably the cost of inputs such as water, and reduce agricultural yields and production. Coupled with increased climate variability and extreme weather events, increased input costs will put pressure on overall farm profitability. Innovation and technological improvements are important mechanisms to support adaptation to climate change impacts and emissions management. R&I programs can create opportunities for new or improved farming operations. To address the risks, nationally coordinated R&I (see discussion of first theme above) and locally delivered deployment is essential.	**Technological** Political Economic
Climate policy certainty	Australia does not have a consistent national climate change policy framework. The resultant policy uncertainty has been a disincentive to industry, markets and governments to reduce carbon emissions. Support for an enduring national climate policy and associated programs will provide industry, markets and governments with the confidence to make the investments needed to adapt to the impacts of climate change and manage emissions and contribute to meeting Australia's commitments under the Paris Agreement.	**Political** Legislative

Theme	Description	PESTLE category
Value-adding along the supply chain	The impacts of climate change can create value capture opportunities along the agricultural supply chain. Such opportunities may include access to new markets, price premiums, and new product opportunities based on supplying goods and services that can be differentiated on the basis of their impact on emissions or climate change. Social license to operate themes can potentially also be addressed along the supply chain and provide market opportunities.	**Economic**
Financial instruments and tax incentives to address climate change	There is a lack of market signals or incentives for emissions reduction. The range of mechanisms in play needs to be expanded to ensure that the market rewards those who act on climate change. The adoption of on-farm adaptation and mitigation mechanisms can be limited by the substantial capital required for implementation. Mechanisms to bridge this gap would encourage action. The lack of appropriate signals has constrained the uptake of financial instruments such as carbon offsets or infrastructure investments designed to manage emissions. The right market signals through well designed and enduring policy instruments (stakeholders have suggested this could include a carbon tax) could encourage investment in offset markets, ecosystem services and natural capital. Similarly, financial instruments such as insurance are potential risk management tools to support adaptation and build resilience.	**Political** **Economic** Legislative
Social cohesion of rural communities and individuals	The impacts of climate change, particularly extreme weather events (such as floods or storms), fires and droughts will disrupt the social fabric of rural communities. This has the potential to create economic, health, welfare and emotional hardship. Strong community cohesion in the face of adversity is a significant factor in recovery. Responding to more frequent extreme events will require investment by governments (e.g. in firefighting equipment, health and social services). Local champions can be vital in driving innovation and adaptation measures, with governments providing information and setting an example.	**Social** Economic Political
Land use planning, competition and management	Climate change impacts will influence the availability and viability of agricultural lands. The increased scarcity of productive agricultural land could increase tensions between current landholders and industry or commodity sectors; new industries; and the community which might prioritise different land uses. There is a risk that agricultural land will become less viable and be used for non-agricultural purposes. There is the potential for land use tensions between food and fibre production and climate change mitigation, such as carbon sequestration and renewable energy production. Alternatively, the changed climatic conditions could encourage new agricultural industries to emerge; changes to existing farm operations (e.g. to incorporate farm forestry to diversify/boost income); and existing operations to migrate to areas with more amenable conditions. There is also the opportunity to boost natural capital through improved natural resource management practices. These impacts will differ greatly between regions and industries.	**Economic** Social
Climate change impact on water policy	The impacts of climate change are expected to reduce water availability in general and increase variability of water supply as a result of extreme weather events and extended dry periods. This will add additional complexity to water management policy across jurisdictions, water catchments, competing agricultural industries, and for government. It is expected there will be increased water scarcity which flow through to increases in the cost of water. In some cases, existing regional water infrastructure is considered inadequate or at risk of not meeting future needs of industry, society and the environment. The transfer of water allocations to higher value uses may lead to stranded irrigation assets. Some stakeholders see the need for better and more information about water resources, including ground water.	**Political** Economic Social Technological Environmental
Leadership and coordination in the provision of climate data	National leadership and coordination of climate modelling and projections to ensure both consistency and robustness of projections, facilitating on-farm use and consistent messaging to industry, government, research organisations and the market. There should be a particular focus on extreme weather forecasting and projections. Data availability (access) and analytics used to drive decision making have potential benefits for adaptation and mitigation at the policy, research and on-farm level.	**Technological** **Political**
Biosecurity	The impacts of climate change will increase the pressure on the biosecurity system, both at the national and on-farm level. The projected increase in air temperatures and rainfall variability will change the distribution of agricultural pests and diseases across the country. This will impact agricultural productivity and profitability.	**Environmental** Economic Technological

Theme	Description	PESTLE category
Infrastructure planning and investment	The projected impacts of climate change, such as increased extreme weather events, the severity of droughts, and more frequent, intense fires, will have significant implications for regional water infrastructure and on-farm infrastructure. The increased frequency of floods and periods of drought may require assessment of the capacity and capability of infrastructure to meet the current and future needs of regions. There can be significant farm-level capital costs in building resilience, introducing adaptation measures and in managing emissions. However, there is the potential opportunity for new agricultural industries/activities and abatement actions (e.g. regeneration and farm forestry) to mitigate some of the impacts of extreme weather events. These aspects will need to be reflected in the planning and investment processes of industry and government.	**Technological** Economic

Notes: The primary PESTLE category is in bold
SOURCE: ACIL ALLEN CONSULTING

The sections that follow discuss each of the themes in the above table in more detail. Each section describes the theme, identifies the key opportunities and risks, and discusses the timeframes and responsibilities for possible action.

3.2 Coordination, collaboration and governance of climate change responses

3.2.1 Theme description

Governments, agricultural industries and research organisations are all engaged in activities to support adaptation to the impacts of climate change and manage emissions. However, these parties often have different goals, objectives and priorities, and there is a lack of coordination of the efforts being undertaken. While this may reflect industry, regional or climatic differences, it increases the potential for significant duplication and fragmentation of responses and may limit each jurisdiction's ability to agree on, and/or meet, common climate adaptation or mitigation objectives.

The lack of coordination and collaboration poses the risk that the measures introduced or investments made by one jurisdiction may duplicate or counteract a measure in another jurisdiction. This means that work to adapt to the impacts of climate change or manage emissions will be less efficient and effective, and less likely to generate optimal outcomes. This is exacerbated by the absence of effective integration of the policy settings across climate, energy, transport and agriculture that are essential to drive adaptation and mitigation.

R&I investments are also disjointed, and the institutions operate in 'silos', which results in conflicting messaging and less than optimal allocation of resources. There is a clear role for national leadership in shaping research priorities on climate change, given the decline since 2012, in advanced climate change research programs and funding across the Rural research and development corporations (Rural RDCs), state agriculture agencies and industry bodies. The end result is stakeholders consider that farmers' needs are not targeted, which highlights the importance of their engagement in the development of policy and programs.

Stakeholders were concerned that poor and uncoordinated responses may impose additional costs on farm businesses; add to agricultural productivity declines; disrupt regional communities; result in disjointed social security responses to extreme weather events and droughts; and potentially result in the loss of export market access. Furthermore, it will undermine the carefully-crafted, but extremely fragile, 'clean and green' image used in international marketing. Improved communication and coordination between industry and government (at all levels) is considered essential to avoid these risks.

An opportunity exists to facilitate better forward planning and enable informed decision making through improved coordination and collaboration in relation to climate modelling, projections and data, rural R&I programs, and responses to extreme weather events and natural disasters (e.g. flood and drought). Strong policy leadership and coordination and better engagement with the professional services community (e.g. agronomists) will result in better outcomes and more efficient resource use.

There is an opportunity to leverage and integrate with other sectors such as tourism, energy and aquaculture. However, it will be necessary to ensure there is flexibility in approaches adopted to enable responses to be tailored to fit different time horizons and jurisdictional/local requirements.

3.2.2 Key opportunities and risks

The changing climate and extreme weather events are major long-term threats to the viability of the agricultural sector. Collaboration between individual entities or jurisdictions, whilst of benefit, cannot deliver the necessary scale, integration or national cohesion for effective adaptation and management of emissions over time. A systematic approach to enable both individuals and the industry as a whole to anticipate, manage and recover from one-off events or longer-term changes is required. The current approach provides some of the answers, but their adoption tends to be limited to individuals rather than occurring across commodities or communities.

The need for coordination and integration applies to the related policy areas of energy, water and biosecurity. The increasing costs of energy, together with decreasing availability of water and increased competition for access to water, further impact on a farmer's terms of trade. The current focus of biosecurity management is at the international border, but with climate change the expansion of pests, weeds and diseases across regions within the country will have far more serious consequences.

Areas that are open to greater coordination and effort include:

— research, development and innovation
— climate modelling and projections
— adaptation and mitigation policies and programs.

Research, development and deployment is a core component to driving adaptive responses. Investment in R&I and deployment has contributed to productivity growth, including through:

— the development of higher-yielding, pest and disease resistant crop varieties
— superior harvesting techniques
— improved livestock genetics.

However, the productivity gains resulting from current R&I efforts will not be sufficient to offset the impact of climate change. This is a fundamental cross-cutting risk, but also an enabling opportunity. Given the considerable costs of adaptation and mitigation, improved collaboration and cooperation would ensure that the R&I funding is spent in the most efficient and effective manner, and in ways that are more likely to deliver the required outcomes.

Currently there is less than optimal collaboration and coordination in R&I. This is due in part to the nature of scientific research; the number and variety of research institutions and funding models; and the distinction between public good and commercial research. This has led to fragmented (rather than integrated) access to information and limited cross-sectoral agricultural research. This is hardly surprising given research by the Rural RDCs is, by design, linear and commodity based. More work is required to integrate R&I efforts and apply the findings in the field at the farm, local and regional level to drive benefits and realise opportunities.

Access to a robust, reliable, consistent, single source of climate modelling and projections that covers the whole of Australia from national to local scale, that is maintained, regularly updated and developed (with secure long-term funding) is essential to inform decision making. Current approaches are fragmented, due in part to the evolutionary nature of the climate change projection capabilities and services provided by government (at both the state and national level). Most jurisdictions have, at different times, developed and released projection capabilities and tools. But they are generally based on different parameters and have limited provision for ongoing maintenance, accuracy improvements, fine-scaling to enterprise level, or work to maintain currency.

There is a complementary need for seasonal and decadal weather forecasting, and comprehensive assessments of risks associated with increasing extreme weather events. Further development of the Australian Actuaries Climate Index, released in late 2018, could provide the statistical basis to link extreme weather directly to risks in a manner that could inform farmers, researchers, markets, insurers, emergency services, governments, and the public.

Stakeholders noted that the emissions reduction challenges faced by producers of different agricultural commodities vary markedly. Farmers working with ruminants could be disproportionally impacted given this sector is currently the dominant source of agricultural emissions (over 80 per cent of agricultural emissions in 2018). This assumes the agricultural sector is required to contribute to meeting emissions targets, and that the need to manage emissions across the agricultural sector was allocated proportionately across all sector commodities.

Moreover, the introduction of mitigation measures at the farm level, whether they be for emissions management or carbon offsets, may require significant up-front investment. However, mitigation measures can also deliver other benefits through diversifying farm income, improving the health of the land and increasing biodiversity. In an uncertain policy environment farmers are disinclined to invest and are also concerned that the asset values associated with such investments will decrease if the rules change.

A framework is therefore required that provides for investment, recognises the differences both geographically and between agricultural commodities, and incorporates sufficient flexibility to enable the players to move at different speeds towards the realisation of agreed outcomes. With appropriate leadership, strong coordination and a stable policy environment, there are a range of measures which can be pursued by both industry and government, either acting in unison or independently, to both better manage emissions and create emissions offsets.

Such a framework could take the form of an aspirational statement by governments as to their goals for adaptation and emissions management for the agricultural sector, at national and regional level, and by sector, at say five and ten year time frames. The statement could include the partitioning of a specific quantum of R&I funding for transformative, cross-sectoral research and its deployment; establishing a clearing house for research and innovation access and uptake; and providing a single, comprehensive source of climate projections; and short-term, seasonal and decadal weather forecast services. The development of a framework could also provide an opportunity to revisit the roles and responsibilities for climate change adaptation agreed by COAG in 2012.

3.2.3 Responsibilities and timeframe

Achieving improved collaboration and coordination is a theme that will reduce costs and provide benefits to all stakeholders. Hence, all stakeholders should share in the responsibility for addressing this theme. For example, governments should have a responsibility to coordinate in areas like the provision of public good information such as climate projections. Similarly, Rural RDCs need to coordinate their research activities where appropriate to ensure the best outcomes are achieved from the significant investments by industry and government in R&I.

Immediate action should be a priority, and to the extent possible changes in approach should be adopted in the short-term (over the next five years), with the recognition that implementation will be ongoing.

3.3 Driving productivity and profitability of agricultural production through R&I

3.3.1 Theme description

Climate change impacts, particularly increased temperatures and reduced rainfall will reduce agricultural yields and production and increase the scarcity (and cost) of inputs such as water. These impacts, coupled with increased climate variability and extreme weather events, put pressure on farm profitability. Innovation and technological improvements are the foundations of resilience, climate adaptation and emissions management. An important component of the system is open access to the fundamental information, systems, analytics, forecasts and projections that can be used to drive operational and strategic decision making.

As detailed in the Stream 1 work, the average annual productivity growth over the last thirty years varies by agricultural commodity from 1.6 per cent for dairy to 0.3 per cent for sheep. Maintaining this level of productivity growth in the future, or preferably increasing it, will be difficult. Stakeholders are concerned that productivity gains (from new research) will not be sufficient to offset the impacts of

climate change, let alone grow yield and profitability. All agricultural commodities are vulnerable. Small declines in productivity can have a disproportionate impact on gross margin and profit and affect individual farm viability. The focus in the future needs to be on productivity as both volume and value not volume/yield alone.

Stakeholders were predominantly focused on present activities and considered that there is an opportunity to improve the application of existing R&I through better coordination across the many agencies involved. There was also a view that there needed to be a stronger focus on the deployment of currently available research in the field.

There is a significant innovation opportunity to improve the application, deployment and adoption of research. The translation of available research into decision making tools, and applications that provide practical management options for farmers - and make a clear distinction between current seasonal variability and future climate changes - will be of particular importance. Stakeholders considered that there was a need for long-term basic research and innovation focused on the impact of extreme weather events, biosecurity threats, productivity decline, and emissions mitigation. In regard to mitigation, there is potential for emissions reduction and carbon credits in the northern beef herd grazing areas.

3.3.2 Key opportunities and risks

Maintaining or lifting productivity growth at both the individual farm level and the broader industry level is a key plank in adapting to climate change. Public and private investment in research, development and innovation has contributed to agricultural productivity growth, including through the development of higher yielding, pest and disease-resistant crop varieties; superior harvesting techniques; and improved livestock genetics. It has also contributed to the development of emissions reduction capabilities.

In addition to climate, there is ongoing pressure on farmers' terms of trade from international competition and in domestic markets, resulting in price volatility. Drivers for this include upward pressure on operational costs, including the cost of energy, water, agricultural chemicals, fodder, plant and equipment, labour, insurance and capital.

R&I and deployment funding in the rural sector is significant (estimated at $3.3 billion in 2014-15). However, a significant portion of this investment has been directed at 'mining' the research investments and data infrastructure of previous decades. To enable the development of the tools required, and to provide the commercial application systems and services needed, the private sector requires access to a robust, reliable and consistent source of climate modelling and projections and associated decadal and seasonal weather forecasting. These are essential to underpin not only research, but the deployment of adaptive responses in the agricultural sector and elsewhere.

The primary source of agricultural sector emissions is from ruminants, in particular grazing cattle. Research has made considerable progress to date in developing the means to moderate these emissions in grazing and dairy cattle. These include viruses and microbes that reduce methane production in the stomach; feed additives (nitrates, tannins and dietary oils); and specific types of pasture that can reduce methane production by up to 20 per cent. The adoption of innovations in livestock management that can reduce methane emissions is a priority area for action.

The development of financial instruments to facilitate mitigation measures will require a sound evidence base as to the impact, efficiency and value of changes. R&I will be required to underpin such mechanisms and to provide the rationale for investment in actions aimed at improving mitigation (e.g. soil carbon, NH_4 and NOx management) and adaptation (soil carbon, water etc.).

Rural RDCs and other research bodies need to increase their output over time to help compensate for lost yield due to the impacts of climate change and to address emissions management. Research to develop new biotypes; real time crop and livestock management systems; and investment in technology to modify how commodities are produced can only be designed effectively if there is a good understanding of the future climate. Similarly, the design of efficient and effective commercial financial instruments (including insurance) and emergency services planning requires a robust understanding of the likelihood, scale, frequency, location and impact of increasingly frequent extreme

weather events. Accurate weather and climate projections is an important precursor for many other activities.

There are considerable opportunities for technology to drive improvements in productivity with the development of commercial decision-making support tools, and the adoption of approaches such as precision agriculture that provide practical management options for farmers. Precision agriculture can maintain or increase yields whilst reducing input cost, thereby improving profitability. It integrates a wide array of information technology systems such as Global Positioning Satellite (GPS) guidance, control systems, robotics, drones, autonomous vehicles, variable rate technology, GPS-based soil sampling, telematics, and software including yield monitors and 'on the go' harvest records.

Resilience in the face of downward pressure on productivity and profitability, coupled with the need to reduce emissions, requires a systematic approach to enable both individuals and the industry as a whole to anticipate, manage and recover from one-off shocks (such as an extreme weather event) or longer-term changes. Resilience requires a suite of adaptation measures to be in place as an integrated, self-reinforcing system. An approach that is selective or directive as to the adaptation measures that should be adopted will not build resilience across agricultural commodities and farming communities, it will merely provide fragmented and limited assistance to a few individuals.

The long-term viability of components of the agricultural sector are at risk in the absence of adaptation responses that deliver a step change in the levels of productivity. Innovative, new research activity, focused on transformational change is required. Consideration of the overall R&I system indicates scope to provide greater coherence in direction, stability of funding, and a stronger focus on delivery at the regional and farm level across the range of institutions, programs, companies and scientific communities engaged in agricultural climate adaptation research, development and innovation. Greater levels of collaboration and cooperation will improve the prospects for the delivery of the quantum of productivity gains needed.

3.3.3 Responsibilities and timeframe

Measures that support the productivity and profitability of the agricultural sector are delivering private benefit. As such, it is primarily the responsibility of the private sector to act to address this theme. However, the fact that the benefits of R&I can accrue to parties that have not supported the work, and the uncertainty about the value of the research outcomes means that governments often play a role in supporting R&I. Mitigation R&I has a clear public benefit.

In addition, the concerns about whether future yield gains from R&I will be sufficient to enable farmers to offset losses due to the impacts of climate change suggests that there may be a need for increased R&I aimed at developing technologies that can drive significant step changes, as distinct from research that delivers smaller, incremental improvements. Given current R&I efforts are not keeping pace with the productivity impacts of climate change, it is highly unlikely they can deliver the necessary impetus to drive the transformational change required over the mid to long-term.

Outcomes from the required long-term research are inherently more uncertain. Accordingly, governments tend to contribute more funding for this kind of research. Given that the realisation of research outcomes and the development and adoption of technological solutions takes time, immediate action is required to put in place the mechanisms to address this serious risk.

3.4 Climate policy certainty

3.4.1 Theme description

Support for an enduring national climate policy and associated programs will provide industry, markets and governments with the confidence to make the investments needed to adapt to the impacts of climate change, and to manage emissions and contribute to meeting Australia's commitments under the Paris Agreement. Stakeholders highlighted the need to reach agreement on time horizons for achieving long-term goals. The existing policy uncertainty has also led to a diversity of approaches by jurisdictions, leading to a fragmented and uncoordinated series of measures that risk sub-optimal outcomes at the national level.

Stakeholders clearly identified a major opportunity for national leadership to engender a partnership approach between industry, researchers and government, working with communities and farmers to create and enable the environment to support change. Stakeholders consider that enduring bipartisan agreement is essential as, given investment cycles of five or more years, certainty is required beyond the election cycle to enable industry to move forward with farm planning and investment.

In addition, there has been frequent, often substantive, change in the programs, incentives, direction and funding of research, and the settings of the regulatory frameworks (e.g. carbon farming markets, biodiversity offsets, etc.). In the absence of leadership, stakeholders considered that there will be a fundamental breakdown in the climate change response due to the inability to undertake long-term planning, decision making and risk management.

Establishing clear lines of accountability between the Australian and state governments, Rural RDCs, and industry and farm businesses will also ensure clarity around who does what, especially the split between public and private sector responsibilities.

3.4.2 Key opportunities and risks

The lack of a consistent long-term policy on climate change has created a stop-start approach to measures to manage emissions and the impacts of climate change. The uncertainty that pervades policy in this area has hampered longer term thinking by the sector. This has reduced the willingness of industry, markets and governments to make investments in long lived infrastructure or land use changes to help mitigate climate change due to the uncertainty around whether policies will remain in place long enough to deliver a positive ROI. This barrier to long-term investments means that farmers are likely to be less resilient and more susceptible to the impacts of climate change.

A long-term stable policy on climate change will provide the agricultural sector with the confidence to invest in developing and implementing measures to both manage emissions and adapt to the impacts of climate change. It will also provide a stable framework for any programs that might provide support to the sector to make those investments. A stable climate change policy is a vital enabling precursor to policies and measures that will help drive the agricultural sector's response to climate change and build resilience.

Stakeholders considered that a coordinated and enduring regulatory and policy framework that is farmer focused, is essential to manage the risks inherent to the sector (including risks stemming from climate change and extreme weather). Such an approach would need to recognise the diversity in agricultural systems across Australia, the considerable differences between regions and commodities, and ensure that farmers, commodity sectors and communities are able to take advantage of the opportunities to adjust and adapt.

Stakeholders also made it clear that such coordination meant a drawing together and integration of otherwise discrete policies and programs. From a farmer's perspective, long-term stability in the settings for energy policy; water availability and security; drought policy; biodiversity and biosecurity programs; agricultural R&I coupled with deployment initiatives; effective water and carbon markets; and emissions reduction commitments, are fundamental to the sector's willingness and ability to make long-term investments in adaptation and emissions management.

There is a disconnect with the possible adaptive responses to climate change that operate over different time horizons and range from incremental change to transformative. For example, moving to a different cultivar of wheat can be done in one season, but the lead time for tree crops is 10 to 15 years and for vineyards 30 years. Similarly, for livestock the benefit of introducing new breeding stock takes several generations to emerge and carbon farming has equally long time horizons. The ROI periods for investments, such as precision agriculture or a new irrigation system, are far longer than the standard five year payback applied in other businesses.

A stable national policy framework is essential to set the level and direction for adaptation research by both the private sector and government through investment in the commercial application of advanced technology; big data and remote sensing; and precision management of agricultural systems. Outcomes need to be aspirational and evolve over time, taking into account R&I results and new information/projections, etc.

Adaptive responses that deliver incremental adjustment, such as changing crop variety between seasons, are relatively low cost but unlikely to deliver the quantum of adaptation necessary in the long-term. More substantive and transformative responses such as consolidating enterprises; moving to other commodities or markets; shifting enterprises to a different climatic locations; or diversifying into other businesses, require significant capital investment and longer lead times.

Agricultural industry/commodity organisations and jurisdictions are already responding to growing community expectations. While individual action will be essential, the absence of an agreed policy framework will inevitably lead to fragmentation and misalignment.

A clearer articulation of goals and objectives at a national level regarding emissions management across the agricultural sector was seen as essential by stakeholders. The policy needs to clearly link Australia's approach to managing greenhouse gas (GHG) emissions across the economy, and tie into international obligations and global approaches. It is considered important that Australia (and Australian agriculture) does its 'fair share', but this does not need result in Australia taking a leadership role. However, there may be opportunities for Australia to market 'clean and green' agricultural products, hence Australia cannot afford to fall behind.

There are many factors at play which will affect the economic impact of any required actions to reduce emissions including:

— the extent to which agriculture might contribute to the overall national target
— the relative splits across the agricultural sector itself (it cannot be assumed that each commodity would reduce its emissions by the same proportion)
— the extent to which reduction can occur simultaneously with maintained/increased productivity
— other factors such as water availability, trade demands and the financial constraints of individual operators to meet abatement expectations.

There are strong concerns that, in the absence of political leadership, existing efforts will stagnate and a 'business as usual' approach will permeate the sector. While perhaps workable in the short-term, most stakeholders considered that it is not sustainable. If the sector does not actively manage its emissions in a sustained manner with clear evidence that progress towards a lower emissions profile is being achieved, government may be forced (by public opinion) to act. The subsequently imposed regulatory outcomes may be far more draconian.

While the overall consumer image of the sector is strongly positive, there are growing stress points (i.e. animal welfare considerations, concerns around water allocations/environmental issues). Action to address emissions is seen as important in maintaining a farmer's 'social licence to operate'. For example, any erosion of the social license raises the risk of encouraging more consumers to seek alternative protein options, thus reducing profitability and increasing grazing sector risks.

3.4.3 Responsibilities and timeframe

A coordinated national approach is crucial. That approach needs to establish high-level policy principles that will allow individual jurisdictions to introduce supporting policies and measures reflecting the specific circumstances of their agricultural sectors. The development of a coordinated national approach for agriculture will require equal participation and commitment of all jurisdictions (whilst recognising that the Australian Government has primary responsibility for climate policy under international conventions).

This theme is one that underpins the way in which the agricultural sector will respond to climate change. The aim should be to address this theme in the short-term.

3.5 Value-adding along the supply chain

3.5.1 Theme description

The impacts of climate change can create value capture opportunities along the agricultural supply chain. Such opportunities may include access to new markets, price premiums and new product opportunities based on supplying goods and services that can be differentiated based on their impact on emissions or climate change. Social license to operate themes can also potentially be addressed along the supply chain and lead to new market opportunities.

Climate change may well lead to increased supply security for some horticulture crops as climate change improves the reliability of production (e.g. in Tasmania). The migration of production zones for some commodities is likely to ensure 'full' supply chains (e.g. dairy in the south east of Australia, cotton expansion into Victoria).

Conversely, it can also bring significant risk. Climate change and increasing weather volatility is creating key issues and uncertainties along supply chains (e.g. the recent Queensland floods and severe cattle losses have major processor/trade implications: droughts and heat waves can impact dairy farm production and milk supply). Retailers and consumers will look to fill supply chain gaps which have been brought about by, for example extreme weather, through alternate means (e.g. importation, alternate products). Producers may find it challenging to 'reclaim' their market position/share when conditions return to normal.

Stakeholders also consistently spoke of market access advantages arising from effective adaptation and mitigation efforts. These can enable producers to sell at a premium to international markets (e.g. bespoke carbon neutral red meat products). Consumers may be willing to pay a premium for carbon neutral products as demonstrated by experience with some certification schemes (e.g. the certification of sustainable cotton provides a $1 to $3 per bale premium). Certification schemes have the potential to add extra value and provide production incentives for low 'carbon footprint' products. In this vein there may be strong potential to expand 'Bush tucker' as a niche product.

3.5.2 Key opportunities and risks

Capturing value-add opportunities along the supply chain will provide farmers with additional or more secure sources of income. If farmers can access new markets, or existing markets at different times or for longer periods, then these will provide additional sources of income. This diversification of activity and markets, and the additional income it can bring, will help to boost famers' resilience. Conversely, market access/trade difficulties can impact farm profitability which in turn limits the scope and level of investment by transitional industry sectors.

To the extent that farmers can develop new products that can be differentiated by virtue of their reduced environmental impacts, this can also provide opportunities to help maintain and strengthen farmers' social licence to operate. This may become particularly relevant if other sectors reduce their emissions and emissions from the agricultural sector become a larger proportion of Australia's total emissions. Such an outcome could put pressure on farmers' social licence to operate. In these circumstances, measures that protect and enhance farmers' social licence to operate will help boost their resilience to disruption.

One response to declining production and productivity is for farmers to seek to increase the relative value of the commodity they produce. Re-engineering the business to produce higher value products may be an option. Building on Australia's 'clean and green' produce image, or targeting niche markets for organic, sustainable or indigenous produce, are others. Certification processes for produce that is 'organic', 'sustainable' or 'biodynamic' can take several years to fulfil and require a significant investment to adjust farming practices. Thus, the business case needs to be thoroughly researched and soundly based.

It is likely that the target market would be export focused, so market intelligence, contacts and support would be essential, as would the need to secure long-term commitments to take produce. The investment and exploration of markets that is required, suggests that this approach is one best undertaken by commodity-based industry groups or large-scale individual producers. However, domestic markets may offer opportunities for smaller scale enterprises. For example, there has

recently been considerable growth in community support for 'farmers markets'. These are also proving to be a draw card for tourists.

To provide some context for this opportunity, the 2018 Australian organic market report found that 12 per cent of Australians consider themselves to be highly committed organic purchasers, usually outlaying 40 per cent or more of their household food spend on organic products. Currently worth $2.4 billion, the organic market is booming. The retail market is now estimated at $1.6 billion – up 46 per cent since 2012 – accounting for 70 per cent of Australia's organic market. Australia holds over 35 million hectares of land under certified organic management, accounting for 62 per cent of the world's organic farmland.[3] Worldwide the market for organics in 2015 was worth US$81.6 billion – a fourfold increase from 2000.[4]

In response to consumer sentiment, the European Commission has undertaken extensive studies in relation to product marketing and labelling from an environmental (including climate change/GHG emissions) perspective, including pilot assessments as to how such schemes could be implemented. While there are only limited examples of government implemented schemes at this time, it is important that Australian agriculture position itself to ensure it is not at a market disadvantage, or potentially even locked out of some markets.

Many stakeholders considered there is a real opportunity to build on Australia's reputation for clean, green products. If emissions are curbed, coupled with appropriate marketing, Australian agricultural products would be well positioned to demand a premium in the marketplace, especially if they can harness early mover advantages. It will also ensure they are not 'punished' should regulatory requirements or consumer preferences demand labelled/certified products in the future.

3.5.3 Responsibilities and timeframe

Addressing this theme will generate private benefits and it is appropriate for industry to have the primary responsibility for action in this area. However, there will be roles for research organisations and governments to play in this field as well. For example, research organisations can direct research towards technologies that might provide the opportunity to value-add to existing supply chains. Similarly, governments can help industry gain access to new markets through trade negotiations with other countries.

This is an ongoing theme and one which should be addressed in the short, medium and long-term.

3.6 Financial instruments and tax incentives to address climate change

3.6.1 Theme description

The lack of financial instruments and incentives to enable adaptation, offset risk or reduce emissions has constrained investment and the uptake of instruments such as carbon offsets. The right market signals through well designed and enduring policy instruments could encourage investment, diversification, offset markets, ecosystem services and natural capital. Improved access to financial instruments such as insurance is a potential risk management tool to support adaptation and build resilience.

There is a wealth of anecdotal evidence that many businesses are already factoring a 'carbon price' into their triple bottom line decisions. This in turn has implications for the return on investments and valuations of capital assets. Leading edge farm businesses already adopt this approach, and there will be continuing pressure from key service providers, particularly the banking and insurance sector, for businesses to factor in a price on carbon as part of everyday agricultural business planning and practice.

There is a need to establish a clear value proposition and incentivise investment as current market signals are inefficient - there are no real climate change price signals, but plenty of cost signals. Income and profitability will drive decision making at the farm level, and farming operations must be profitable in the long-term if they are to continue. Additional sources of income may help to ensure

[3] https://insidefmcg.com.au/2018/05/11/australians-prefer-organic-produce/
[4] https://austorganic.com/publications/ao-market-report/

profitability. For example, farmers could receive 'payment' for the way in which they run their operations (e.g. by providing ecosystem services).

The absence of a coordinated national approach, compounded by policy uncertainty and the governance/compliance costs of some schemes, makes access to capital more difficult and means farmers are less inclined to invest. The problem is exacerbated due to concerns the asset valuation of such investments will decrease if the rules change.

3.6.2 Key opportunities and risks

A lack of financial instruments and tax incentives is a brake on investments to adapt to the impacts of climate change and manage emissions and risk. Farmers will, therefore, find it exceedingly difficult to maintain viability and liquidity, whilst responding to increased extreme weather events and declining productivity.

Across virtually all forms of adaptation there is a need for farmers to make significant upfront long-term capital investments that often have far longer than normal periods for ROI. The need to adapt comes at a time when productivity is under downward pressure, and farm cash flows are highly variable or negative. There may be extended periods, often several years, before income streams are restored. This severely constrains farmers' ability to take up adaptation opportunities, unless appropriate incentives or 'bridging' financial instruments are available.

In a similar vein, tax measures and other incentives can encourage capital investment in infrastructure and resources (e.g. fodder reserves) which can be called upon in times of stress (e.g. drought). Transformational adaptation or recovery from extreme weather may not be possible under current settings owing to the significant upfront capital investments required. Delaying investments can lead to more rushed and costly investments in the future, or investment may be delayed too long and businesses will simply fail.

The market is also currently unable to provide appropriate financial instruments for risk mitigation. There is a market failure - insurance cover is not readily available or too costly for many aspects of agriculture, due in part to the current inability to adequately assess climate and extreme weather risk in the absence of actuarial and predictive analytics. There is also the associated problem of the extent to which the development of a market for production risk insurance is undermined by government provision of drought and natural disaster assistance. This puts farm enterprises in the invidious position of not having access to incentives and products to either adapt to climate change; offset risk; recover from its immediate impacts; or mitigate emissions, and thus locks in the status quo.

There is a range of commercial products that can assist in managing production risk and market risk arising from the volatility of commodity prices, exchange rate fluctuations and access to international markets. For market risk, price hedging can be used as a price risk management tool. Futures contracts, options and swaps can be used in commodity markets to offset gains or losses made in physical markets or foreign exchange markets to manage the risk of changing terms of trade. However, there are only limited options in terms of commercial insurance products to spread production risk, with 'Named-peril' insurance (hail, fire and frost) being the main, long standing product.

The major market gap is in the ability to obtain cover for extreme weather events. Whilst there are a few new products, their uptake is low and costs high. 'Multi-peril' (minimum yield, income protection, and weather index based/parametric) insurance has only entered the market in the last few years. The key feature of index-based insurance is that payouts are not determined by actual losses for an individual farm but rather on indirect proxies for yield losses such as rainfall at a local weather station or shire-level yields. For parametric insurance payouts are made if a trigger event occurs. For example, a farmer may have risk mitigation in place to deal with a category 4 tropical cyclone but takes an alternative risk transfer solution in the form of a parametric policy to deal with a cyclone above a category 4. Parametric insurance is still under development in Australia.

Another approach is for a farmer to limit the exposure to agricultural risk through broadening the income base to alternative farm income and non-farm activities, such as diversification to land uses for carbon offsets, carbon farming (bioenergy crops), renewables infrastructure (wind farms and solar), or ecosystem services (biodiversity). Effective financial instruments that provide incentives and market

certainty are necessary for investment and market participation. However, the feedback from stakeholders is that, even for large operators, the assessment and accreditation process for the Climate Solutions Fund (CSF) (formerly the Emissions Reduction Fund (ERF)) is complex and expensive, with the need to invest two years of upfront effort to complete the application. This is considered a disincentive to the uptake of CSF projects. Simplification of existing programs, and broadening the range of offerings and programs, is needed to encourage greater participation.

There are two clear pathways to mitigate emissions from the agricultural sector, the first is to change farming practices to actively manage emissions from stock, fertiliser use and manure management, and the second is to invest in a range of soil carbon and other offset measures. Both routes require strong financial incentives (primarily in the form of price signals) and the financial instruments to underpin investment. In the absence of such incentives there is a high risk that action will stagnate, and little will be done to reduce/address emissions.

Carbon price signals, such as those generated by the Australian Carbon Credit Units scheme by the Clean Energy Regulator for each $tCO_{2\text{-}e}$ stored or avoided by a project, are likely to become important for agricultural operations. They may also generate more interest in carbon farming approaches which can be incorporated within an agricultural business or become an agribusiness in itself.

However, increased interest could result in land use competition, and in certain instances the potential conversion of productive agricultural land to non-agricultural uses. In order to drive decisions and investments by farmers on emissions mitigation, clearer signals on carbon price, offsets and sequestration are required, together with clarity around emissions policy and impacts on agriculture. A clearer market signal on carbon price can be facilitated by governments articulating a set of specific goals for adaption and emissions management. This could be complemented by establishing a range of carbon funds for trade in carbon credits by the not-for-profit or private sector as well as those of governments.

3.6.3 Responsibilities and timeframe

The CSF establishes a market for carbon offsets. Under the CSF, eligible emissions reduction activities are specified by 'methodology determinations', or 'methods' for short. The 'methods' set out the rules for estimating emissions reductions from different activities. They ensure that emissions reductions are genuine (i.e. real) and additional to business as usual.

Expanding the 'methods' to allow for a broader range of activities that deliver offsets or other ecosystem services is an ongoing activity. The government normally prepares the 'methods' in consultation with stakeholders. To enable the market to operate more effectively, these issues should be addressed in the short-term.

There is a gap in current market offerings, such as insurance products better attuned to addressing increasingly frequent extreme weather events. While producers are increasingly encouraged to invest in resilience measures, there is a lack of financial tools and incentives aimed at narrowing the risk/reward gap. There is scope for government to work with the finance/banking and agricultural industries to address this risk.

3.7 Social cohesion of rural communities and individuals

3.7.1 Theme description

The impacts of climate change, particularly extreme weather events, flood, fire and storm as well as droughts will disrupt the social fabric of rural communities. This has the potential to create economic, health, welfare and emotional hardship. Strong community cohesion in the face of adversity is a significant factor in recovery and local champions can be vital in driving innovation and adaptation measures to reduce the impacts on local communities. While a strong history of self-support exists, rural communities may be put under greater pressure as social stresses rise due to the impacts of climate change.

Since deregulation of most agricultural commodities and exposure to export markets, on average, economically sustainable businesses have continued to grow in size, whereas smaller and less viable businesses have exited the industry. In the short to medium-term, this trend is likely to continue in part driven by climate change impacts. There are also a range of broader social costs which might be exacerbated by climate change impacts. However, there is surprisingly little large-scale quantitative analysis of the social impacts of drought (and climate change impacts more broadly).[5] These impacts include:

- community development and sustainability - community social cohesion, participation in community organisations and the availability of key services and infrastructure (e.g. schools, hospitals, aged care, financial services)
- residential mobility - household members' rates of mobility out of an area, including mobility between rural areas
- financial wellbeing - household incomes, levels of financial hardship and changes in financial position
- employment opportunities (e.g. lower employment due to mechanisation)
- economic impact on farmers
- family relationships - relationship separation, the quality of couple relationships, family functioning and family conflict, mental and physical health.

Working with affected communities when designing responses, and tailoring communications to different groups according to their unique challenges, would minimise disruption to rural communities while helping to ensure their support.

Inevitably there will be some that are left behind as adjustment to climate change occurs. Mental health issues will be exacerbated by the uncertainty engendered by climate change, and the need to adapt as changed weather events and extremes impact on farmers' profitability and sustainability. It will be critical that both adaptation and emissions management efforts are well considered and take into account the wider socioeconomic implications for rural businesses, families and their communities.

Stakeholders suggested that one way to deal with the theme is to foster community engagement around solutions to climate impacts, and how they fit within a much wider focus on climate change responses generally, and broader economic/prosperity issues.

3.7.2 Key opportunities and risks

Communities where there is a strong sense of cohesion will be better placed to support each other during times when climate change disrupts the lives and normal activities of the community. This will tend to increase the community's and individual's resilience to, and ability to recover from, such disruptions. Conversely, a lack of social cohesion will lead to less resilient farmers and communities.

Through investing in (and rewarding) resilience, both farmers and communities can better position themselves to face extreme weather events, drought etc. and recover more quickly. However, there will inevitably be (justifiable) calls for government intervention and assistance measures. The design and availability of assistance measures is both complex and fraught with downside risk. To address this risk, governments need to ensure that assistance:

- is directed to those in real need
- or the 'promise of assistance', does not discourage investment in resilience measures, or favour/reward those who choose not to invest in such measures
- does not distort markets or have unanticipated impacts on adjacent areas and other jurisdictions.

The long-term shift in agricultural production to more suitable climatic zones, enterprise consolidation, and the increased frequency of local and regional extreme weather events, will impact on rural and regional communities and individual farmers. These effects will be economic and social and are likely to reduce the viability of a number of rural townships and regional centres (especially those which are solely or primarily reliant on agriculture as the key economic driver). This may occur incrementally or

[5] Australian Institute of Family Studies, Social and economic impacts of drought on farm families and rural communities; Submission to the Productivity Commission's Inquiry into Government Drought Support; Prepared by Ben Edwards, Matthew Gray and Boyd Hunter https://www.pc.gov.au/inquiries/completed/drought/submissions/sub092.pdf

rapidly, particularly if a locality experiences several extreme weather events over a short period leaving little time to adjust or recover. The long-term impacts are likely to be profound and will bring with them major social and economic costs.

A key priority will be to ensure that people in the agricultural sector have the appropriate skills base to address the climate change issues they face. As the tools available to farmers become more sophisticated and farming systems responses more complex, there will be an increased focus on integrating multifaceted data sets and considerations. Both farmers and farm service providers will need to understand the application of these new tools. The decline of regional and rural townships may add to the challenge of accessing skill development opportunities.

Given the specific challenges faced in managing emissions from some agricultural commodities (e.g. grazing cattle, dairy), farmers in these sectors are particularly vulnerable, especially when faced with limited mitigation options on the immediate time horizon.

3.7.3 Responsibilities and timeframe

The risks associated with the social cohesion of rural and farming communities have been recognised for some time and all governments have taken proactive measures to address the theme, for example mental health initiatives and financial support for drought. Climate change impacts will inevitably heighten anxiety and increase pressures on both government and community services. Urgent action to address the risk is required. Many of the issues and options identified under this theme extend beyond AGMIN's remit. Action in response to these issues will require a whole-of-government approach/position to be reached.

3.8 Land use planning, competition and management

3.8.1 Theme description

Climate change impacts will influence the availability and viability of agricultural lands. The increased scarcity of productive agricultural land could increase tensions between current landholders and industry or commodity sectors; new industries; and the community which might prioritise different land uses. Agricultural land may become unviable and be used for non-agricultural purposes. Alternatively, the changed climatic conditions could encourage new agricultural industries to emerge and existing operations to migrate to areas with more amenable conditions. These impacts will differ greatly between regions and industries.

If land is used for carbon sinks by large emitters as an alternative to reducing their own emissions at source, this may reduce access to land for farming. It may also reduce the ability of farmers to access suitable land for carbon sinks to offset their remaining CH_4 and N_2O emissions (after management options are implemented). This could impact on their ability to retain their social licence to operate, particularly if other sectors of the economy are successful in significantly reducing their emissions, and the relative share of Australia's total emissions derived from agriculture increases as a consequence. However, it may be possible to use less productive agricultural land for carbon sinks, while retaining and potentially growing existing agriculture uses (e.g. by using soil carbon to enhance the land).

Land use change is already leading to increased land-use conflict, including when commodities adopt new production methods (e.g. as horticulture moves to more protected cropping). To realise the opportunities in this area, it will be necessary to engender better conversations between farmers and urban communities/developers regarding land use.

Land clearing conditions/controls and reafforestation can also generate opportunities. There is scope for cooperation between agriculture and forestry sectors to revegetate, but the right policy and framework will be essential to encourage this collaboration. Land use decisions will reflect competitive advantages. However, there are risks associated with the design of carbon policies that drive increased forest/plantation land use that need to be heeded (e.g. lessons from the failed 2000's managed investment plantation schemes). While mosaic agriculture is an option for adaptation, there are red and green tape barriers which need to be addressed to create positive regulatory systems to generate patient capital flows. A better understanding of water availability will also be essential.

3.8.2 Key opportunities and risks

Agricultural producers may expand their areas of operation to allow for the possibility that the region(s) they are currently operating in could become less productive or less suitable for their agricultural activities over time. This will facilitate opportunistic agriculture production to better match weather/climate circumstances and increase farmers' flexibility and resilience in the face of changes in the climate or extreme weather events.

A reduction in the land available for agricultural uses could reduce the ability of farmers to adapt to the impacts of climate change by changing (or increasing) their area of operations. This could impact on their viability, which would have a negative impact on their resilience.

As the extent of climate change and frequency of extreme weather increases, incremental adaptive measures will not be sufficient to maintain production, productivity and profitability. Precision agriculture can be applied to match land use to land use capability, and address sustainability by optimising profitability in the productive parts of the landscape, while conserving biodiversity and the natural resource base in less productive areas.

However, the main adaptive approach will be for enterprises to make the business decision to diversify to manage climate risk. Initially this may comprise moving from a single crop regime to mixed broadacre, or from crop to livestock and vice versa depending on location. Larger enterprises may also seek to spread the risk across several farm business locations and commodities in various jurisdictions. Similarly, upscaling through consolidation of enterprises in one area could deliver productivity efficiencies and flexibility in management, but major capital investment is required.

There is also the opportunity to boost natural capital through improved natural resource management practices at the farm level. Improvements to soil biodiversity by boosting soil carbon through a range of sequestration methods (driven by the value of carbon offsets) will enhance overall productivity. These approaches need to be coupled with a proactive approach to broader environmental management issues. For example, extreme summer rainfall related flooding, worsening fire conditions, etc. that may result in lost crops, equipment and infrastructure.

As the strength of the climate warming signal emerges from 2030 onwards, some areas (particularly in the south of the continent) will become unsuitable for the commodities produced there today (due to increased temperatures, declining rainfall and reduced access to irrigation). In this case, major sectoral shifts of commodities will occur, in particular the migration of production to regions further south in the New South Wales Highlands, Victoria and Tasmania. This trend has already commenced in regard to wheat and dairy and is most pronounced in viticulture with most major wine companies now having a presence in Tasmania. This trend will have structural effects through consolidation and relocation of enterprises, and change the commodities produced to those that can afford water rights. This will have a dislocating effect on communities, impact on land and asset values, and affect rural and regional centres, services and employment.

The migration of enterprises to areas with better suited growing conditions can also generate land use competition (between the traditional producers and those moving in) as land and other asset valuations change and competition for resources (e.g. water) increases.

With appropriate carbon price market signals there are a wide range of mitigation measures which may offer a sound investment decision for landowners. Viable economic alternatives to traditional agriculture production (i.e. carbon farming, sustainable farming practices that build carbon assets, biofuels etc.) will offer choice to farmers, and enable them to diversify income streams and build alternate asset bases.

There is also significant capacity for mitigation efforts in these areas to improve both adaptability and productivity from traditional agricultural practices. Increased soil carbon can enhance water holding capacity and thus boost crop yields. Shelter-belt plantings and other reafforestation measures, while operating as carbon sinks, also improve water management and can boost plant and animal productivity.

However, there is a risk that instead of addressing their own (agricultural) emissions, landowners will seek to maximise alternate income streams through providing offsets to those sectors willing to pay a premium (e.g. electricity generation, transport) or potentially (given the appropriate policy and governance settings) global emissions from outside Australia. This may well improve the profitability of an enterprise through providing a secure alternate income source, but there is a risk that the agricultural sector may find itself effectively locked out of the market.

The introduction of adaptation measures can lead to community disharmony. There is anecdotal evidence of peri-urban communities reacting negatively to the introduction of intensive, high density, protected horticultural practices. Their lifestyle choices were in part driven by promotions showing bucolic images of rolling green orchards, market gardens etc. The introduction of widescale use of netting and shade structures or rows of greenhouses may not match those expectations.

Governments will need to ensure that land use decisions are made with as much information and policy certainty as possible, with incentives to account for public and off-site benefits/costs, within a social policy framework that recognises the social and individual costs of change.

3.8.3 Responsibilities and timeframe

Land use decisions will be made by individual farmers and businesses based on the changes to the climate and policy settings in areas such as those mentioned above. These will largely be commercial decisions.

To the extent that changes in land use begin to raise tensions between stakeholders or raise concerns about food security and the retention of highly productive agricultural land, there may be a role for government to make changes to policies that influence land use decisions. In some cases, governments may need to act (e.g. change zoning laws, leasehold provisions) to facilitate mitigation actions and greater use of offset provisions. This is more likely to be the case in the medium to long-term.

3.9 Climate change impact on water policy

3.9.1 Theme description

The impacts of climate change are expected to reduce water availability in general and increase variability of water supply (and hence the cost of water) as a result of extreme weather events and extended dry periods. The strong competition for water between industries, and within the agricultural sector, is putting pressure on traditional users.

This will add additional complexity to water management policy across jurisdictions, water catchments, competing agricultural industries, and for government. In some cases, existing regional water infrastructure is considered inadequate, or at risk of not meeting future needs of industry, society and the environment. The transfer of water allocations to higher value uses may lead to stranded irrigation assets. Some see the need for better and more information about water resources, including ground water. Agricultural practices to increase water holding capacity, efficient irrigation practices, or precision farming to minimise water usage need to be encouraged.

Stakeholders called for a national approach that moves beyond current approaches and models. Recent developments in the Murray-Darling Basin (MDB) have shown that water access and availability is a key issue for agriculture and, given predicted changes to rainfall and runoff, the problem will only worsen. The demand for, and price of, irrigation water will rise. There are varying perspectives on whether the water market is working and whether there needs to be a greater role for 'public good' in management of water entitlements.

There has been an expansion in the areas, crops and pastures irrigated. Irrigated crops such as cotton demonstrate great flexibility, with the area planted and water used varying on a seasonal basis by up to 70 per cent depending on rainfall and water availability. Sugar cane has less flexibility, as it has a five-year cropping cycle and can be severely damaged by waterlogging or water stress. Tree crops and vineyards have even less flexibility, with time to maturity of five years plus and a replanting cycle of 20 to 50 years.

While the debate tends to be focused on riparian water sources, climate change will also impact ground water resources, albeit the impact may not be as manifest in the immediate future. The range of issues discussed in this section have equal applicability to groundwater.

3.9.1 Key opportunities and risks

A failure to address the impacts of climate change on water could have highly negative outcomes for farmers. A lack of secure and adequate supplies of water would put severe downward pressure on farmers' resilience. The agricultural sector is the major consumer of water in Australia at 62 per cent in 2016-17, followed by households at 12 per cent. The changes generated by climate change will put pressure on the availability of water and increase its variability. More rainfall will occur in heavy storms and floods with increased run off and soil erosion. This will be juxtaposed with an increase in the frequency and intensity of severe drought, increasing temperature extremes leading to high evaporation rates and reduced streamflow and soil moisture, together with the depletion of soil carbon.

Reliable, long-term access to a known quantity of water is particularly important to certain commodities and farm enterprises. At a farm level, rain and dam water can be directly managed, but run off into streams, rivers and major dams is regulated and managed at a jurisdictional level (or cross-jurisdictional in the case of the MDB). However, greater emphasis is needed in relation to on-farm water resource management for livestock production (water quantity and quality) and the strategic use of groundwater resources.

The pressures of water availability are already manifest with economic and structural impacts. Over the past 50 years Australia's real gross farm product has declined by 27.5 per cent during droughts, with wheat and grazing enterprises being the most severely impacted.

Water availability is particularly important for irrigated agriculture. Some 25 per cent of agricultural enterprises irrigate, and the gross value of irrigated agricultural production was $15.5 billion in 2016-17. The total area of land under irrigation in Australia has increased by some 30 per cent since the early 1990's. Agriculture saw a 12 per cent increase in water consumption in 2016-17 and the total area watered increased four per cent to 2.2 million hectares, driven by increases in land used to grow cotton, rice, sugar cane and pasture-fed stock finishing.

The capacity to further expand the area of land irrigated and the volume of water available for irrigation is clearly limited. There is already increasing competition for water in the main areas of agriculture irrigation, especially the MDB. This is leading to increasing consolidation and enterprise scale, and also the regional domination of certain commodities with concomitant impacts on communities and regional centres. This tips the balance in favour of commodities such as cotton which are seasonally planted and high value, compared to other high uses such as tree crops, orchards and vineyards which have lifecycles of 30 years or more and require a regular, secure and known quantity of water.

Thus, while the agricultural sector needs to plan for and manage periods when there is not reliable access to a known quality of water, this is not feasible for all commodities, in all parts of Australia. This is particularly the case for non-irrigated enterprises, where on-farm water resource management (e.g. better farm management practices to improve the water holding capacity of the land, and investment in efficient water use practices) is key, as is water quality and the availability of 'safe' water resources for livestock.

There is likely to be increasing competition for scarce and highly variable water supplies between agricultural commodities and communities, which could lead to an increased price for water, structural adjustment and dislocation of communities.

Water availability (or the lack of it) will heighten the focus on alternative land use options (and the diversification of income sources) for carbon offsets and land conversion from productive agriculture to carbon banks. There is a risk that farmers may not be able to avail themselves of these opportunities unless there are clearer carbon market signals in relation to offsets, sequestration and the valuation of natural capital (including carbon), as well as more workable governance arrangements around offsets accounting.

3.9.2 Responsibilities and timeframe

Government has a role in clarifying uncertainties around water availability and use. Many of the issues and options identified under this theme extend beyond AGMIN's remit. Action in response to these issues will require a whole-of-government approach/position to be reached.

3.10 Leadership and coordination in the provision of climate data

3.10.1 Theme description

National leadership and coordination of climate modelling and projections is considered essential to ensure that comprehensive and comparable projections are available, on-farm use is facilitated, and that there is consistent messaging to industry, governments, research organisations and the market. There needs to be a particular focus on extreme weather forecasts and projections in addition to long-term climate signals. Broad availability and access to data and the analytics used to drive decision making has potential benefits for adaptation and mitigation.

A key theme identified by stakeholders was the lack of reliable climate projections beyond 2030. Longer-term projections (say to 2035 or 2050) would align better with farm planning time horizons and recognise the time it takes for research to be funded, delivered and adopted (new technologies can take up to 30 years to implement). Also, greater time horizons are needed for strategic planning and government decision making. A long-term view is essential to ensure that industry does not 'fall off the cliff'. Incremental adaptation based on short-term projections will not be sufficient to manage medium to longer-term change.

The current approach to projections (focused on Natural Resource Management (NRM) clusters) does not align with agricultural production regions or reflect local-scale climate conditions that drive local production systems. A number of state governments have undertaken projections to fill these gaps, but there is a lack of commonality in approach and assumptions making it difficult to compare like with like. The lack of longer-term planning can be viewed as a market risk where government has a role.

Up-to-date climate projections and greater knowledge of their implications are essential to reduce uncertainty. The projections need to be based on a consistent framework, methodology, assumptions and big picture climate scenarios to ensure comparability of results and properly informed decision making. While climate modelling and prediction needs to be led nationally, local/regional scenario specifics are vital, and projections need to be at a scale and in a form that enables 'on-farm' application.

Better forecasting (especially of rainfall) in the short, medium and longer term is also required (the 3-12 month window is particularly important) to enable informed farm level decision making. Climate scenarios need to be consistently presented and interpreted (to reduce conflicting analysis).

Furthermore, there is a lack of information on extreme/discrete events or particular climate parameters that can be key determinants of suitability for a selected commodity. Historically much of the modelling and information outputs have targeted the needs of extensive industries like grazing and grains, rather than intensive or more 'niche' industries (which, while they occupy smaller land areas, may offer much greater returns per unit area). As a result, the projections are not particularly useful in supporting actual decision making by farm managers across many commodities.

While the long-term projections provide invaluable guidance, the lack of certainty limits their value as planning and decision-making tools (especially at the enterprise level). Improving the ability to better forecast variability/extremes and decadal projections will be important for enhancing the capacity of businesses to make better informed decisions about adaptation to climate change and emissions management.

3.10.2 Key opportunities and risks

The lack of timely and consistent climate modelling and projections for on-farm use will act as a barrier to industry, research organisations and markets engaging in long-term planning of their operations. The provision of better and more user-friendly information to farmers will help them gain a much deeper understanding of the risks and opportunities, and how best to adapt to the impact of climate change. Farmers that have timely access to farm level climate change projections can incorporate that information in their business planning and be better prepared for the impacts of climate change. This will improve their resilience.

The majority of jurisdictions have established a climate change projection capability to inform climate change policy and programs, and to provide access to data for commercial enterprises, research and the public. As each of these capabilities has been developed at different points in time, the climate models, emissions scenarios and baseline periods used all differ, as do the projection periods and areas covered. Each capability has also been developed as a one-off package, rather than as a system with ongoing funding that is maintained, improved and updated over time. Thus, effort has been duplicated, and a consistent ongoing national capability that meets the needs of all jurisdictions and stakeholders is lacking.

Public good access to a robust, reliable and consistent source of climate modelling and projections that covers the whole of Australia from national to local scale is required. The modelling and projections need to be regularly updated and further developed, and also require secure long-term funding. Complementary to this is the need for the provision of equivalent seasonal and decadal weather forecasts, and comprehensive assessments of risks associated with more frequent extreme weather events. This could be made even more powerful and useful to the agricultural sector if combined with other core data sets, such as soil and soil moisture mapping, and remotely sensed data (e.g. bush fire hot spots, vegetation coverage and flooding).

Access to high quality global climate projections will facilitate informed decision making in relation to emissions management and Australia's response. At the farm level, improved projections data may inform decisions as to the need for on-farm mitigation measures and investment, while its absence may lead to ill-advised decisions. However, the availability of the data alone is only part of the solution. There is a need to expand the range of tools available to use/apply projections for genuine opportunity/risk analysis at an on-farm level.

The information is essential to underpin research, development, innovation and deployment of adaptive responses and mitigation action in the agricultural sector and elsewhere. This capability in climate systems and forecasting could be drawn together and provided through national leadership. The private sector would then be able to develop the tools and provide the commercial application systems and services that are needed by the agricultural sector. The benefit of these capabilities is also far broader than agriculture and would apply to other sectors, including emergency services, insurance providers, urban planners and commodity markets.

Risk assessment systems are also required to provide national and local statistically based metrics on the frequency, scale and likelihood of impacts of climate change, particularly extreme weather events. This is essential to underpin commercial financial instruments; insurance and actuarial systems; extreme weather preparedness and response systems; and government support. The further development of the Australian Actuaries Climate Index, released in late 2018, which could achieve this by providing the statistical basis to link extreme weather directly to risks.

3.10.3 Responsibilities and timeframe

The provision of information of this kind is a task for governments. BoM and CSIRO, in conjunction with state agencies are well placed to take a leadership role, but this will be contingent on government funding/support. Providing farm level data that is consistent across the country should be a short-term and continuing priority.

3.11 Biosecurity

3.11.1 Theme description

The impacts of climate change will increase biosecurity risks at the national and the farm level. The projected increase in air temperatures and rainfall variability will change the distribution of agricultural pests and diseases across the country. These shifts will place pressure on the biosecurity system, which is a risk to an island state that leverages its biosecurity and product origin status in both domestic and international markets. This will impact agricultural productivity and profitability.

Increasing temperature may also increase exposure and susceptibility of animals to parasites and diseases, especially vector-borne diseases. However, the potential impact of climate change on parasite populations and subsequent effects on animal production is as yet not well understood, and therefore difficult to project. This theme will be exacerbated by extreme events, such as drought where fodder/livestock is moved around the country to a greater extent. While protocols are in place, there is the possibility that the normal high standards for on-farm biosecurity measures/practices may need to be relaxed due to the stressful/unforeseen circumstances.

Changed climate can shift pest distribution as well as opportunities for spread as increasing drought periods and climate extremes add pressures. Weed incursions into areas in, or recovering from, drought will rise, especially given landholders will be under financial stress and may not be able to afford control measures. The changing distribution of pests and diseases (including new arrivals from overseas) will see the introduction of novel pests with greater management costs, increased chemical use issues and implications for marketability and market access.

Effective management of biosecurity issues has the potential to enhance Australia's reputation for clean, green products, especially if conditions deteriorate elsewhere in the world. With appropriate marketing Australian agricultural products would be well positioned to demand a premium in the marketplace. Within Australia some regions and localities may be able to position themselves as havens from certain diseases and pests and derive competitive advantage from this status.

3.11.2 Key opportunities and risks

Increases in the prevalence of pests and diseases may lead to reduced yields and/or reduced prices for agricultural produce. The presence of pests or diseases may also impact farmers' ability to access some markets. While biosecurity threats arising from climate change include incursions from overseas, the main threat of species migration (weeds, pests and diseases) is from neighbouring regions within Australia.[6]

Weed control is a critical factor in Australian agricultural production, with agricultural losses due to weeds estimated at over $4 billion per year. Climate change will exacerbate both the cost to agriculture of weeds and the threat to biodiversity. New and changed levels of weed impact on the environment will arise, requiring new or significantly altered adaptation responses to reduce negative impacts. This is also the case for agricultural pests and diseases (e.g. the spread of Gamba grass (*Andropogon gayanus*) – which was originally introduced to improve grazing - greatly heightens fire risk and intensity and reduces biodiversity).

Adaptation responses for weeds, pests and diseases include the management techniques of quarantine barriers; eradication and containment; biological control; agricultural and veterinary (AgVet) chemicals; and the development of genetically resistant strains and breeds of plants and livestock. Maladaptation, that is, management responses to climate change that may prove to be detrimental, is also a risk. The introduction of new (native or exotic) pasture species for grazing or new biofuel crops, (in response to climate change) offers potential benefits. However, the attributes that make plants ideal biofuel crops are frequently the same as those that make them invasive, namely: fast growth, high yields, and tolerance to a wide range of environmental conditions. The past record in Australia illustrates that the introduction of new pasture species has often led to new weed species.

[6] Scott, J.K., Webber L.B., Murphy, H., Ota, N., Kriticos, D. J., and Loechel, B. 2014. AdaptNRM. Weeds and Climate Change: Supporting weed management adaptation

An example of the nature of this potential pest problem is provided by scenario modelling of the impact of climate change on the suitability of habitat of the Queensland fruit fly (*Bactrocera tryoni*).[7] This shows that compared to now, large tracts of the southern Australia will become suitable fruit fly habitat under all climate change scenarios from 2030 onwards. These states are all major fruit growing areas.

Adaptive responses to biosecurity risks will be facilitated by the development of models and application of remote sensing and big data. Models are needed to simulate and predict responses and changes in distribution of existing invasive species, emergence of new invasive 'sleeper' species, and the spread and transmission of diseases in Australia under likely scenarios of climate change and habitat modification. This type of work would assist government in undertaking improved risk assessments for applications to bring new live plant and animal species into Australia.

The application of specialist expertise to information technologies, such as the use of remote sensing, in combination with current data and models, is needed to identify and monitor emerging diseases and pest habitats. The development of a computational biosecurity model is necessary research infrastructure for Australia's preparedness for pest diseases, and their management in instances of outbreak.

There is also a need to investigate the adoption of current techniques for tracking changes in mating habits, increasing genetic diversity, or shifts in gene patterns that could indicate the imminent risk of shifting from a 'sleeper' pest or weed to a problematic invasive species. In addition, there is much to be learnt from jurisdictions that already have considerable experience in seeking to prevent and control such pests, weeds and diseases.

Moreover, pests, diseases and invasive species have the potential to destroy much of the asset value related to carbon offsets. Biosecurity incursions can put at risk mitigation efforts such as shelter-belt plantings and other reafforestation measures.

3.11.3 Responsibilities and timeframe

Addressing biosecurity risks is a joint government/industry responsibility. Given the potential impact on plant and animal health (and potentially human health), immediate and ongoing action is essential.

3.12 Infrastructure planning and investment

3.12.1 Theme description

The economic impacts of climate variability are already being felt, particularly in the increasing incidence and severity of extreme weather events. Over the past 50 years Australia's real gross farm product has declined by 27.5 per cent during droughts. Some 310 major Natural Disasters have resulted in losses of $171.5 billion over a similar period. This figure does not include events where damage was less than $10 million or caused by droughts and heatwaves. The impact will increase as the climate warming signal becomes more evident. An increase in the frequency and severity of extreme weather events, including bushfires, floods, severe storms, tropical cyclones, heatwaves, and storm surges can be expected. Rising sea levels also increase the likelihood of coastal erosion and severe inundation.

The projected impacts of climate change, such as increased extreme weather events and the severity of droughts, will have a significant impact on regional water and on-farm infrastructure. The increased incidence of flood and periods of drought may require assessment of the capacity and capability of infrastructure to meet the current and future needs of regions.

[7] Sultana, John B. Baumgartner, Bernard C. Dominiak, Jane E. Royer & Linda J. Beaumont. Potential impacts of climate change on habitat suitability for the Queensland fruit fly Sabira. 2017.ScieNtific REPoRTS | 7: 13025 | DOI:10.1038/s41598-017-13307-1

There can be significant farm-level capital costs in building resilience, introducing adaptation measures and in managing emissions. This will need to be reflected in the planning and investment processes of industry and government. Producers will need to manage all risks over periods of time longer than individual seasons, or years. This may require a new approach to how farm business enterprise plans are developed, how infrastructure is funded and greater utilisation of financial risk instruments.

Existing infrastructure will need to be adapted for new purposes, and given the competition for investment finance, infrastructure investments will need to be adaptive. New business models and capitalisation/funding mechanisms will be required to meet infrastructure needs. There is considerable scope to improve the efficiency in irrigated water use/conservation through infrastructure investment.

Farmers are already investing in new/remodelled infrastructure to address the impacts of climate change (e.g. protected horticultural systems, changes in dairy farm systems, and infrastructure to reduce reliance on irrigated pastures). There is a risk of stranded irrigation assets if new development focuses on relatively inefficient flood irrigation for lower value field crops. Equally, milk processing infrastructure may become stranded if a region becomes unsuitable for dairy farming. Future investment should be determined by consideration of both climate and market risk in financing.

An increase in the incidence of extreme weather events may also disrupt supply chains, both domestically and internationally. Given over 80 per cent of Australia's agricultural value is derived from exports, transport disruptions at any stage in the supply chain can have a significant impact, potentially calling into question Australia's reputation as a reliable supplier of quality produce. Road freight is critical for most commodities, with those produced in the north of the country reliant on a very limited number of routes. Weather related closures already occur, but these are likely to become the norm unless there is a significant investment in upgrading infrastructure. Investment needs should be determined based on environmental vulnerability assessments.

More frequent extreme weather events will also place strains on the capacity of emergency services to respond. There have already been examples where the number of fires during extreme heat waves have exceeded the capacity of fire services to attend them all.

3.12.2 Key opportunities and risks

Increased planning for, and investment in, infrastructure will help to reduce the potential disruption of that infrastructure by the impacts of climate change. This will in turn increase the resilience of the communities and the individuals dependent on that infrastructure. Additional infrastructure may be needed to ensure that emergency services have the capacity to respond in a timely fashion to increasingly frequent extreme weather events. There may also be a need to provide additional resources to organisations providing longer-term support to the agricultural sector to aid recovery following such events.

A failure to plan for and invest in infrastructure that can cope with more frequent extreme weather events and the long-term impacts of climate change will increase the risk of agricultural activities being disrupted. This is likely to result in reduced earnings for farmers and a loss of resilience.

On-farm resilience measures (e.g. fodder storage, additional water points, upgraded irrigation systems) may be capital intensive, and not necessarily within reach of all landholders. There is a risk that the financial market will not correctly value these assets/investments, and that many farmers will not be in the financial position to undertake the works even though they recognise their long-term value.

Extreme weather events, whether flood, fire, or storm, can impact on infrastructure cutting off roads, power and communications isolating farmers. This can prevent farmers from accessing stock; cause mortality in livestock in controlled environments (if there is no power); and similarly cause loss of produce if cool-sheds lose refrigeration. Farm infrastructure can also be lost or damaged, for example irrigation systems, feed storage and fencing. Little of this damage and down time is covered by insurance, and thus recovery and reinvestment by farmers can take several years as income streams may be low or non-existent following such disruptions.

Farmers can implement a range of adaptive measures to buffer against increasing extreme weather. Investment in infrastructure such as irrigation equipment and dykes; additional fodder storage capacity to cover several seasons; cool sheds; standalone power; sprinkler cooling systems for livestock; shaded/netted yards and orchards, and protected agriculture enables the farm system to adapt. While there are clear incentives to invest to maintain and grow farm profitability, it does not necessarily follow that most farmers can afford to do so, especially during times of climate induced financial stress. The decision to make such investments is predicated on the assessment of relative risk.

At present, there is only limited capacity to assess the overall impact of all events across the country on an annual basis. Government support may be available for natural disasters and drought. However, there is a need for new mechanisms and systems to better inform and assist agricultural sectors, individual farmers, and communities reduce the risks, moderate the impacts and facilitate recovery from regional and local extreme weather events. This need is exemplified by the projected increase in fire danger days given there was a 40 per cent increase in fires in the five years to 2013. In the absence of such information, it is difficult for governments, communities and farmers to identify the priorities for protecting and upgrading infrastructure and services.

A further major risk is that the planning and response strategies currently in place to address infrastructure failures will not effectively address the impacts of more severe, and more regular, extreme weather events on infrastructure.

On-farm emissions management measures will also require investment to facilitate changes in farming systems and practice (i.e. in feedlot and feedstock management, manure management, use of organic rather than synthetic fertilisers etc.). The introduction of large-scale offset initiatives on marginal land (or land that becomes marginal due to climate change) may require significant infrastructure investment. For instance, the conversion of broadacre cropping lands to rangeland carbon banks may require extensive fencing. Undertaking the necessary investment can be challenging for many landholders given the optimum time for conversion probably coincides with the time of most stress (i.e. after several crop failures).

However, carbon farming investments may also become more attractive as prices are increasingly determined by market demand, with European offset prices already exceeding 25 Euros. Such investment requires forward planning, recognising that the new low rainfall, high temperature era has applied for some time. Research by industry groups such as Meat and Livestock Australia (MLA) has already identified areas where cumulative adaptation could offset the impacts of climate change, as well as those areas where adaptation may be less effective. It will be important for governments to consider such information and make it widely available to aid decision making on transitional/transformational adaptation.

3.12.3 Responsibilities and timeframe

Infrastructure is a shared responsibility of industry and government, and both need to take responsibility for planning and investment in the infrastructure that they rely on for their operations. The impacts of climate change on infrastructure are becoming increasingly apparent and planning and investment in that infrastructure should begin in the short-term. Many of the issues and options identified under this theme extend beyond AGMIN's remit. Action in response to these issues will require a whole-of-government approach/position to be reached.

4 CONCLUSIONS AND NEXT STEPS

This chapter summarises the key conclusions based on the analysis of opportunities and risks undertaken as part of the Stream 2 work. This assessment will inform Stream 3 as to which themes should be prioritised as needing to be addressed as part of any work program for a coordinated national approach to adaptation to climate change and emission management in the agricultural sector.

4.1 Stream 2 conclusions

4.1.1 Key themes

The Stream 1 work identified the underlying climate related issues that agriculture will face. Stream 2 explored, in detail, the opportunities and risks that climate change presents to the sector. It considered them within the broader context of the many factors influencing decision making by both government and industry. To ensure stakeholders' views on opportunities and risks were properly captured, stakeholder consultations were undertaken.

A qualitative assessment was undertaken of the issues, grouping them into high level themes, incorporating both opportunity and risk elements in each. Some themes present as affording both significant opportunities and risks, while others are predominantly one or the other. The themes are:

- Coordination, collaboration and governance of climate change responses
- Driving productivity and profitability of agricultural production through R&I
- Climate policy certainty
- Value-adding along the supply chain
- Financial instruments and tax incentives to address climate change
- Social cohesion of rural communities and individuals
- Land use planning, competition and management
- Climate change impact on water policy
- Leadership and coordination in the provision of climate data
- Biosecurity
- Infrastructure planning and investment.

4.1.2 Priority action areas identified

A coordinated and enduring regulatory and policy framework is essential

- Stakeholders considered that a coordinated and enduring regulatory and policy framework that is farmer focused is essential to managing the risks inherent to the sector (including risks stemming from climate change and extreme weather)
  - such an approach needs to recognise the diversity in agricultural systems across Australia, the considerable differences between regions and commodities, and ensure that farmers, commodity sectors and communities can take advantage of opportunities to adjust and adapt.
- Coordination requires the drawing together and integration of otherwise discrete policies and programs that exist or may be developed
  - from a farmer's perspective, long-term stability in the settings for energy policy; water availability and security; drought policy; biodiversity and biosecurity programs; agricultural R&I coupled with deployment initiatives; effective water and carbon markets; and emissions reduction commitments, are fundamental to the sector's willingness and ability to make long-term investments in adaptation and emissions management.
- Adaptive responses that deliver incremental adjustment, such as changing crop variety between seasons, are relatively low cost but unlikely to deliver the quantum of adaptation necessary in the long-term
  - more substantive and transformative responses such as consolidating enterprises, moving to other commodities or markets, shifting the enterprise to a different climatic location, or diversifying into other businesses, require significant capital investment and longer lead times.

Better coordinated R&I effort to drive transformation

- The long-term viability of components of the agricultural sector are at risk in the absence of adaptation responses that deliver a step change in the levels of productivity
  - innovative, new research activity focused on transformational change is required.
- A review of the overall R&I system indicates a lack of coherence in direction, instability in ongoing funding, and insufficient focus on delivery at the regional and farm level
  - ensure farmers' needs are targeted and improve their engagement in the development of R&I policy and programs.
- Improved coordination between the institutions, companies and scientific communities engaged in agricultural climate adaptation research, development and innovation programs would deliver better outcomes.

A consistent national climate change policy framework

- The perceived lack of a consistent long-term policy on climate change is considered by stakeholders to have created a stop-start approach to measures to manage emissions and the impacts of climate change
  - the uncertainty that pervades policy in this area has hampered longer-term action by the sector
    - which has reduced the willingness of industry, markets and governments to make investments in long-lived infrastructure or land use changes to help mitigate climate change due to the uncertainty around whether policies will remain in place long enough to deliver a positive ROI.
- A long-term, stable policy on climate change will provide the agricultural sector with the confidence to invest in developing and implementing measures to both manage emissions, and adapt to the impacts of climate change
  - it will also provide a stable framework for programs that might provide support to the sector to make those investments
  - a stable climate change policy is a vital enabling precursor to policies and measures that will help drive the agricultural sector's response to climate change.

Building on Australia's supply chain opportunities

- There is an opportunity to build on Australia's reputation for clean, green products
  - if agriculture emissions are curbed then, coupled with appropriate marketing, Australian agricultural products would be well positioned to obtain a premium in the marketplace
  - it will also ensure they are not 'punished' should future regulatory requirements or consumer preferences demand labelled/certified products
  - action is required to facilitate this opportunity, and to also address possible disruptions to the supply chain arising from climate change.

Harnessing financial instruments and tax incentives to their full effect

- A lack of financial instruments and tax incentives is seen as hampering action given many forms of adaptation require farmers to make significant upfront long-term capital investments that have longer than normal periods for a ROI
  - the need to adapt comes at a time when productivity is under downward pressure and farm cash flows are highly variable or negative which
    - severely constrains farmers' ability to take up adaptation opportunities, unless appropriate incentives or 'bridging' financial instruments are available
    - limits transformational adaptation or recovery from extreme weather events.
- Tax measures and other incentives can encourage capital investment in infrastructure and resources (e.g. fodder reserves) which can be called upon in times of stress (e.g. drought)
  - there is a risk that the financial market will not correctly value these assets/investments and that many farmers will not be in the financial position to undertake the works even though they recognise their long-term value
    - but delaying investments can lead to more costly and rapid investments, in the future, or investment may be delayed too long and businesses will simply fail.
- Agricultural emissions can be managed by either changing farming practices to actively manage emissions from stock, fertiliser use and manure management, or by investing in a range of soil carbon and other offset measures
  - both require strong incentives (e.g. price signals) and instruments to underpin investment
  - stakeholders identified the need for clear carbon price signals for each tCO_2-e stored or avoided
    - but the lack of a clear price signal around offsets is stifling market growth.
- To drive investment decisions on emissions mitigation, clearer signals on carbon price, offsets and sequestration are required, together with clarity around emissions policy and impacts on agriculture
  - a clearer market signal on carbon price can be facilitated by governments articulating a set of specific goals for adaption and emissions management
  - which could be complemented by establishing mechanisms for trading in carbon credits by the not for profit or private sector as well as governments.

Building social cohesion

- The long-term shift in agricultural production to other more suitable climatic zones, enterprise consolidation, and the increased frequency of local and regional extreme weather events will impact on rural and regional communities and individual farmers
  - the effects will be economic and social, and are likely to reduce the viability of a number of rural townships and regional centres
    - especially those which are solely or primarily reliant on agriculture as the key economic driver.
- This may occur incrementally or rapidly, particularly if a locality experiences several extreme weather events over a short period leaving little time to adjust or recover.
- The long-term impacts are likely to be profound and will bring with them major social and economic costs
  - a key priority will be to ensure that people in the agricultural sector have the appropriate skills base to address the climate change issues they face, especially given the decline of regional and rural townships may add to the challenge of accessing skill development opportunities.

Managing land use tensions

- Agricultural producers may expand their areas of operation to allow for the possibility that the region(s) they are currently operating in may become less productive or less suitable for their agricultural activities over time
  - this will facilitate opportunistic agriculture production to better match weather/climate circumstances and increase farmers' flexibility and resilience in the face of changes in the climate or extreme weather events.
- A reduction in the land available for agricultural uses could reduce the ability of farmers to adapt to the impacts of climate change by changing (or increasing) their area of operations
  - this could lead to land use conflicts
  - a reduction in the land available for agricultural uses could reduce the ability of farmers to adapt to the impacts of climate change.
- As the extent of climate change and frequency of extreme weather increases, incremental adaptive measures will not be sufficient to maintain production, productivity and profitability
  - precision agriculture can be applied to match land use to land use capability, and address sustainability by optimising profitability in the productive parts of the landscape, while conserving biodiversity and the natural resource base in less productive areas.
- The main adaptive approach will be for enterprises to make the business decision to diversify to manage climate risk
  - initially this may comprise moving from a single crop regime to mixed broadacre, or from crop to livestock, and vice versa depending on location
  - larger enterprises may also seek to spread the risk across several farm business locations and commodities in various jurisdictions
  - similarly upscaling through consolidation of enterprises in one area could deliver productivity efficiencies and flexibility in management, but major capital investment would be required.

Access to water will be crucial for agriculture

- The agricultural sector needs to plan for and manage periods when there is not reliable access to a known quality of water
  - for non-irrigated enterprises, on-farm water resource management (e.g. better farm management practices to improve the water holding capacity of the land, and investment in efficient water use practices) is key, as is water quality and the availability of 'safe' water resources for livestock
  - there is likely to be increasing competition for scarce and highly variable water supplies between agricultural commodities and communities, which could lead to an increased price for water, significant structural adjustment and dislocation of communities.

Ensuring decisions are fully informed by the best climate data

- Access to a robust, reliable, consistent, single source of climate modelling and projections at a national, regional and local scale, that are regularly updated and further developed, is required to underpin actions.
- Quality projections will facilitate informed decision making in relation to emissions management and Australia's response
  - at the farm level improved projections data may inform decisions as to the need for on-farm mitigation measures and investment
    - its absence may lead to ill-advised decisions
  - there is also a need to expand the range of tools available to use/apply projections for genuine opportunity/risk analysis at an on-farm level.
- The information is essential to underpin research, development, innovation and deployment of adaptive responses and mitigation actions in the agricultural sector and elsewhere
  - this capability in climate systems and forecasting could be drawn together and provided through national leadership
  - the private sector would then be able to develop the tools and provide the commercial application systems and services that are needed by the agricultural sector.

Coping with increased biosecurity risks

- Increases in the prevalence of pests and diseases may lead to reduced yields and/or reduced income for agricultural producers
  - pests and diseases also have the potential to destroy much of the asset value related to carbon offsets.
- While biosecurity threats arising from climate change include incursions from overseas, the main threat of species migration (weeds, pests and diseases) that needs to be addressed is from neighbouring regions within Australia.

Facilitating new and protecting existing infrastructure investments

- Increased planning for, and investment in, infrastructure will help to reduce the potential disruption caused by the impacts of climate change
  - additional infrastructure may be needed to ensure that emergency services have the capacity to respond in a timely fashion to increasingly frequent extreme weather events.
- A failure to plan for, and invest in, infrastructure will increase the risk of agricultural activities being disrupted, resulting in reduced earnings for farmers and a loss of resilience
  - key areas for both public and private infrastructure investment need to be identified.

4.2 Work program for Stream 3

Stream 3 will involve identifying options for consideration by the Senior Officials Group and the Agriculture Senior Officials' Committee (AGSOC) in preparing advice for AGMIN on actions and a work program that could inform the development of a national strategy for adaptation to climate change and emissions management in agriculture.

It will propose options for actions reflecting the stakeholder feedback on opportunities and risks, exploring each with an emphasis on what is achievable in terms of responses. The selection of actions will focus on what is the 'appropriate' form of intervention to address any market failure or to realign government actions where they have led to market distortion or unexpected outcomes. The design of actions will draw on program logic considerations (to assess likely outcomes and impacts) and focus on actions which governments and other stakeholders can realistically take.

A STAKEHOLDER CONSULTATION

A.1 Stakeholder consultation process

The process reflects the objective of Stream 2 which is to identify from first-hand sources the opportunities and risks climate change poses to the agricultural sector. A list of stakeholders was drawn up in close collaboration with all jurisdictions. Stakeholder input was sought through three main channels - workshops, interviews and written input.

The following sections address the details of the stakeholder consultation:

- A.1.1 Understanding the opportunities and risks
- A.1.2 Stakeholder selection
- A.1.3 Consultation process which includes the following:
  - Workshops
  - Interviews
  - Written input

The remainder of the appendix details the outcomes of the stakeholder consultation:

- A.2 Summary of workshop outcomes
- A.3 Summary of interview outcomes
- A.4 Summary of written submissions
- A.5 Research findings and jurisdictional issues identified under Stream 1

A.1.1 Understanding the opportunities and risks

Stream 2 considers them within the broader context of the many factors influencing decision making. The work is focused 'on-farm' but also identifies significant opportunities beyond the farm gate.

The Stream 1 analysis identified a wide range of issues and learnings which form the starting point for the Stream 2 work. A thorough analysis of the relevant literature, strategies and programs was conducted to identify opportunities and risks. Commentary from jurisdictions on the Stream 1 analysis served to both verify and build consensus around key issues, and to identify matters for further consideration in Stream 2. The issues identified as part of the Stream 1 work are listed in Section A.5.

To ensure stakeholders' views on opportunities and risks were properly captured an extensive stakeholder consultation was undertaken. The objectives of the consultations are outlined in Box A.1.

BOX A.1 STAKEHOLDER ENGAGEMENT OBJECTIVES

The stakeholder engagement strategy has three objectives:

1. to build ownership of, and support for, the project and to inform AGMIN's deliberations regarding developing a coordinated national approach
2. to source the necessary information and views from stakeholders required to complete the project, and in particular to capture their views in relation to opportunities and risks
3. to review and test the findings of the analysis with jurisdictions and stakeholders to ensure that the outcomes are valid and supported.

The intergovernmental nature of the task posed both opportunities and challenges which were central to the approach taken for stakeholder engagement. The development of a consensus document (at the government level) which has broader stakeholder buy-in (as against formal endorsement) that is meaningful, realistic and enables pragmatic implementation was central to the task.

SOURCE: ACIL ALLEN CONSULTING

A.1.2 Stakeholder selection

A selection process was used to identify stakeholders and determine how best to engage with them. The priority assigned to a stakeholder and the method of engagement was based on their:

- ***Importance*** – to the project's overall success and engagement objectives and AGMIN
- ***Influence*** – within agriculture, climate change and jurisdictions.

The simple assessment was undertaken (in partnership with jurisdictions) to determine where individual stakeholders sit in the matrix shown in Figure A.1.

FIGURE A.1 STAKEHOLDER SELECTION MATRIX

	LOWER INFLUENCE	HIGHER INFLUENCE
HIGHER IMPORTANCE	Consulted collectively	Consulted individually
LOWER IMPORTANCE	Not engaged directly	Opportunity to participate

SOURCE: ACIL ALLEN CONSULTING

This approach was used to identify the stakeholders to be consulted and the appropriate mode of consultation, including:

- *Individual interviews* - for higher importance-higher influence stakeholders (unless they opted to attend workshops) - these stakeholders were consulted by phone calls or some face to face meetings
- *Workshops* - for high importance-lower influence and lower importance-higher influence stakeholders
- *Written responses/input* in response to key questions – for lower importance-higher influence stakeholders not engaged in workshops and those who could not attend workshops.

The process was used to guide the development of the detailed list of stakeholders consulted as part of the project, with the intent being to capture a diversity of interests with a broad range of views across a variety of issues.

Table A.1presents an alphabetical listing of all stakeholder organisations that participated in the consultation process. These stakeholders were engaged through the workshops, telephone interviews and face to face discussions. Additionally, some stakeholders provided a written submission.

TABLE A.1 STAKEHOLDER PARTICIPANTS

Stakeholder	Stakeholder	Stakeholder
ACT NRM; AG Excellence Alliance; AgForce QLD; Agricultural Bureau of SA; Agriculture Victoria; AgriGrowth Tasmania; AK Consultants; Alinytjara Wilurara NRM (SA); Apple and Pear Australia Ltd; Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES); Australian Dairy Farmers; Australian Export Grains Innovation Centre; Australian Meat Processor Corporation; Australian Pork Ltd; Bureau of Meteorology (BoM); Canegrowers Association (QLD); Cattle Council of Australia; Central West Local Land Services (LLS, NSW); Clean Energy Regulator; Climate Research Strategy for Primary Industries (CRSPI); ClimateWorks Australia; Commonwealth Scientific and Industrial Research Organisation (CSIRO); Cotton Australia; Cotton Research and Development Corporation; Curtin University; Dairy Australia; Department of Agriculture and Fisheries (DAF, QLD); Commonwealth Department of Agriculture and Water Resources (DAWR); Department of Environment and Natural Resources (DENR, NT); Department for Environment and Water (DEW, SA); Department of Environment, Land, Water and Planning (DELWP, VIC); Department of Environment and Science (DES, QLD); Department of Jobs, Precincts and Regions (DJPR, VIC); Department of the Premier and Cabinet (SA); Department of Premier and Cabinet (TAS); Department of Primary Industries (DPI, NSW);	Department of Primary Industries and Regional Development (DPIRD, WA); Department of Primary Industries, Water and Environment (DPIWE, TAS); Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP, QLD); Department of the Environment and Energy (DEE, QLD); Department of Water and Environmental Regulation (DWER, WA); Environment, Planning and Sustainable Development Directorate (EPSDD, ACT); Farmers for Climate Action; Grains Institute of Western Australia; Grains Research and Development Corporation; Growcom (QLD); Hort Innovation; Horticulture Coalition of SA; Livestock SA; Meat and Livestock Australia; Murdoch University; National Australia Bank; National Farmers' Federation; National Irrigators Council (ACT); Natural Resources, Adelaide and Mount Lofty Ranges; Natural Resources Eyre Peninsula; Natural Resources Kangaroo Island; Natural Resources SA Arid Lands; Natural Resources SA (Northern and Yorke); North Central Catchment Management Authority; North East Catchment Management Authority; Northern Agriculture Catchments Council; NRM North; NRM Regions Australia; NSW Farmers' Association; Northern Territory Cattlemen's Association;	Northern Territory Farmers Association; Office of Environment and Heritage (NSW); Pastoralists and Graziers Association of WA; Perth Region NRM; Port Phillip and Westernport Catchment Management Authority; Primary Industries and Regions South Australia (PIRSA); Queensland Farmers Federation; Queensland Treasury Corporation; Rangelands NRM; Ricegrowers Association of Australia; RMCG agricultural consultants; RMIT University; Dairy SA; Southern Australian Meat Research Council; South Australian Murray-Darling Basin NRM; South Australian Research and Development Institute (SARDI); South Coast NRM; Southern Queensland NRM; Strawberry Innovation; Tasmanian Beekeepers Association; Tasmania Conservation Trust; Tasmanian Crop Pollination Association Inc; Tasmanian Farmers and Graziers Association; Tasmania Institute of Agriculture; The Northern Territory Mango Industry Association; University of Melbourne, Primary Industries Climate Challenges Centre; Verterra Ecological Engineering; WA Farmers Federation; Wheatbelt NRM; Wine Victoria.

SOURCE: ACIL ALLEN CONSULTING

A.1.3 Consultation process

Workshops

Workshops were conducted in each jurisdiction with participants representing both government and industry to obtain their views on the risk and opportunities associated with climate change adaptation and emissions management in the Australian agricultural sector.

ACIL Allen worked with each jurisdiction and Agriculture Victoria, as the lead jurisdiction for the project, to deliver the workshops. Jurisdictions worked with ACIL Allen and Agriculture Victoria to identify stakeholders to be consulted and the appropriate workshop format and location. The workshops were facilitated by ACIL Allen. The workshops had a common agenda focused around the following four key questions:

Question 1: What do you see as the main opportunities and risks that climate change presents for the agricultural sector?

Question 2: What do you see as the most important adaptation and/or emissions management approaches that are currently in place or could be introduced in the future?

Question 3: What are your key priorities, objectives and expectations for a nationally coordinated approach?

Question 4: Are there particular issues to consider or proactive approaches that could be adopted to meet the challenges?

A summary of the views obtained from more than 160 industry and government stakeholders who attended the workshops is at Section A.2. The summary represents the views expressed during the workshops but may not be a complete representation of the risks and opportunities associated with climate change in agriculture. These views are presented in line with the four questions used to facilitate discussion at the workshops.

A key objective was to allow stakeholders to express views from their perspective rather than being constrained by a particular framework or analytical lens. Care has been taken to retain the richness of views expressed by summarising the key points raised under each question rather than applying a common structure across all the workshops. These views feed directly into the analysis of opportunities and risks.

Interviews

Individual interviews were conducted with a number of key stakeholders including senior officials in each jurisdiction, scientists and researchers from major agencies (e.g. CSIRO, BoM, several Rural RDCs) and industry groups. Jurisdictions worked with ACIL Allen and Agriculture Victoria to identify stakeholders to be consulted. The interviews generally addressed the same four questions posed in the workshops.

A summary of the views obtained is at Section A.3. These views are presented in line with the four questions used to facilitate discussion at the workshops. The views feed directly into the analysis of opportunities and risks.

Written input

While there was no general call for written submissions, the invitation to attend a workshop did provide the option for stakeholders to provide written commentary by email. This was primarily intended to provide a mechanism to enable stakeholders who were unable to attend to put their views forward. It also allowed them to provide additional material or elaborate on issues raised which they considered germane to the project. A summary of the views obtained is at Section A.4.

A.2 Summary of workshop outcomes

Table A.2 through Table A.5 summarises the key issues captured during the Stream 2 stakeholder workshop series. The issues have been distilled to thematic level, whilst maintaining a level of detail regarding the issue at hand. The tables are separated into the four questions that were posed to all workshop groups.

What do you see as the main opportunities and risks that climate change presents for the agricultural sector?

TABLE A.2 WORKSHOP OUTCOMES: OPPORTUNITIES AND RISKS

Opportunities
– Accelerating broader adaptation to develop/defend the agricultural sector in the future
– Agricultural production
– Incremental improvement and transformation of existing farming systems and infrastructure
– Productivity gains which also reduce emissions, waste, restore soils and improve energy efficiency
– Developing new goods and services (agricultural, forestry, carbon sequestration, ecosystems, energy)
– Re-locating industries to less impacted/more favourable locations
– Building markets and supply chains
– Market access and premiums based on climate/emissions/ethically differentiated goods and services

Opportunities

- Integration by contract and ownership to strengthen supply chains
- Carbon markets for on-farm sequestration and offsetting agricultural emissions

- Strengthening financial resilience
  - Preparedness and responsiveness to more frequent and extreme weather events
  - Diversification to reduce risk through flexible production systems and off-farm income
  - Incentives for emissions reduction and energy efficiency
  - Financial instruments to manage commercial risk (insurance, natural capital included in financing)
- Regional/off-farm infrastructure
  - Develop transport, ICT and community infrastructure to additional agricultural and regional development
  - Reconfiguration of land and water infrastructure to best available use (avoiding stranded assets)
- Social and environmental
  - Improving the natural environment while sustaining production at the same time
  - Building social networks/adaptive capacity to build purpose and identity for industry/communities
- Political and legislative reform
  - Use climate change as a national goal focused on development/endurance to focus and build pride
  - Opportunity to remove long-standing legislative blockers and strengthen institutional fabric

Risks

- Climate change has high levels of uncertainty – so perspective and timeframe influence whether issues raised are seen as opportunities or risks for industry and government
- Climate change reduces the productive potential of agriculture, reducing business/regional/industry viability
- Cost of increased frequency of extreme (localised and extended) weather events to industry/government
- Emissions reduction obligations incur costs which cannot be offset economically, and reduce profitability
- On-farm carbon sequestration and emissions reductions methods are not feasible
- Consumer and societal trends result in loss of markets and/or additional costs
- Avoidance due to complexity of climate change (political, economic, social, technical, environmental etc.)
- Inability to act due to personal circumstances (capital, skills, life cycle stage, options etc.)
- Lack of policy clarity and bipartisan support slows response by industries, markets and institutions
- Institutional complexity – (shared) responsibility that cuts across industry/governments/functions increasing coordination costs
- Disruptive (step) change leading to maladaptation and sub-optimal outcomes
  - Resources concentrate to those with greater capability leading to stranded assets, unviable businesses and poor social structures
  - Conflict arising from land use change (intensification and re-location)
  - Loss of confidence in key policies (e.g. water allocation and management)
  - Labour and finance loss of confidence in (parts of) agriculture
  - Short-term reactive institution responses
- Agriculture is diverse with considerable differences between regions and industries, making alignment between national approaches/policies and local application challenging
- International structures provide mitigation framework/measures, but lack similar for adaption/resilience

SOURCE: ACIL ALLEN CONSULTING

What do you see as the most important adaptation and/or emissions management approaches that are currently in place or could be introduced in the future?

TABLE A.3 WORKSHOP OUTCOMES: ADAPTATION/EMISSIONS/RESILIENCE APPROACHES

Adaptation

- Best available information on future climate, weather and options will assist businesses to adapt
- Need to pursue adaptation of existing and new production systems simultaneously
- In terms of production there are three dominant themes
  - Sustainable intensification – concentrating resources to higher value use (e.g. protected cropping)
  - Enduring systems – maximising inputs to make best use of available resources (e.g. regenerative agriculture)
  - Flexible systems – ability to produce under varying conditions and swap in/out of commodities

Adaptation
–

– New production systems should not need to be solely focused on existing commodities and include:
  – New agricultural goods (food, fibre and bio-energy)
  – Alternative products (renewable energy, tourism, ecosystem services etc.)

– Regional development will be a central driver
  – Adaptation options increase when more than one (agricultural) industry is considered
  – Alignment with traditional owners' interests critical in Northern Australia
  – Each region has different potentials – labour and infrastructure dimensions important

– Market considerations
  – Businesses, regions and industries must meet market needs, and assistance support should factor in how this will happen in time to avoid surplus supply
  – Many of the market signals are confusing and populist – need information and ability to filter

– Transition to a completely new farming system, product, business model, industry or region is complex   – Greater clarity on roles and (shared) responsibilities between individuals/government/industry will help
– There is an expectation that frequency of pest/disease impact, variable water availability and extreme weather events will increase – requiring technologies and incentives for preparedness and responsiveness
– Financial and risk management tools and services (including natural capital)
– Productivity (efficiency) is a current and enduring focus which now needs to include emissions impact
Mitigation
– Emissions reduction targets are understood to be necessary but are potentially threatening, especially for livestock industries which account for a large source of agricultural emissions. There are also tensions around clearing
– The potential for on-farm carbon sequestration and emissions reduction is important to the sector – both as an offset as well as an additional source of income
– There is interest in developing co-benefits with carbon sequestration - biodiversity conservation, ecosystems services, savannah burning with traditional owners, farm forestry etc.
– Emissions reductions through waste management and energy efficiency improvement are also potential sources of offsets and additional income
– Valid methods, appropriate compliance regimes, and suitable accounting and trading mechanisms need to be developed
Resilience
– Adaptation approaches that address climate change will often address other drivers which affect agriculture and regions such as markets, exceptional circumstances and wider structural change
– Mitigation is seen as a risk or opportunity that can't be understood until policy settings are clearer
– Resilience is an integrating concept that includes but goes beyond both agricultural adaptation and mitigation to climate change. Resilience has been used in exceptional circumstances, natural resource management and social/regional development
– Resilience is consistent with the history and lived experience of agricultural development and evolution in Australia. It provides a potentially powerful base on which to structure a nationally coordinated approach to supporting agriculture adapt to climate change.

SOURCE: ACIL ALLEN CONSULTING

What are your key priorities, objectives and expectations for a nationally coordinated approach?

TABLE A.4 WORKSHOP OUTCOMES: COORDINATED NATIONAL APPROACH PRIORITIES

Key priorities
– Commitment to emissions reduction and targets (such as net zero emissions) in the future are widely understood and seen has important mechanisms to drive coordination (if not fully supported at present)
– Similar goals and targets do not exist for adaptation and resilience. They also overlap with other policies and drivers making it hard to differentiate and determine if the nationwide focus is appropriate
– Inclusion of exceptional circumstances and industry/regional development would create a more complete overview of the policy dimensions around climate change – key performance indicators (KPIs) to track progress need to be developed

Better information
– Better information on climate predictions and weather forecasts will assist industry to adapt. Greater coordination will reduce duplication and allow for improved services to industry and business
Coordinated innovation to underpin adaptation and emissions reduction
– The rural innovation system is important and complex, and largely organised on industry/jurisdictional lines – Adaptation to climate change focused on short and long-term outcomes must be a priority for the system, along with associated collaborative frameworks and investments – The interface between the innovation system and agricultural businesses and local/regional adaptation needs to be refined. It is not about re-creating last century's government funded and delivered extension services. A refined system should include, access to information, transfer of technology, and developing communities of practice which span the research community, farmers and industry service providers
Exceptional circumstances and industry/regional development
– Climate change preparedness/responsiveness should continue as a core principle for exceptional circumstances and responses to lesser/localised emergencies – Industry/regional development provides a useful vehicle to identify and focus on adaptation options and will drive integration with other infrastructure, labour and social services
Mitigation – leveraging emissions reduction and co-benefits
– Emissions reduction targets and associated accounting/offsetting mechanisms need national coordination – Energy efficiency and emissions reduction technology should be part of the innovation agenda – Co-benefits arising from ecosystems services, nature conservancy, environmental restoration should be encouraged/incentivised - this is likely to be localised given the environment varies considerably
Financial instruments and risk management
– Information and systems which allow the finance sector to price climate change impact and good practice in their insurance and borrowing services should be encouraged and backed by science and evidence – Incentives play an important role in stimulating adaptation. They should be applied to both the innovation system and industry using both direct incentives, and potentially the tax system

SOURCE: ACIL ALLEN CONSULTING

Are there particular issues to consider or proactive approaches that could be adopted to meet the challenges?

TABLE A.5 WORKSHOP OUTCOMES: PARTICULAR ISSUES OR PROACTIVE APPROACHES TO MEET CHALLENGES

Clear, consistent and enduring message
– Climate change is a non-discriminating disruptor that will require an enduring response to minimise the risks and realise opportunities from the changes it will bring – The high degree of uncertainty around climate change impacts means the shared response by government and industry must be adaptive. This could take the form of nationally agreed principles and aspirational commitments/targets, combined with tangible actions which have both short and long-term outcomes, focused on mitigation and adaptation/resilience for at least a decade
Recruiting stakeholders
– Jurisdictions have recently completed, or are currently in the process of, developing climate change strategies, thereby creating a logical step/process to engage stakeholders – Stakeholders reported high levels of interest in progressing mitigation emissions reduction targets and mechanisms to manage/offset emissions that include leveraging off other sectors (including energy) – A nationally coordinated framework to engage stakeholders on mitigation is required to build support, and determine where specific opportunities, risks and associated trade-offs lie – Adaptation will require a nuanced response because it involves drawing on and coordinating the considerable resources and capability already present in the agricultural sector - there is a high level of industry and government interest in harnessing this adaptive capability to address climate change – Climate change (and the agricultural sector's capacity to adapt/manage emissions) needs to be clearly designated as a national priority in terms of government R&I support for agriculture, which can then drive a revamping of the system to ensure the appropriate arrangements with sufficient flexibility are put in place

– Alignment and leverage outside traditional agricultural policies (e.g. regional development, social services and non-agricultural communities' environmental/ethical needs) provide opportunity - a first step is to outline how they interact and then explore the potential on a case by case basis

Outcomes focus

– The principle of triage needs to be applied to both mitigation and adaptation. Climate change requires an enduring response that will build on existing and new capabilities that will evolve based on experience
– A road map outlining the roles and responsibilities of industry and government is the foundation
– A commitment to providing the best available information to all agricultural businesses on climate predictions/scenarios and weather forecasts - and options farmers could pursue - is also needed
– Triage to identify and remove blockers to agricultural businesses realising the options should be the focus for targeted and coordinated support - the support need not be universal, but rather focused in areas with the highest risk or potential to realise opportunities

Measuring progress

– Supporting agriculture to adapt to climate change will require industry and government to change
– Measuring progress made by industry and government is important given the outcomes lie in the future.
– A national indicator series will provide a valuable resource to track progress with indicators providing a measure of adaptive capacity that will vary over time and be affected by other factors that can be analysed to inform future responses
– Indicators should address government policies and their efficacy and include the status of the various capitals (human, natural, physical, financial), resource use efficiency and alignment with markets and climate predictions

SOURCE: ACIL ALLEN CONSULTING

A.3 Summary of interview outcomes

Table A.6 through Table A.9 summarises the key issues captured during the Stream 2 stakeholder interviews. The issues have been distilled to thematic level, whilst maintaining a level of detail about the issue at hand. The tables are separated into the four questions that were posed to all interviewees.

What do you see as the main opportunities and risks that climate change presents for the agricultural sector?

TABLE A.6 INTERVIEW OUTCOMES: OPPORTUNITIES AND RISKS

Opportunities

Agricultural production
– Adaptation may improve resilience, sustainability and productivity of farms (e.g. lower input costs of new energy sources, improved energy efficiency, improved land use planning, incremental and/or transformational change)
– Increase the investment in Northern Australian agriculture as area may be more resilient to climate change

Resources/inputs
– Increase energy efficiency by using less energy intensive systems
– Increase water efficiency and irrigation systems
– Increase the use of renewables (solar, hydro, wind) to reduce costs

Economic
– Increase carbon market participation by reducing reporting burdens and simplifying methodologies
– Leverage Australia's agricultural 'clean and green' brand to increase international market share

Financial resilience
– Attract greater financial sector investment in agriculture
– Attract foreign/corporate investment in agriculture as this may be more resilient to total crop failure
– Increase carbon market participation to provide income diversification

Social and environmental
– Sustainable and resilient agricultural businesses can support regional communities and social infrastructure

R&D, technology, data and forecasting
– Provide farmers with the tools, data, and research to improve on-farm applications
– Improve long-term weather forecasting so agricultural businesses can make informed business decisions
– Increase farmer education and understanding of climate change, adaptation, new technology and research to drive adaptation and adoption of new methods
– More needs to be done to understand climate thresholds and tipping points, and the implications for agriculture

Risks
Natural resources
– Declining water quality and availability, contamination and competition for water resources amongst commodities
– Resource scarcity leading to cross commodity competition for water and land
– Adaptation ability may not be able to keep pace with climate change pace/impact
Production and output
– Falls in yield, output and quality of agricultural commodities
– An increase in marginal agricultural land and a fall in prime agricultural land
– Agriculture is susceptible to higher input costs (e.g. systems that heavily rely on energy)
Economic and social
– Depopulation of regional economies/ regions
– Loss of regions or towns that rely heavily on agriculture
– Exit of farmers and businesses from the industry due to financial stress
– Social licence to operate worsens, clean green brand diminishes, increase in activists and conflict
Climate and weather
– More extreme weather events (e.g. drought, flooding, cyclones, storms, heat waves)
– Seasonality changes are impacting production methods
– Fall in rainfall and soil moisture
– Increased threat to animal welfare (e.g. increased heat stress)
– Bio-security threats are expected to increase in a changing climate
Emissions and carbon farming
– Decline in international demand for Australian agricultural products due to emission standards and price
– Low carbon products may not be as in demand as thought - cheaper alternatives to low carbon products
– Loss of market share to foreign suppliers
– Reduction in area of productive agricultural land due to conversion to carbon farming

SOURCE: ACIL ALLEN CONSULTING

What do you see as the most important adaptation and/or emissions management approaches

TABLE A.7 INTERVIEW OUTCOMES: ADAPTATION/EMISSIONS/RESILIENCE APPROACHES

Adaptation approaches
Forecasting tools
– Increase the investment, research and product development of weather forecasting tools and data
– Improve the availability and useability of information platforms
Natural resource management
– Introduce strategic irrigation systems and strategic water systems (that incorporate data and forecasts)
– Water use efficiency initiatives
– Improving soil architecture and chemistry
– Biosecurity research initiative - strategic approaches where collaboration, research and extension are be targeted
Economic
– Income diversification - carbon market participation
– Improve fixed infrastructure for livestock and horticulture (e.g. shade houses, protected cropping)
– Long term investment in higher rainfall areas that may be better protected against climate change (i.e. Northern Australia)
– Invest in R&D - crop genetics, animal genetics, crop varieties

Mitigation approaches
Carbon farming, sequestration and carbon market participation
– Introduce an effective carbon market that is user friendly and scalable
– Improve carbon mapping technology
– Changing land use for carbon capture
Fertiliser use efficiency
– Reduce fertiliser use by adopting forecasting tools and incorporating data relating to soil chemistry, soil requirements and crop requirements
Energy
– Introduce and increase the application of energy efficient machinery
– Increase the adoption of renewable energy

Various emission reduction initiatives

- Methane capture in dairy/pork; change in feedstock; biomass sinks and biofuel; reducing fertiliser use; increasing fertiliser efficiency; no till farming
- Revegetating landscapes and reducing forest clearance

SOURCE: ACIL ALLEN CONSULTING

What are your key priorities, objectives and expectations for a nationally coordinated approach?

TABLE A.8 INTERVIEW OUTCOMES: COORDINATED NATIONAL APPROACH PRIORITIES

Priorities
Political/policy
– Increase the understanding and perception of agriculture and be more proactive in telling the narrative
– Communicate that the industry is in a transitory period and that change will take time
– Develop key goals and targets so there is greater capacity to engage people to work towards a solution
– The approach to adaptation needs to be incremental, persistent and timely because there's no single solution
Government approach
– The government must provide leadership and certainty based on clear objectives
– Needs to adopt a long-term vision that is bipartisan, endures beyond a single election cycle, and provides investment certainty to enable the private sector to mitigate climate risks
– Introduce policy that directs R&D through RDCs and other mechanisms to create both public good outcomes and private outcomes (e.g. fertiliser efficiency both reduces emissions and the cost to farmers)
Government and industry collaboration
– Regulation alone won't be effective - there needs to be an all-embracing, collaborative approach
– The current approach is too 'granular' and needs to be more 'across the board'
– A 'funding lottery' exists for some commodities
– Increase government and industry partnerships to deliver real change (e.g. in relation to biodiversity or the ERF)
– Greater inter-jurisdictional learning is required to reach consensus on the key climate issues to be focused on in the near term
– Coordination needs to be targeted and efficient, and not just for the sake of it
– It is essential to acknowledge that coordination is not 'cost free' – there are inherent time, money and resource costs
– Greater consultation with industry is required to determine appropriate funding arrangements
Research
– There are too many individual, fragmented research efforts/studies that prevent the development of effective policy on broad issues and shared priorities
– Fragmentation is also limiting public and private investment
– Better R&D knowledge transfer – there is a lot of research but it's fragmented by commodity
– Increase the transparency, identify duplication and increase the effectiveness of research

SOURCE: ACIL ALLEN CONSULTING

Are there particular issues to consider or proactive approaches that could be adopted to meet the challenges?

TABLE A.9 INTERVIEW OUTCOMES: PARTICULAR ISSUES OR PROACTIVE APPROACHES TO MEET CHALLENGES

Primary actions to take
Promote agriculture's value
– Increase government and industry proactiveness in promoting agriculture's narrative about what is being done in the industry
– The current perception of agriculture is poor/negative and needs to be turned into a positive to maintain social licence
Education
– Increase climate change literacy for farmers - dedicated resourcing for farmers to help them make better business decisions regarding climate change
– Improve their access to, and use of, these resources and tools
– On ground workshops and teams of advisers could assist in the extension efforts

Primary actions to take
Carbon market participation
– Carbon market credits are priced too low and the cost of participation is too high
– A simpler sequestration process and better funding access for these projects would be beneficial
– Emissions need to be benchmarked so the industry can discuss the issues and develop effective policy
Agriculture and finance
– Improve the banking and agricultural relationship – agencies like CRSPI could increase the climate literacy of the banking and finance sector (i.e. by addressing data projection consistency)
– Improve the financial sector's understanding of insurance and risk transfer of climate change, agricultural lending and parametric insurance
– Capital restrictions - farmers tend to be cash poor and are unable to access new equipment which limits their ability to adapt or mitigate
– Entice early adopters to drive the change and provide them with support and incentives
Research and development
– Provide greater support for industry advisers (who provide extension services) to educate farmers about research, methodologies and new technologies to drive adoption
– Increase community collaboration and drive adoption through the 'Champion Grower Model' where R&D is demonstrated on a Champion Grower's property to prove the benefits to existing farmers
– Entice early adopters to drive the change and provide them with support and incentives
Biosecurity
– Increase the awareness of the threat that climate change poses to biosecurity
Climate data and forecasting
– Increase the work done to identify the gaps in mitigation work, and explore opportunities for future mitigation
– Improve modelling accuracy – climate modelling is currently limited by the accuracy of inputs and lack of data networking
– Forecasting could be improved with the deployment of more sensors, better computer technology, and data transparency
– Improve forecasting and availability of information and data – there is no central depository for data sets

SOURCE: ACIL ALLEN CONSULTING

A.4 Summary of written submissions

The written submissions that were received have been summarised in the same broad format as the workshops/interviews. That is, by the way in which they address the four key questions posed to all stakeholders. Table A.10 through Table A.13 summarises the key issues arising from the written submissions.

What do you see as the main opportunities and risks that climate change presents for the agricultural sector?

TABLE A.10 WRITTEN SUBMISSIONS: OPPORTUNITIES AND RISKS

Opportunities
– Public good investment – the challenge will be how Australian agriculture can 're-boot' focus and investment on climate change adaptation and emissions reductions to fast track innovations and deployment
– A key focus should be on taking learnings from previous work and approaches, applying what's worked, not repeating past mistakes and applying a much more interactive and engaged response in the next decade
– Learn as we go - agile policy, research, development and adoption to capture data as events happen
– Carbon asset stewardship - if existing assets are well understood, monitored and protected, then this forms the base to which further sequestration can be added

Risks
– Productivity reduction and supply chain disruption - more effort is required in agricultural policy, research, development & adoption to maintain productivity
– Water availability pressures – arising from increased variability, challenging future demands and catchment behaviour no longer following long-term cycles
– Resource base condition and change - understanding and monitoring the base condition of the environment to better understand the response to a changing climate - need clarity around base resource condition monitoring between environmental, water and agriculture agencies
– Political risks – including inappropriate solutions with unintended negative impacts and risk, giving rise to political backlash and program volatility - there are four key lenses through which to view policy solutions and impacts (farm business, community/catchment, state, and industry/supply chain lenses) - impacts can be positive at one level, but have profound ramifications on other levels - need to seek a 'silver buckshot' approach rather than a 'silver bullet' and learn from the past
– Drought response – more severe droughts are anticipated due to climate changemaking it essential to learn how to improve preparation, response and recovery from drought episodes
– Mental health – an acceptance of climate change comes with discomfort for farmers as it undermines their hopes/dreams for the future
– Physical, policy and people – need to address physical climate change impacts; risks to agriculture due to policies; and risks around people's responses
– Biosecurity – changed climate, increasing drought periods and climate extremes can shift pest distribution, as well as opportunities for spread

SOURCE: ACIL ALLEN CONSULTING

What do you see as the most important adaptation and/or emissions management approaches that are currently in place or could be introduced in the future?

TABLE A.11 WRITTEN SUBMISSIONS: RESILIENCE/ADAPTATION/EMISSIONS APPROACHES

Adaptation
– Multiple approaches – requires a multitude of approaches - not just a carbon price signal
Resilience
– Extension and outreach - go to where the people are already working through people they trust. - needs to be well supported with sufficient training, with a skilled and driven 'Community of Practice' style approach to linking practitioners and researchers working on adaptation and emissions management across the whole of Australia

SOURCE: ACIL ALLEN CONSULTING

What are your key priorities, objectives and expectations for a coordinated national approach?

TABLE A.12 WRITTEN SUBMISSIONS: COORDINATED NATIONAL APPROACH PRIORITIES

Leadership
– National effort should focus on innovation and adoption/change. Clear accountabilities between federal, state governments, Rural RDCs, industry and farm businesses to ensure efficiency
– The role of leadership is to actively work across sectors to be applying best practice in all key industries

SOURCE: ACIL ALLEN CONSULTING

Are there particular issues to consider or proactive approaches that could be adopted to meet the challenges?

TABLE A.13 WRITTEN SUBMISSIONS: PARTICULAR ISSUES OR PROACTIVE APPROACHES TO MEET CHALLENGES

Primary actions to take
– Place particular scrutiny on the value of public investment to ensure a range of policy measures are utilised in working towards reducing emissions in agriculture
– Learning from the past, particularly the Carbon Farming Extension & Outreach Initiative and Climate Proofing Australia (Red Meat Advisory Council)
– Agriculture activities cover a vast range of technical disciplines, industries and farm systems so a multi-faceted response will be needed
– Carbon offset dumping ground for big emitters: there needs to be a strong focus on regional and rural development not a situation where large industrial scale emitters seek to use the rural countryside as their carbon offset

SOURCE: ACIL ALLEN CONSULTING

A.5 Research findings and jurisdictional issues identified under Stream 1

Table A.14 lists the issues identified in as part of the Stream 1 research work and through feedback from jurisdictions. The issues are reported at a thematic, condensed, issue specific and (in some cases) verbatim response level. All issues listed have been included in the analysis conducted in Chapter 2 of this report.

TABLE A.14 OPPORTUNITIES AND RISKS IDENTIFIED DURING STREAM 1 WORK

Theme	Issue	Detail
Input costs/availability	Change in streamflow	There needs to be a focus on streamflow, and the challenge changing streamflow presents to the agricultural sector, especially irrigation (as distinct from rainfall itself). Groundwater is also a very important emerging issue for the sector.
Input costs/availability	Water access	Access to 'new' water (groundwater, out-of-season rainfall, water from other industries (i.e. energy/coal)).
Input costs/availability	Water availability	Issues relating to water availability are important. As recent developments in the MDB have shown, water access and availability is a key issue for agriculture. How climate change will on impact river systems and water availability is important.
Input costs/availability	Water availability	The future availability of water needs to be considered in detail, especially as it relates to irrigated crops.
Input costs/availability	Fertiliser application	Need to explain why use of fertiliser may increase in future, and/or may decrease as a risk mitigation strategy.
R&D	Opportunity for adaptation benefits in Northern Australia (starting from low base)	Differences in income explain more about the profit gap, between the average and the top 25 per cent of farm performers, than do expenses. Nearly all differences in income between grazing herds are attributable to productivity differences. Nearly all productivity differences between herds can be attributed to the better performers achieving: – higher reproductive rates – lower mortality rates – heavier sale weights. Such findings suggest that there is considerable potential for adaptation in the northern industry because base case productivity is low. Furthermore, industry does not face the pressures of declining rainfall and change in rainfall seasonality as in the south.
Climate models	Improve modelling performance past 2030	There is a need to address model problems and how to improve modelling beyond 2030 time horizons. Up to 2030 we have useful information to help drive planning.
Climate models	Rainfall models past 2030 not clear	Temperature trends are clear. Rainfall trends separate out after 2030 – need to better understand how to incorporate and plan for this variability.

Theme	Issue	Detail
Climate models	Climate change planning horizons	The 2030 time horizon is too short and needs to be pushed out to at least 2035. Fifteen years aligns more realistically with farm planning time horizons. It also recognises the time taken for research to be funded and delivered, and that the adoption of new technologies can take up to 30 years.
Climate models	Alignment of NRM cluster boundaries and modelling	Not only do the NRM cluster boundaries not align with jurisdictional boundaries, this approach doesn't align with agricultural production regions or reflect local-scale climate conditions that drive local production systems. State governments are working (independently) to fill these gaps and are looking to coordinate projection models and data delivery systems to increase efficiency.
Climate models	Information of extreme, discrete events	In addition to the weakness in the NRM cluster approach, there is also a lack of information on extreme/discrete events or particular climate parameters (e.g. chilling hours) that determine suitability for a selected commodity. Historically, much of the modelling and information outputs have targeted the needs of extensive industries like grazing and grains, rather than intensive or more 'niche' industries (which, while they occupy vastly smaller land areas, offer much greater returns per unit area). As a result, there is little to support actual decision making by farm managers in many industries.
Climate models	Coastal inundation and seawater intrusion for irrigation	This is an important climate related factor for sugar production that also applies to other coastal production systems (i.e. coastal inundation and seawater intrusion into irrigation systems, aquifers etc.). Information on the likely extent of the issue would be helpful – including possible identification as a priority research issue.
Cross-sector collaboration on R&I	CRSPI status	There are divergent views as to the success, or otherwise, of CRISPI. Some stakeholders believe it has stagnated and is no longer delivering against its objectives. Conversely, other stakeholders consider the recent adoption of the third phase of the strategy could generate momentum to deliver on CRSPI's purpose.
Collaboration and coordination	Roles and responsibilities for Climate Change	COAG 2013 had an agreement on climate change - 'Roles and responsibilities for climate change adaptation in Australia'.
Collaboration and coordination	Adaptation working group (cross jurisdiction collaboration)	Cross-jurisdictional collaboration is facilitated by the Adaptation Working Group and related activities, such as Victoria's Sector Adaptation Workshop in May 2018 which presented on the process, progress and lessons from the work. This can be a valuable resource which could be utilised further.
Collaboration and coordination	Collaboration opportunity	There is a significant opportunity for further and improved collaboration.
Emissions management	On-farm emission reduction opportunities	The emerging R&D opportunities/issues do not cover stock feed management to manage changing climate and to reduce emissions: – how the feed base needs to be managed and additional supplements/additive options – manure management to reduce emissions and re-use – increased use of bio-digestors to reduce emissions and create energy options – genetic solutions and delivery of genomic breeding values – heat tolerant *Bos taurus* animals. Need to address the development of systems to better utilise the feed base and improve productivity and profitability through reduced input costs.
Emissions management	Irrigation development to increase productivity	Need to reflect the Tasmanian Government's plan to grow the annual farm gate value of the agricultural sector to $10 billion per year by 2050, underpinned by ongoing investment in the development of new irrigation schemes. Irrigation development is a strategy to both increase productivity and assist adaptation by providing increased water surety for agriculture, taking advantage of Tasmania's relatively abundant water resources (approximately 12 per cent of Australia's rainfall in less than 1 per cent of Australia's land area).
Land use competition	Land use and offset policy	A key risk if land is used for carbon sinks by large emitters instead of reducing emissions at source. At some stage farmers/agriculture may be those needing the land sinks to balance against remaining (but lower) emissions from CH_4 and N_2O.
Social considerations	Rural mental health	Need to address the issue of rural health/mental health. Another key issue is clarifying 'accountabilities' between governments, industry, farmers etc.

Theme	Issue	Detail
Social considerations	Rural adjustment/social dislocation	Since deregulation of most agricultural commodities and exposure to export markets, economically sustainable businesses continue to grow in size on average, whereas smaller and less viable businesses have exited the industry. In the short to medium term this trend is likely to continue, in part driven by climate change impacts. There is also a range of broader social costs which might be exacerbated by climate change impacts. These include: – community development and sustainability - community social cohesion, participation in community organisations and the availability of key services – residential mobility - household members' rates of mobility out of an area, including mobility between rural areas – financial wellbeing - household incomes, levels of financial hardship and changes in financial position – employment – economic impact on farmers – family relationships - relationship separation, the quality of couple relationships; family functioning and family conflict;, mental and physical health. However, there is surprisingly little large-scale quantitative analysis of the social impacts of drought[8] (and climate change impacts more broadly).
Economic implications	Financial challenges	Need to address the financial challenges facing agricultural operators to meet emissions reduction targets. There is considerable evidence from prediction modelling regarding economic impacts, such as loss of production and decrease in value of produce. However, every decrease over time in farm profitability means a potential decrease in the financial ability of farmers to implement systems that will help meet emissions reduction. This is an area/issue that might be further investigated.
Economic implications	Global markets	Global markets have not been included in the economic analyses of the Stream 1 report - these will be very important considerations in understanding the risks and opportunities for agriculture from climate change as production and markets shift. Global market changes/impacts should be addressed in the Stream 2 report.
Economic implications	Business model and capital infrastructure decisions	Conclusions relating to protected horticultural systems seem to have an 'optimistic' spin. Closed greenhouse environments/protected cropping are still a very small proportion of horticulture production with significant constraints. The potential to 'migrate' is not consistent e.g. the long time to maturity, and even longer to cost recovery, for tree fruit crops verses annual vegetables. There are significant constraints that must be addressed (sunk investments into bespoke infrastructure, costs of new plant/relocation etc.).
Economic implications	Economic implications arising from impacts on production	There are many factors in production that may influence the overall impact of climate change on yield and productivity (e.g. impacts on quality and therefore marketability and price); seasonal shifts in production, potentially affecting market windows, competitive advantages and price; and changed distributions of pests and diseases which bring increased costs of management and challenges for export market access). Analysis of these factors (which will apply across all agricultural commodities) is an issue for the opportunities and gaps analysis.
Economic implications	Economic impacts due to changes in productivity	The focus on yield and productivity obscures other critical effects, such as impacts on quality (and therefore marketability and price); seasonal shifts in production (potentially affecting market windows, competitive advantages and price); changing consumer preferences; and changed distribution of pests and diseases (bringing increased costs of management and challenges for export market access). Equally important, it also excludes the effects of drought and storms and other extreme weather events/shocks which are increasingly important in terms of their economic impact on agriculture. These issues and their economic impact need to be explored further.

[8] Australian Institute of Family Studies, *Social and economic impacts of drought on farm families and rural communities*; Submission to the Productivity Commission's Inquiry into Government Drought Support; Prepared by Ben Edwards, Matthew Gray and Boyd Hunter https://www.pc.gov.au/inquiries/completed/drought/submissions/sub092.pdf

Theme	Issue	Detail
Economic implications	Economic impacts associated with reducing emissions	Jurisdictions and individual agricultural commodities will fare differently assuming there is pressure to reduce emissions from agriculture. The simple relationships assumed in Stream 1 (that is any emissions reduction will be met by reducing production, and this will have no impact on prices, or result in leakage) needs to be further explored - given it will not hold in reality. Producers will have the capacity to intensify production or modify management to reduce emissions intensity per unit product; and landholders may switch to alternate commodities which will result in nett emissions changes etc.
Economic implication	Economic impacts associated with reducing emissions	The most emission intensive sectors in agriculture are cattle and milk (due to dairy cattle). There are many factors at play which will affect the economic impact of any required actions to reduce emissions. These include, amongst others: – decisions as to what extent agriculture contributes to the overall national target – the relative splits across the agricultural sector itself (it cannot be necessarily assumed that each commodity would need to reduce its emissions by a proportionate share) – the extent to which emissions reduction can occur concurrent with maintained or increased productivity – other factors such as water availability, trade demands and the financial constraints of individual operators to meet target expectations. The Stream 1 analysis in relation to emissions reduction assumed impacts were in effect 'ring fenced' from the earlier analysis relating to productivity losses. In reality the two are fully intertwined with one offsetting the other. These considerations will be explored further as part of the opportunities and gaps analysis in Stream 2.
Economic implications	Economic impacts	The economic implications for each jurisdiction have been analysed for key commodities. The assumption underlying the analysis is that changes in productivity and yield will directly and proportionately flow through to value. It is accepted that this approach oversimplifies and possibly overstates the impact. The analysis is essentially an extrapolation of biophysical impacts rather than economic modelling per se. The modelling does not consider demand side effects, nor does it address changes in global markets which may have a significant impact on the value (both positive and negative) as future import/export opportunities play out. As indicated above, there are many factors in production that may influence the overall impact of climate change on yield and productivity. Analysis of these factors is an issue for the opportunities and gaps analysis.
Economic implications	Economic impacts	There are a range of other outcomes with economic implications flowing from the impacts of climate change which add further to the complexity of the assessment. These include building resilience to address increased climatic extremes, in particular drought and flood; the implicit or explicit pricing of carbon and carbon price signals; rural adjustment, in part driven by climate change impacts; and broader asset valuation issues.
Economic implications	Trade risks	Trade risks need to be expanded upon given they are an important risk.
Economic implications	Change in farming system in MDB	The wheat industry is not likely to be able to rely on technical adaptation alone, especially if confronted by drought impacts on cash flow. It will need to consider both changes in farming system and changes in occupation. The number of smaller and less profitable operations could fall quickly, presenting a transformational adaptation and resettlement challenge to the government. Given known trends in water availability, the same trends could be present in smaller properties relying on irrigation water in the southern MDB.
Economic implications	Declining productivity impact on gross margins	Need to consider the impact of declining productivity on gross margins, profitability and thus survivability in the sector. Small declines in productivity can have a disproportionate impact on gross margin and profit. One useful output could be an estimate of how far productivity can decline under climate change at constant prices, before the crop is not viable to produce with today's technology.

Theme	Issue	Detail
Economic implications	The value of carbon	Given the commitment to reduce overall emissions by all jurisdictions, there will be a continuing focus on total emissions generated by agriculture, and further measures which might be taken to abate those emissions. Abatement will in effect result in an implicit price on carbon, even in the absence of a more formalised market mechanism. There is a wealth of anecdotal evidence that many businesses are now factoring a 'carbon price' into their triple bottom line decisions, along with its economic implications for valuations, capital assets etc. Leading-edge farm business already adopt this approach, and there will be continuing pressure from key service providers, particularly the banking and insurance sector, to require the integration of 'carbon pricing' as part of ongoing agricultural business practice. Carbon price signals, such as those generated by Australian Carbon Credit Units issued by the Clean Energy Regulator for each tCO_2-e stored or avoided by a project, are likely to become important market signals for agricultural operations. They may also generate more interest in carbon farming approaches which can be incorporated within an agricultural business or be an agribusiness in itself. However, increased interest could result in land use competition in certain instances (and the potential conversion of productive agricultural land). Carbon farming may provide the opportunity to diversify income streams, for example by undertaking an ERF project, and build economic resilience while also delivering productivity benefits to the primary agricultural practice (i.e. improved pasture and crop productivity; manure management can reduce costs; tree belts can enhance productivity of livestock and crops). The resilience building activities encouraged by ERF methods, including vegetation, will be explored further in Stream 2 work.
Economic implications	Valuation	Agricultural producers have a strong understanding of the impacts of seasonality, soil replenishment (or fallowing), and other practices on the value of their assets and their capacity to produce. There is also a growing awareness and acceptance that both planning and investment is required in the medium-term in preparing for drought, flood and cyclones. These assets form part of the farm capital value. Climate change impacts will bring the value of these assets, and other adaptation initiatives, into sharp relief. The scarcity of water in particular will become an important factor in valuation. A property with secure water resources and suitable land will increase in relative worth in comparison to those lacking such assets.
Business and farm planning and adaptation, and extension services	Realistic management options for farmers	The scope for sectoral, industry or regional adaptation plans may be unlimited, but they also tend to be of little use (so far). One reason is that most existing plans don't address the needs of actual decision-makers, which are the farm business owners/managers rather than industry bodies, government agencies, Rural RDCs, R&D organisations etc. This limitation needs to be noted, otherwise it will never be addressed/overcome. The other is that likely adaptation actions include changing commodities or regions, and these aren't supported by commodity-based or regionally-based plans that are the norm under the existing fragmented industry structure.
Business and farm planning and adaptation; extension services	Potential adaptation benefits for Northern grazing systems	The trends in southern livestock systems are very different from those in the north, where productivity is low but rainfall is slowly increasing, albeit with increasing temperatures. The northern Beef industry represents almost half of the total beef industry and, despite financial challenges and markets, it does have potential for adaptation using very simple techniques, such as increased watering point density and fencing for heifer management. A slow decline in productivity is not necessarily what will occur in northern systems. MLA found that management, rather than climate or other factors, was key.[9]
Business and farm planning and adaptation; extension services	Adaptation planning	The NT does not have an agricultural adaption plan – rather it contributes to research, development and extension on adaption wherever it can.

[9] file://upvvirtclus01fs/Users$/A18051/Profile/Downloads/B.COM.0348_Final_Report.pdf

Theme	Issue	Detail
Government actions	Role of the political environment	Need to emphasise the role of the political environment in shaping industry research priorities. For example, between about 2005 and 2012, there were numerous advanced climate change research programs across the Rural RDCs, state agriculture agencies, and also industry bodies funded by other sources. Changes in governments and political appetite for climate change saw these programs cut or eroded. The altered appetite flowed through to Rural RDC strategic planning, where climate change was downplayed as a strategic research priority. Horticulture Innovation Australia is a particularly strong example, where this change in environment overlapped with the review and restructure, resulting in climate change essentially disappearing from the work program. Even now climate change may be recognised as a challenge or threat in industry strategic investment plans, but rarely as an R&D priority, or is watered down to be less politically sensitive. The mechanism leading this change has ranged from simple disinterest, funding cuts/changes, to direct politically-driven obstruction. It is also reflected in the change of 'CCRSPI' to 'CRSPI', the end of NCCARF etc. The fragmented industry investment plans do not help, with inconsistency and difficulty in addressing climate being a cross-industry issue (which was handled relatively better in the former Horticulture Australia Limited and their 'across horticulture' program). In short, this review must acknowledge political motivations, the lack of policy consistency, and the lack of bipartisan support for climate change R&D as the main reason for the current state of play (this applies just as much at the state government level).
Government actions	Policy responses and issues	A poor policy response will burden farm businesses with additional costs; result in a drop in agricultural productivity; disrupt regional communities; potentially lose export market access; and undermine Australia's carefully-crafted but extremely fragile 'clean and green' image used in international marketing. It is critical for the review to highlight these kinds of interactions.
Risk management frameworks	Application of risk management frameworks	The risk management matrix is more of a framework/guideline than a digital resource. While the matrix may not necessarily have been developed with cross-jurisdictional engagement, its application is not restricted to Queensland.
Biosecurity	Livestock - disease and pest distribution	Increasing temperature may also increase exposure and susceptibility of animals to parasites and disease especially vector-borne diseases. However, the potential impact of climate change on parasite populations and the subsequent effects on animal production is as yet not well understood, and therefore difficult to project.
Biosecurity	Biosecurity risk and change in pest and disease distribution and their linkage with national strategies and programs	Biosecurity risks need to be stressed (and not just for horticulture). There is a significant risk across all agricultural commodities in relation to pests and diseases changing distribution under a changing climate; the introduction of novel pests; changes in insect pest generation times etc. which will generate greater management costs; chemical use issues; and implications for marketability and market access. Need to build links to national biosecurity strategies and programs. Biosecurity is a key issue for industry going forward.
Biosecurity	Potential risk of tropical pests and diseases	How a warming trend will impact the incursion risk or spread of a disease or pest on horticulture – needs to be explained. Need to consider the potential risks of tropical pests and diseases spreading to areas previously immune from such outbreaks, or the possible frequency of outbreaks appearing in horticulture in more southern regions of Australia.
Productivity decline	Impacts on cotton production	The simulations of cotton production showed that changes in the influential meteorological parameters caused by climate change would lead to decreased future cotton yields without the effect of CO_2 fertilisation. By 2050, the yields would decrease by 17 per cent. Including the effects of CO_2 fertilisation ameliorates the effect of decreased water availability and yields increase by 5.9 per cent by 2030, but then decrease by 3.6 per cent in 2050. Importantly, it was necessary to increase irrigation volumes by almost 50 per cent to maintain adequate soil moisture levels. In addition, the study advises that the physiological response of plants to climate change needs to be better understood to avoid making inaccurate projections of yield and potentially constraining investment or increasing risk. In general, cotton production enterprises are relatively adaptable in years of water limitations as they already practise a high degree of water efficiency. However, a combination of increased incidence of drought and reduced stream flows is likely to impact on production going forward.

Theme	Issue	Detail
Productivity decline	Horticulture yield and productivity	Australia's fruit and vegetable growers already deal with a highly variable environment. A large proportion of fruit and vegetable production in Australia is irrigated and many crops are susceptible to small changes in temperature (in terms of overall productivity and quality, as well as growing season). However, that proportion of the produce which is grown in closed greenhouse environments will be less exposed to climate change impacts (provided energy and water remain available, and are priced at a level that allows the crop to be economically viable). Annual horticultural crops also have the potential to 'migrate' with temperature change subject to land availability, competing land uses and water availability, but 'tree' crops (which have an average productive life generally measured in decades) will have less flexibility. As a high value per hectare crop, horticulture is likely to displace other agricultural sectors, but faces encroachment challenges from urbanisation etc. Accordingly, there are many factors in production that may influence the overall impact on yield and productivity. For many products the one-off impact of climate variability in a season (or disease) can cause major losses of 30 to 100 per cent. Modelling of the impacts of high temperature climate scenarios on vegetable gross margins determined that reductions in yields (against the 2010-12 baseline) were between 20 to 50 per cent.[10]
Policy	Meat and livestock carbon neutrality by 2030	The Australian Beef Sustainability Framework is a contemporary sectoral approach that considers climate change and tracks indicators over time. The framework was developed in collaboration with stakeholders to meet changing consumer, customer, investor and stakeholder expectations. The framework is dependent on whole sector collaboration and uses meaningful metrics to track progress over time.[11] MLA have released a report indicating Australia's red meat industry can be carbon neutral by 2030.[12] This research and other material will be considered further as part of the opportunities and risk analysis.
Policy	Policy framework	While there is considerable action, the lack of an overarching framework to bring together both adaptation and emissions reduction efforts has led to a lack of consistency and no enduring long-term approach. This issue is often exacerbated by marked directional changes before outcomes can be realised and has resulted in a confused and disjointed set of responses. There are a number of models which could be readily adopted (e.g. the 2018 National Drought Agreement) as a template to drive this agenda going forward through Stream 2 and 3 work.
Other	Building resilience	Increased climatic extremes, in particular drought and flood events, will increase the risk profile of all agricultural industries. The viability of the agricultural sector is dependent on individual businesses' ability to manage increased climatic variability through medium to long-term preparedness planning and risk assessment. The development of assets to mitigate the risk may require additional capital investment (e.g. in terms of drought - improved water utilisation technologies for water intense sectors such as horticulture, cotton and grains; feed grain or hay storage facilities; redevelopment of pastures that are more resilient in longer dry periods; or the introduction of better adapted cattle breeds such as Brahman's or Droughtmaster). Climate change will also result in increased/changed exposure to other risks such as biosecurity incursions. Producers will need to manage all risks over a longer time horizon than individual seasons, or years. This may require a new approach to how farm business enterprise plans are developed, how infrastructure is funded, and greater utilisation of financial risk instruments.
Other	Change enterprise mix or relocation of business	A further issue is that adaptation actions may include changing commodities or regions, and these approaches are generally not supported under commodity based or regionally based plans (currently the norm).
Other	Findings from Victorian Climate Initiative	Additionally, the recent Synthesis Report submitted to the Victorian Government could provide further information in relation to adaptation possibilities.[13]

[10] Rogers, G & Montagu, K. (2013) Understanding and managing impacts of climate change and variability on vegetable industry productivity and profits. Applied Horticultural Research Pty Ltd.

[11] Sustainability Working Group (2018) Australian Beef Sustainability Framework. Accessed 20 February 2019, file:///C:/Users/dlord/Downloads/Australian_Beef_Sustainability_Framework_2018_Brochure.pdf

[12] Dianne Mayberry, Harriet Bartlett, Jonathan Moss, Stephen Wiedemann, Mario Herrero; CSIRO: 3, April 2018, Published by Meat and Livestock Australia Limited; Greenhouse Gas mitigation potential of the Australian red meat production and processing sectors

[13] Hope, P, Timbal, B, Hendon, H, Ekström, M, Potter, N. 2017. A synthesis of findings from the Victorian Climate Initiative (VicCI). Bureau of Meteorology, 56pp, Australia)

Theme	Issue	Detail
Other	Averaging change in regional winners and losers is dangerous	The productivity/economic conclusions for wheat do not account for increasing climate extremes and variability. The conclusion should mention that the averaging of regional winners and losers across Australia is dangerous.
Other	Difference between incremental and transformational change	Need to address incremental verses transformational change, and limits to adaptation. In some scenarios, some industries and regions are likely to require transformational change (including moving out of agriculture).
Other	Trade-off between regions that benefit and lose from climate change	Assumption around average annual productivity losses (i.e. 0.1 per cent per year loss in productivity) do not tell the full story. Some areas, like Tasmania, are likely to increase productivity which will offset changes in other areas. Also need to consider the ability of dairy farmers to adapt to heat events (as per Henry et al 2018).

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