



Managing Climate Variability Research and Development Strategy, 2008–2014

Goal To help farmers and natural resource managers manage risks and exploit opportunities given Australia's variable and changing climate

- By**
- Improving forecasting accuracy, lead-time and ease of use
 - Providing tools and services for managing climate risk
 - Increasing adoption of climate risk management

The Managing Climate Variability strategy focuses on investments which increase forecasting accuracy, build the predictive capability of key attributes such as soil moisture, and develop tools which translate climate forecasts and resource attributes into decision support tools for primary industries and natural resource managers.



The strategy responds to the predictions for Australia made by the 4th Assessment Report by the Intergovernmental Panel on Climate Change (IPCC, 2007) of:

- Reduced precipitation and increased evaporation, meaning water security problems are projected to intensify by 2030 in southern and eastern Australia
- Significant loss of biodiversity occurring by 2020 in some ecologically-rich sites including the Great Barrier Reef, Queensland Wet Tropics, Kakadu wetlands, south-west Australia, sub-Antarctic islands and the alpine areas
- Coastal development and population growth in areas such as Cairns and south-east Queensland increasing risks from sea-level rise, storms and coastal flooding by 2050
- Production from agriculture and forestry by 2030 declining over much of southern and eastern Australia due to increased drought and fire
- Having substantial adaptive capacity due to our well-developed economy and scientific and technical capability, but facing constraints in natural systems to adapt and being challenged by extreme events

Australian agriculture can best adapt to a changing and more variable climate through decisions at the timescales (seasonal, annual, decadal) of the enterprise.

Robust climate risk management requires:

- 1) More reliable forecasting
- 2) Tools translating these forecasts into applications
- 3) Knowledge exchange to foster adoption and improve management

Water storages are predicted to become even less reliable as Australia's climate becomes more variable under climate change.

Building on a 15-year track record

With its origins in the 1992 National Drought Policy, Managing Climate Variability was created by a partnership of rural research and development corporations to increase Australia's capacity to capture opportunities and manage risks related to climate variability.

Over the last 15 years the research program has broadened in focus beyond drought to climate risk management.

Managing Climate Variability research has substantially contributed to:

- The Bureau of Meteorology's Predictive Ocean Atmosphere Model for Australia, which simulates the interactions between the ocean and atmosphere to provide forecasts up to nine months ahead
- The Queensland Department of Primary Industries and Fisheries package, RAINMAN, and its Streamflow module, which provides farmers with probabilities of rainfall at a particular time and location
- AussieGRASS and other pasture prediction tools that provide information so graziers can assess the likely pasture growth and soil moisture outlook
- Yield Prophet®, Whopper Cropper and related agronomy tools, which incorporate forecasts to provide growers with information about the likely benefits for crop yield and quality of various management decisions
- The National Agriculture Monitoring System with its Australia-wide role in assessing the Australian Government's Exceptional Circumstances program
- Extension services for climate risk management that increase farmer understanding and use of tools and techniques for seasonal forecasting
- Making climate data more accessible through tools such as SILO, which compiles and makes available relevant meteorological information

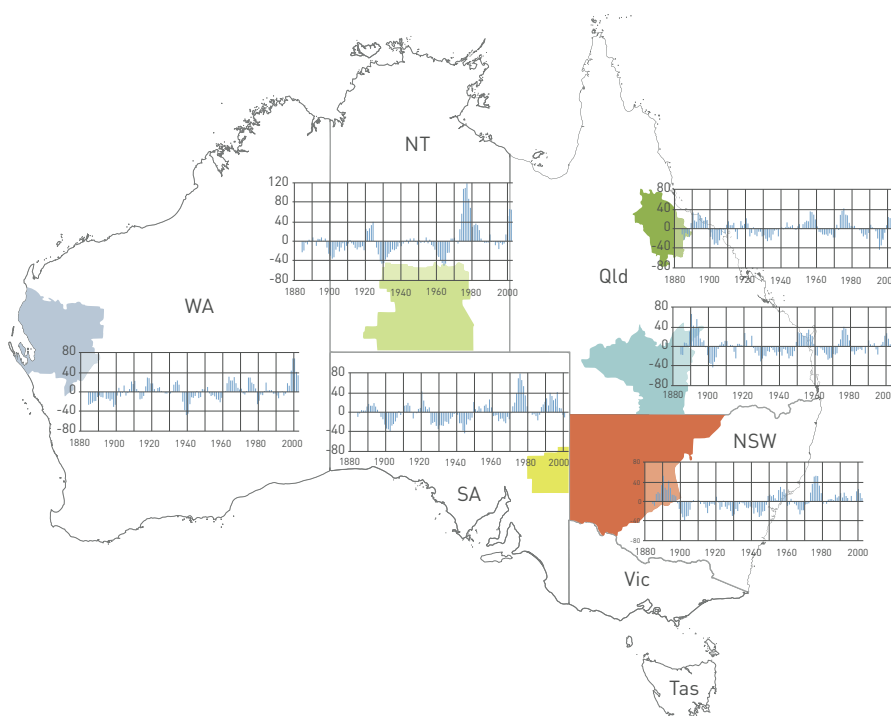
Independent evaluation in 2007 by Agtrans Consulting identified a return of \$444.65 million on an investment of \$93.87 million by Managing Climate Variability, delivering to date a 4.74:1 benefit-cost ratio from this 15 year investment.

Across Australia, annual rainfalls vary widely from the 'average'. With our variable and changing climate, the concept of average rainfall has limited application.

Source:

McKeon G.M., Hall W.B., Henry B.K., Stone G.S. and Watson I.W. (2004). *Pasture degradation and recovery in Australia's rangelands: Learning from History*. NRSc publishing, Queensland Natural Resources, Mines and Energy.

Henry B.K., Carter. J.O., Day, K.A., McKeon G. M. and Bruget D. (2004) Management of climate variability in extensive grazing systems. *Proceedings Outlook 2004 Conference*, 2-3 March 2004, Canberra.



Meeting climate variability challenges in a changing climate

Our task is to provide Australia's farmers and natural resource managers with skills for managing our variable climate. We must achieve this within the broader contexts of climate change and emissions control.

The Intergovernmental Panel on Climate Change (IPCC, 2007) predicts that our Australian climate will:

- Become even more variable, with temperature, wind and rainfall affecting evaporation, frost frequency and severity, soil moisture and water availability
- Be less predictable, making forecasts based on historical data less reliable
- Experience greater frequency of extreme events—droughts, floods, storms and cyclones, with consequent management implications for natural resources, water supply and agriculture such as soil erosion, nutrient loss, and deep drainage
- Shift the geographic opportunities and constraints for primary production and natural resource management

For primary production and natural resource management to be profitable and sustainable under an increasingly variable climate more precise forecasts are essential. Such forecasts—at the time of year decisions are made and in a form that is locally relevant—are essential.

Managing Climate Variability is investing in research that delivers improved forecasts that help Australian agriculture and natural resource management to adapt to an increasingly variable climate. It is doing this by:

- Linking with long term climate change science to help develop global circulation models that more accurately represent Australia's climate drivers and are better able to predict seasonal climate conditions
- Using forecasts to predict key biophysical attributes, such as soil moisture and runoff
- Providing tools that incorporate forecasts and projections for biophysical attributes that can feed into the decisions users need to make to better adapt to Australia's changing climate

These tools focus on practice opportunities that deliver benefits across profitability, sustainability and carbon mitigation. New practices that help resource users manage their climate risk are also likely to deliver a reduced greenhouse gas footprint.

Managing Climate Variability research is delivering now and in the future. We are generating knowledge that is of immediate use to primary industries and natural resource management as they adapt to climate change, as well as investing in knowledge and tools for a more climate-resilient Australian economy.

Masters of Climate:

Supporting champions of climate risk management

For primary producers and natural resource managers, adapting to climate change is achieved by improved responses to Australia's variable climate, such as adopting new practices and plant varieties, changing land uses, and using forecasting to develop profitable synergies between practice and production.

Managing Climate Variability is supporting leading farmers, agricultural advisors and natural resource managers through the Masters of Climate initiative. Leaders are supported through training and access to experts and relevant knowledge to champion further industry uptake of climate risk management tools, skills and information.

The initiative has been trialled in three regions in a very successful collaboration between Managing Climate Variability, the Bureau of Meteorology, the Bureau of Rural Sciences, Birchip Cropping Group, Meat & Livestock Australia and state agriculture departments.

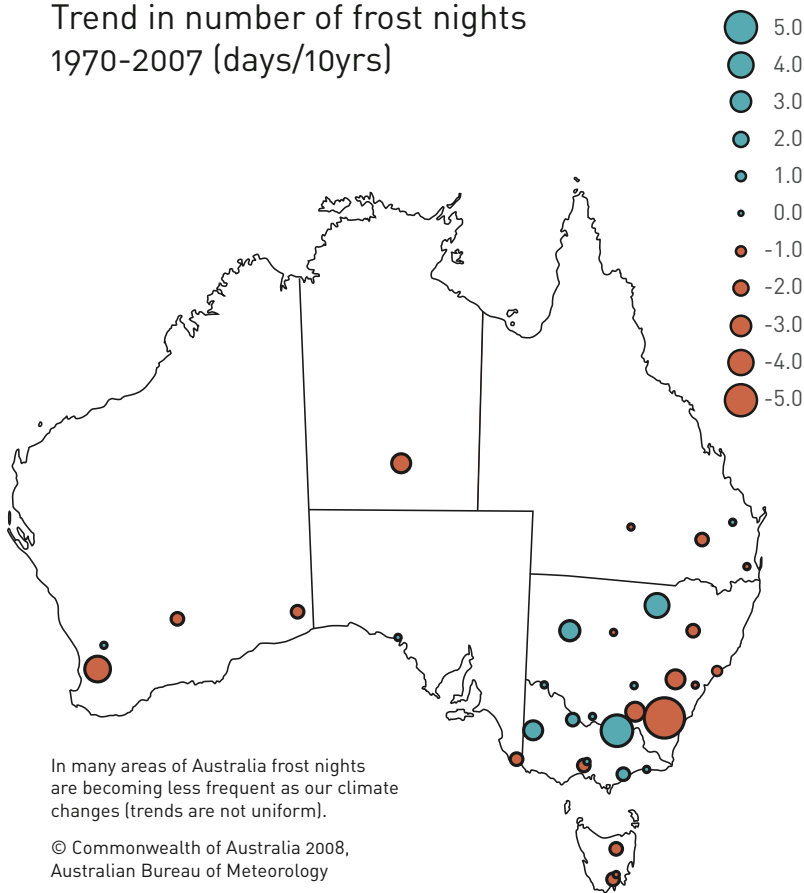
Producers based in the Victorian Mallee, South Australia (principally Eyre Peninsula) and the North-East Agricultural Region, (east of Geraldton, Western Australia) have participated in the pilot. Masters workshops held in each region identified the key concerns and information needs for farmers in the region and the support that leading farmers, agricultural advisors and natural resource managers would need to be Masters of Climate.

Producer groups in these regions then hosted well-attended farmer forums to address the key information needs and concerns of their producers, including: the drivers of climate, what recent seasons in the region indicate, adaptation opportunities and mitigation options.

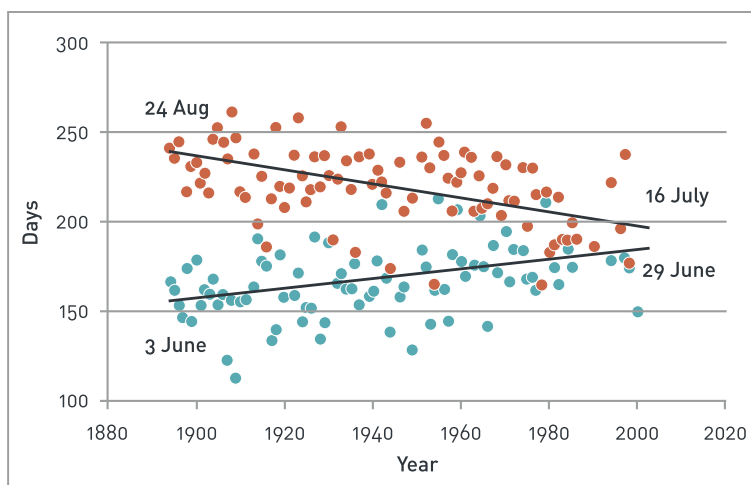
In next stage, the Masters of Climate team will work with leading farmers and agricultural advisors for major commodity groups and regions across Australia. By 2010 Managing Climate Variability aims to:

- Support at least 25 to 50 Masters of Climate farmers and agricultural advisors from across Australia who are willing to proactively interact with other farmers and agricultural advisors in their region about managing climate risk
- Extend the farmer forums across Australia in close cooperation with the Masters of Climate and in partnership with producer groups, natural resource bodies and commodity groups

Trend in number of frost nights 1970-2007 (days/10yrs)



Frost frequency in Emerald



Frost frequency for Emerald is declining, creating opportunities for some crops and limitations for others.

Source: Bureau of Meteorology

- first frost day of the year
- last frost day of each year

Investment principles

Our investment is guided by the following principles:

- **Capitalise on global science investment and findings**

The massive global investment in the science of climate change is to Australia's benefit. We are identifying opportunities to build on international findings, link to international activities, and increase collaboration with international research agencies.

- **Link with other relevant initiatives for co-investment**

There are a multitude of research initiatives and programs looking at climate change. We define the topics for investment in this strategy to focus the science on climate variability; the key to adaptation. We also identify synergies with other programs and initiatives and opportunities for co-investment.

- **Provide knowledge to meet need**

The knowledge needs of Australia's agriculture, water and natural resource managers vary in topic, scale and timeframe. We have canvassed commodity groups, water authorities, and natural resource groups to identify opportunities likely to deliver a high return on science investment.

- **Build on the knowledge available**

Australia is recognised internationally as a leader in applying forecasting skill to benefit agriculture. We are capitalising on prior investment.

- **Realise the benefits of an integrated investment portfolio**

Identifying interdependencies and interactions between research investments is challenging. An important part of our strategy is a conceptual framework for integrating projects, sharing data across projects, identifying the pathways to adoption, and allocating resources for maximum benefit.

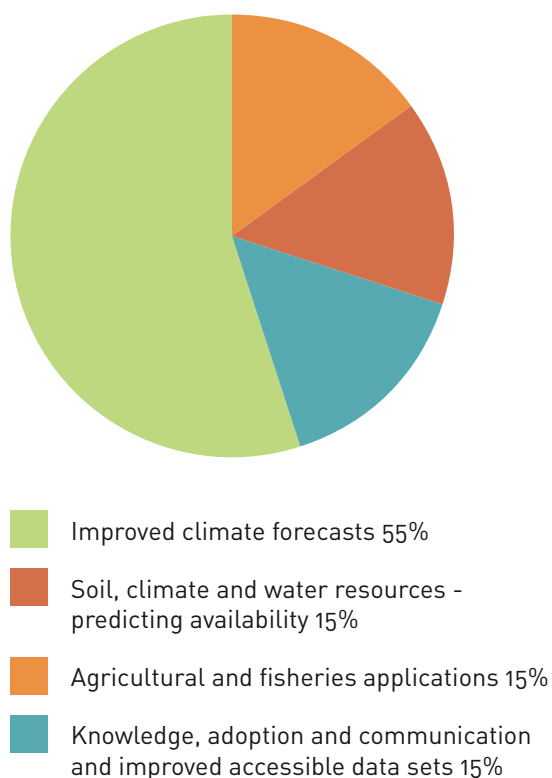
- **Allow partners to invest selectively**

All industries face a variable and changing climate and can benefit from climate science research. We can build commodity-specific applications and adaptation strategies more cost-effectively on that base science. Our partners gain all the benefits of an integrated program while remaining targeted in their investment.

- **Foster science partnerships**

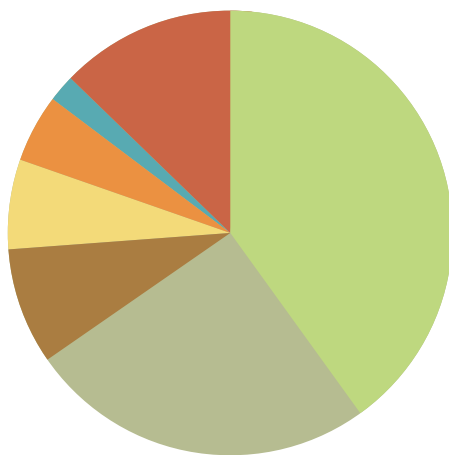
Much of Australia's science is done by multi-disciplinary consortiums across institutions. We are the vehicle for negotiating joint investments with Australia's leading science providers.

Proportion of investment in each theme





Reasons farmers give for not using forecasts when making decisions



- The information is unreliable
- The information is not specific enough for my region
- The information is not timely
- The information is not practical
- The information is not relevant to my industry
- The information is too complex
- Other

Focus on user needs:

Farmers want more reliable and specific forecasting information

In a 2007 survey to assess the forecasting needs of farmers, we found that 17 per cent of farmers still did not use forecasts to make decisions. The two main reasons for this result were their perception that the information was not reliable enough or specific enough for their region. While most farmers do use forecasts to make decisions, these forecasts need to be improved to deliver more reliable results.

The majority of farmers want reliable forecasting information on the following weather elements, in order of importance:

1. Rainfall amount
2. Rainfall intensity
3. Air temperature
4. Frost occurrence
5. Wind

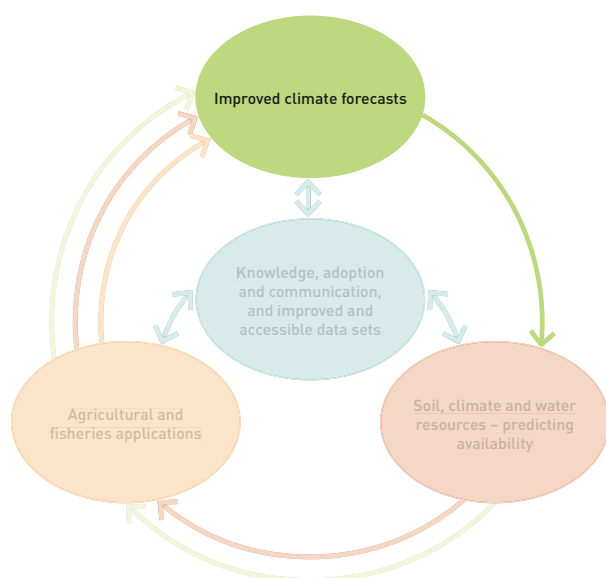
The survey found that farmers wanted forecast information to link to key decisions, which are based on things such as soil moisture, catchment runoff, likelihood of frosts, breaks in the season and extreme events.

For a copy of this survey go to:
<http://products.lwa.gov.au/products/PF081456>



Theme 1:

Improved climate forecasts



Outcomes

More certainty in climate forecasts for monthly, seasonal, annual, and inter-annual to decadal timescales.

Challenge

We need to improve climate forecasting capability if we are to meet the challenge of Australia's changing and ever more variable climate.

The massive investment worldwide in climate change science has already yielded a series of global circulation models, at least six of which are seen as having capability in seasonal forecasting. Selectively combining these models with traditional statistical-based forecasting will bring more precision—in both location and time—to forecasts at weekly to seasonal and longer timescales. We also need to better link these forecasts to the decisions of farmers, agribusiness consultants, producer groups and natural resource managers.

What does success look like?

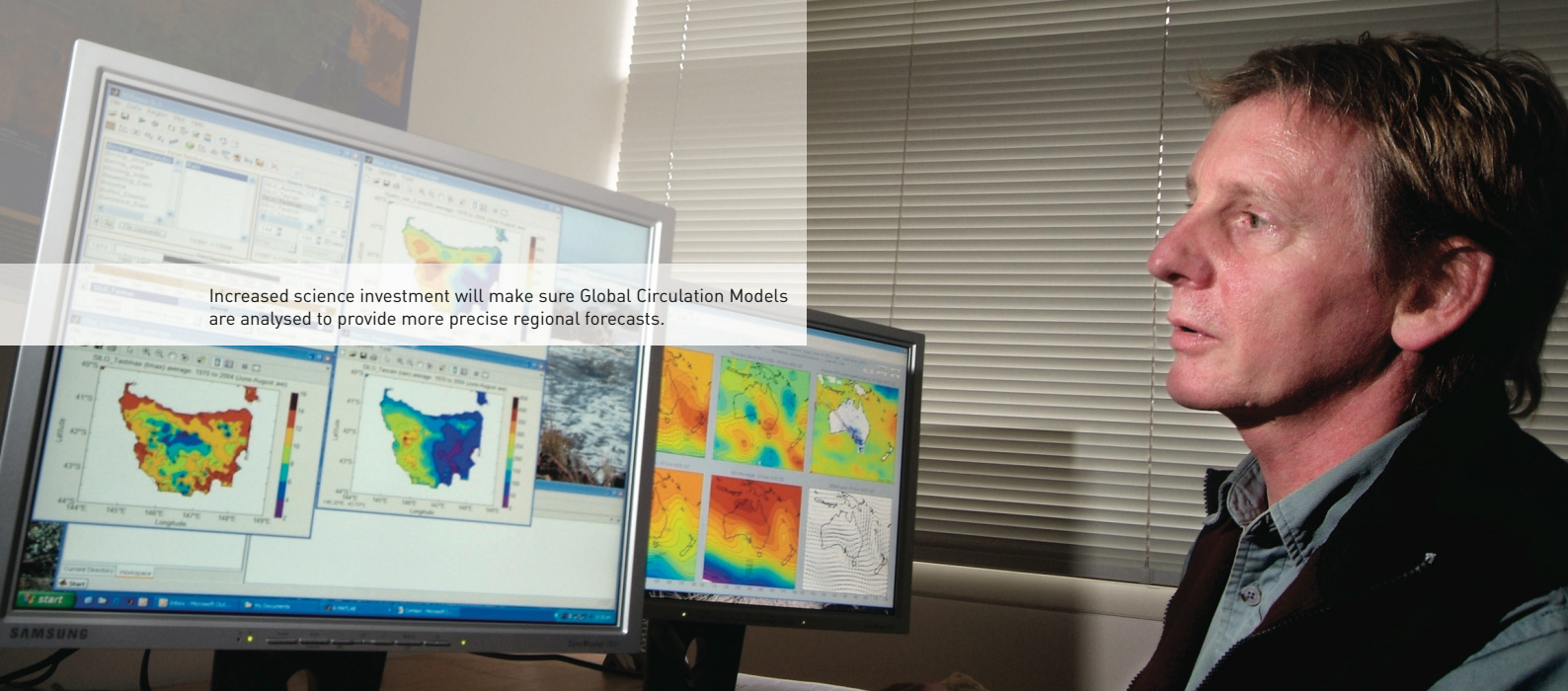
- The agricultural sector can better make decisions on dryland production mixes and practices by linking their on-farm decisions to predictions for key attributes such as plant-available water, frost frequency, and forage availability.
- The irrigation and rural water industries can better determine water allocations within irrigation areas for the next irrigation season and at the bulk entitlement level, several years out.
- Urban water authorities can better link their various supply and demand management strategies to the predicted available water, several months ahead.
- Emergency services, governments and the community are aware of the likelihood of extreme events, and are better prepared to deal with drought, flood, or bushfires.
- Policymakers are better able to manage the process of going into, and coming out of drought.
- Commodity marketing groups are able to better project the forthcoming crop size and the implications for forward selling, product handling and processing.

Success will take time. It will require a concerted investment over at least the next five to seven years to refine our forecasting capability through global circulation models. By then there is likely to be further improvements in climate science, such as a better understanding of the drivers and interactions that form Australia's weather. Success will depend upon the ability to combine the improving predictive capacity for climate change with increased capability in forecasting so that projections of likely climate variability up to six to ten years out can be achieved.

Investment must be ongoing and long term if we are to continually improve our forecasting capability to meet the ever-increasing complexity of weather and climate-related decisions.

A consortium of Australian and international collaborators is needed to maximise success. Joint investment from science providers and across various investor programs reinforces science direction, clarifies science tasks and, most importantly, improves science capacity.





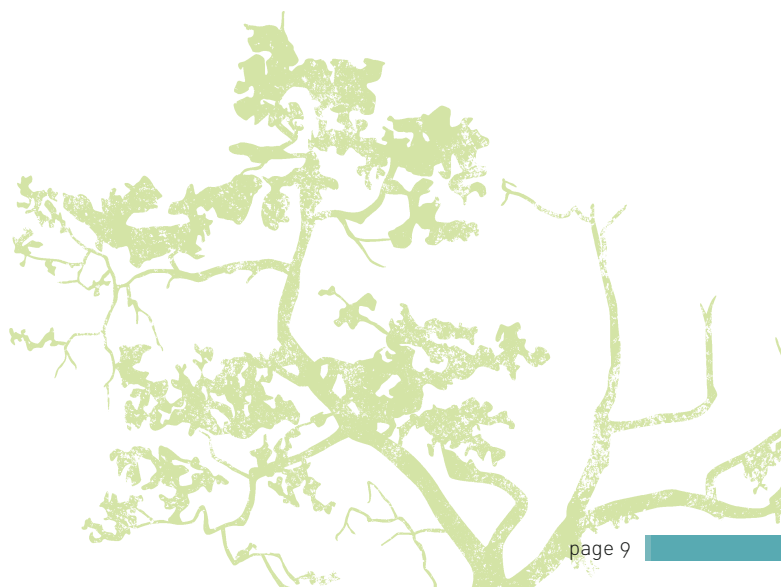
Increased science investment will make sure Global Circulation Models are analysed to provide more precise regional forecasts.

Key research questions

- Can we markedly improve our forecasting capability to a level that is equal to the predictive capability for other variables such as commodity prices that are part of on-farm decision making?
- How can we routinely document and predict the regional scale climate drivers and the implications of these weather patterns three to six months in advance? (Australia-wide but with emphasis on key regions where this capability is useful)
- Can we develop capability to accurately predict the onset, nature and duration of monsoon seasons, preferably at least six months in advance?
- Can we improve understanding of climate variability interactions with a changing climate, including the implications of a changing climate for climate variability?
- How do we routinely and cost-effectively exploit global circulation models at timescales relevant to users and provide thorough cross-correlation across global circulation models and forecast predictions relevant to management decisions?
- How can we make the most of statistical forecasts as a further input to refine global circulation model outputs, and how can we retain some statistical forecasting value in an increasingly changing climate?
- How can we effectively articulate and ensure better understanding of the dynamic nature of forecasts, improving the confidence of users in the way they use the outputs of forecasting science?
- How can we improve the predictability of key extreme events—especially droughts, floods and cyclones?

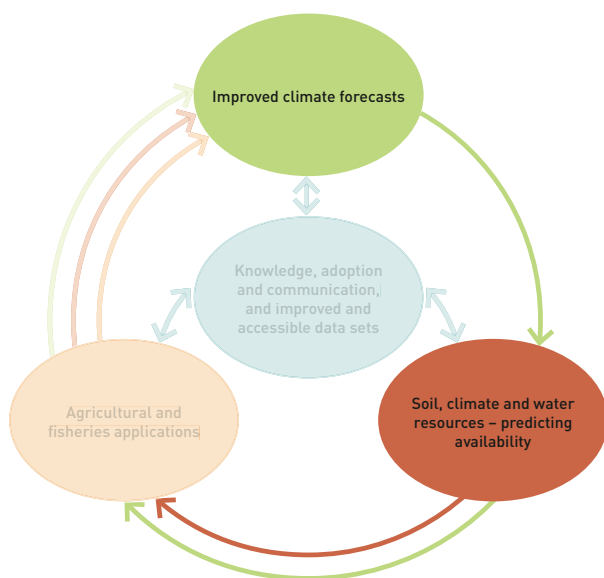
Likely major investments

- Working with other investors and science consortia to implement five to seven year forecasting initiatives for:
 - o South-western Western Australia
 - o Northern Australia
 - o Eastern Australia
 - o South-eastern Australia
- Integrating focused investments across these climate regions to improve overall Australian forecasting capability, including combining statistical and global circulation model outputs into the next generation of climate models for Australia
- Commissioning research to improve Australia's understanding of the interaction between climate change and climate variability to predict trends in variability as our climate changes
- Commissioning research to clarify region-specific climate drivers, a key input to improving model skill and forecast capability
- Investing in international collaboration to improve the prediction of extreme events



Theme 2:

Soil, climate and water resources – predicting availability



Outcomes

Australians have the knowledge to predict key attributes—for example soil moisture, frost, catchment runoff, wet season duration—over time and across landscapes as our climate varies and changes.

Challenge

The variability of available water in Australia has led to a suite of policies and activities to better manage water for urban, agriculture, irrigation and environmental uses.

Working within our climate forecasting capability, we need to be able to better predict water availability and variability. This means more accurately quantifying likely rainfall, soil moisture, frost, evaporation, runoff and deep drainage.

With these key physical attributes quantified, we will then be able to better model storage volumes, flow in rivers and to estuaries and oceans. Applications include irrigation and environmental water allocation and delivery, crop potential and fertiliser needs, urban water management strategies and the fluctuation of commercial fishery populations.

This task is a substantial scientific challenge, complicated by the need to translate our improving knowledge of Australia's changing climate into a greater capability to predict key physical attributes and most importantly, their interaction. As an example, a 10 per cent reduction in mean annual rainfall due to climate change is likely to lead to a 20–30 per cent reduction in mean annual runoff. This compounding impact will be greater in drier regions and catchments that already have low runoff.

What does success look like?

- Weeks to months ahead information is available about likely heat stress, frost occurrence and bushfire risk.
- Seasonally, croppers and pastoralists have better estimates of likely soil moisture to make decisions about their cropping and grazing strategies.
- Annually, irrigators, urban water authorities and environmental asset managers have better estimates of the water available for use and for trade.
- Fishers have better estimates of likely fish and prawn populations recruiting to the commercial fisheries.
- Two to 10 years ahead, all water users can identify likely changes to water availability and estimate the relative proportions of evaporation, deep drainage runoff, river flow and storage; influencing their decisions about, for example, investment in irrigation infrastructure and alternate urban water supply.
- Over 20 to 30 years ahead, policymakers and natural resource users are considering the predicted changes in biophysical attributes as input to climate change adaptation scenarios.



Improved forecasts need to be translated into profitable on-farm practice—field verification is an essential part of developing tools.

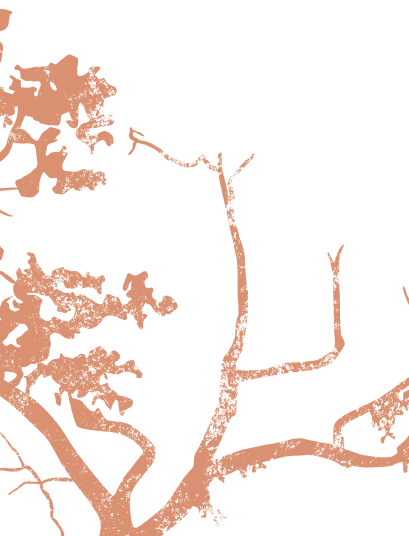


Key research questions

- How can we better predict the impacts of our variable climate and provide information on attributes such as soil moisture, runoff, frost frequency and water availability by connecting our forecasting capability with hydrological models?
- How might climate variability within a changing climate impact on attributes such as water availability at various timeframes (seasonal, annual and longer)? What are the implications for policy and management?
- What will the future climate (particularly rainfall) look like? How will streamflow change as a result of changes in climate? How can we most effectively model rainfall data to estimate climate change impact on runoff characteristics?
- What are the likely variations and longer term changes in soil moisture for each agricultural region and soil type, and what are the implications for commodity production, grass cover, and cropping?
- How will changes in climate impact on the severity and frequency of extreme events such as droughts, floods, storms and cyclones, and at what lead time are we able to accurately predict these extreme events?

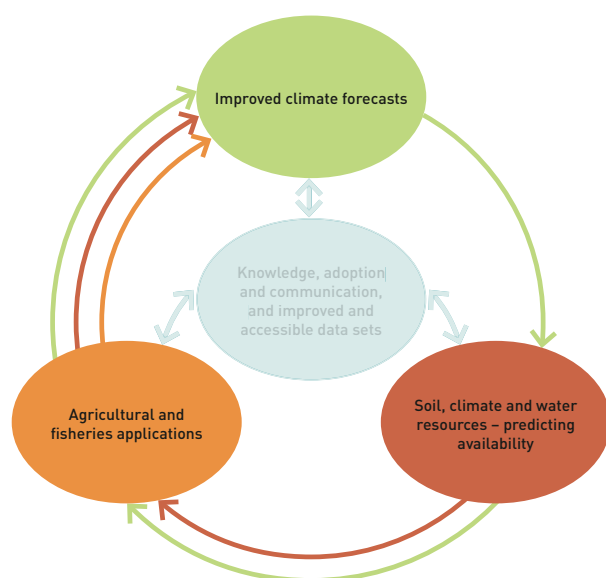
Likely major investments

- Working with key players such as the Bureau of Meteorology, CSIRO, State agencies and Murray Darling Basin Authority to link our forecasting capability with water resource management, allowing us to better predict our water availability
- Providing dryland agriculture with improved soil moisture, frost and heat stress prediction, both short term and medium term as Australia's climate changes
- Developing long term scenarios on likely changes to key biophysical attributes as input to climate adaptation strategies
- Interpreting extreme event predictions to provide users with likelihoods of risk from events such as floods, droughts or bushfires



Theme 3:

Agricultural and fisheries applications



Outcomes

Climate variability related commodity-specific decision support tools that identify benefits and opportunities for increased profitability and sustainability.

Challenge

Australia has an international reputation for creating decision support tools that translate climate data into commodity-specific information for improving productivity and profitability. Examples include AussieGRASS, Rainman, the Northern Prawn Fishery Stock Assessment and Yield Prophet®.

We need to build on these successes and develop decision support tools for all those industries where incorporating greater knowledge of climate variability into decision making could deliver substantial benefits to productivity and risk management.

Tools must be tailored to user demand, and foster increased profitability and sustainability while responding to a changing climate and emissions control policies.

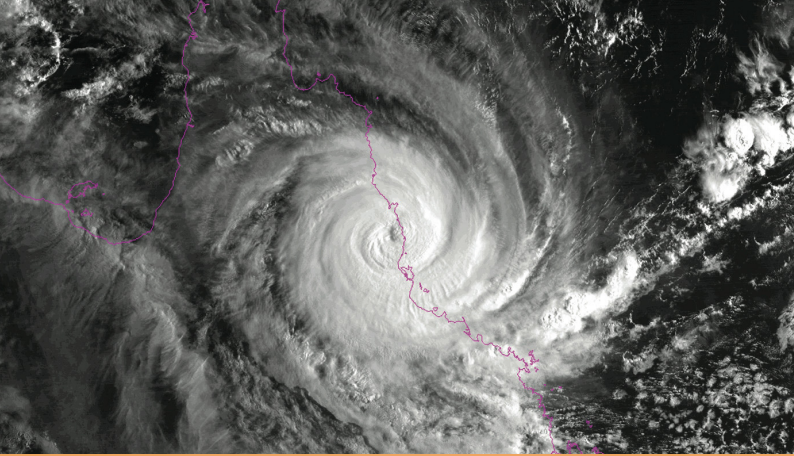
They must focus on those areas where decision making can be improved by incorporating forecasts into the enterprise system.

We are evaluating proposals for investing in decision support tools against these key criteria:

- The capacity of climate science to deliver accurate enough forecasts upon which to base the proposed tools
- The potential for the proposed tool to improve decision making at both farm and landscape scales and deliver both profitability and sustainability outcomes
- The likely return on investment across profitability, sustainability and emissions control outcomes for the rural research and development corporations as investors
- The proposed adoption pathways and how any constraints on adoption will be addressed as part of the proposal

What does success look like?

- Farmers and fishers are using practices and commodity mixes that respond to Australia's increasingly variable climate, delivering improvements in profitability and natural resource condition. Key opportunities:
 - o Improved profitability and sustainability by incorporating seasonal forecasting into cropping decisions, fertiliser and chemical applications and practice changes, especially the grain, sugar, cotton, horticulture and forage industries.
 - o Graziers across tropical Australia are incorporating predictions of monsoonal duration and magnitude into pasture management, breeding turnoff strategies, and weed and feral animal control strategies for the tropical savannas.
 - o Mixed cropping/grazing farmers are exploiting predicted soil moisture and drawdown rates according to their soil type, commodity and practice.
 - o Fishery stocks are better predicted and applied as an input to setting annual effort for various fisheries such as east coast prawn, lobster and barramundi.
 - o Effort in weed and feral animal control is increased during period of stress, for example drought.



Above: Tropical Cyclone Larry over the Queensland coast, near Cairns and Innisfail.

Photo: Japan Meteorological Agency and Bureau of Meteorology.



Right: A banana plantation in Innisfail, Queensland, is decimated by Tropical Cyclone Larry, March 2006.

Photo: Jim Davidson, Bureau of Meteorology

Key research questions

- How can we make sure our decision support tools are designed to meet the needs of users?
- How can we provide the opportunities for highest return on investment from improved decision support incorporating climate information?

Within the context of these key research questions:

- Which tools require further development to foster greater climate resilience in agriculture, fisheries and natural resources management?

Likely major investments

- An audit of existing Australian and international climate risk management tools across the agriculture, fishing and natural resources sectors. This will compare tool functionality against the needs of users, to determine where tool improvement or innovation is likely to improve profitability and/ or sustainability.

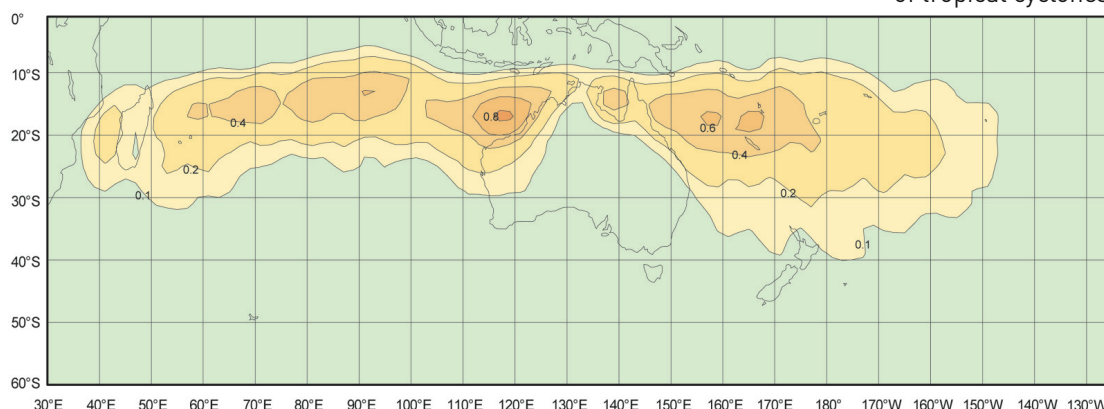
In parallel to the audit:

- Developing a suite of tools for the grains industry, based on the lessons learnt and successes of Yield Prophet®, Whopper Cropper, PyCal and Horses for Courses

Using the results of the audit:

- Developing a suite of tools for the tropical grazing industry, based on and exploiting AussieGRASS, Pastures from Space and the breakthroughs underway in predicting monsoon break, intensity and duration
- Developing population and effort-management support tools that are similar to tools developed for the northern prawn fishery and the West Australian rock lobster fishery for other key fisheries such as the east coast prawn, barramundi and scallop fisheries
- Producing a series of commodity-based tools for industries such as sugar, grape or dairy
- Producing a series of resource-based tools for key natural resource issues such as water quality and specifying criteria for land use practice, with the Great Barrier Reef catchments being the initial pilot
- Using the improved predictions of water availability and runoff to storages to produce a series of tools for irrigation industries, urban water, environmental flow and water-trading activities

Average annual number of tropical cyclones



The severity of tropical cyclones is expected to increase. Better forecasting will be essential for extreme event management.

Source: Bureau of Meteorology

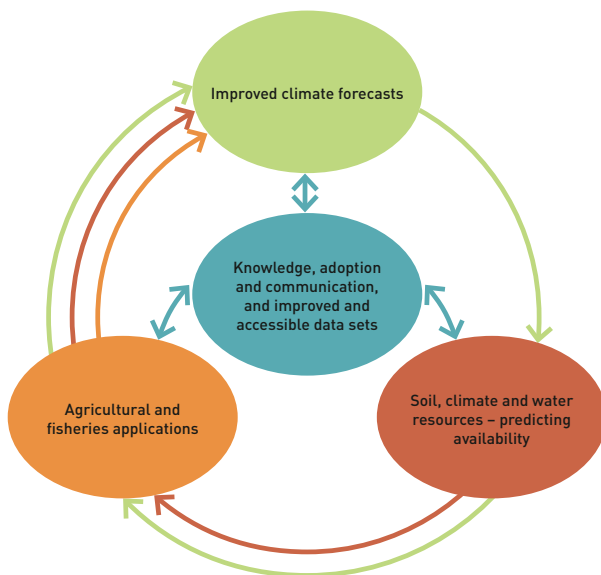
Based on a 2 x 2 degree resolution gridded analysis using 36 years of data (1969/70 to 2005/06 tropical cyclone seasons).
© Commonwealth of Australia, 2008

Number of tropical cyclones

0.1 0.2 0.4 0.6 0.8 1.0

Theme 4:

Knowledge, adoption and communication



Outcomes

Increased understanding and uptake of climate-related opportunities that benefit agriculture and Australia's natural resource condition.

Challenge

Part of the challenge for Managing Climate Variability is to work within the rapidly changing policy environment around climate change to deliver opportunities for Australia's primary industries and natural resource management agencies to respond to increasing climate variability and adapt to climate change. Incorporating climate variability into day-to-day and longer term decision making will do much to equip Australia's primary industry sector to deal with the longer term implications of climate change.

The challenge is to identify where improved forecasting knowledge and decision support tools can provide the most benefit and make sure that these opportunities are captured.

The translation of climate information into real-life action requires three essential components (Meinke et al. 2006). These are:

- Salience—the perceived relevance of the information
- Credibility—the perceived technical quality of the information
- Legitimacy—the perceived objectivity of the process by which the information is shared

Improving knowledge and uptake of climate information requires improved understanding of climate variability and climate change, and an ability to apply these in a risk management context.

What does success look like?

- Improved awareness and understanding of basic scientific facts associated with climate variability and climate change
- Agribusiness-led training and implementation, particularly to incorporate decision support tools into normal business operations
- Multiple communication methods to meet a diversity of user needs—workshops, newsletters, field days and websites
- Focused training through Masters of Climate to make sure there are champions for adoption across all sectors and regions
- Partnerships between scientists, industries and communities that cross institutional boundaries and disciplines

Key development questions

- What are the barriers to adoption of climate risk management within decision making?
- What has fostered successful uptake and adoption in the past? Can such initiatives be maintained or improved in the future?
- What are the sectors, commodities and regions where understanding, adoption and uptake will deliver the most benefit?
- How can climate risk, including global risks and climate change, be communicated effectively to foster awareness and action at the spatial and temporal scales of most primary industries?



Ian McClelland of the Birchip Cropping Group in north-western Victoria is a Master of Climate. He is a recipient of the Order of Australia and a strong advocate for improved climate risk management.

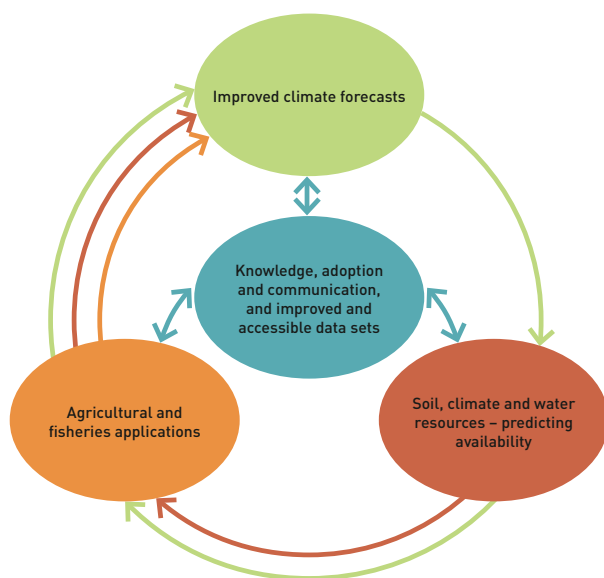
Likely major investments

- Evaluate existing barriers to adoption and uptake to identify any opportunities for improvement.
- Develop a seamless web system for knowledge interchange, co-investing with the Bureau of Meteorology to improve their Water And The Land website, providing a climate knowledge website and linking to various climate risk management tools.
- Use the Masters of Climate initiative to improve climate risk management skills of regional communities and commodity/farmer groups across Australia. This would be linked to state agency and agribusiness initiatives and would include:
 - o Communication to improve understanding, and increase adoption and uptake of climate risk management tools and knowledge
 - o Case studies and messages to demonstrate the benefits of using climate information, particularly various forecast outputs
 - o Innovative methods of describing and presenting climate information
 - o Workshops in rural and regional Australia to build awareness and understanding of climate variability and climate change
 - o Resourcing for Masters so that they can champion climate risk management concepts and tools across their regions and sectors
 - o Interaction with these Masters to continuously improve Managing Climate Variability research direction, outputs and products



Theme 5:

Improving and accessing data sets



Outcomes

Improved, quality assured, and readily available fundamental data sets.

Challenge

The policies and protocols set up under the Australian and New Zealand Land Information Council clearly define fundamental natural resource datasets; their role, quality control, custodianship, documentation and access. However, implementing these policies can be challenging in an environment where scientific institutions compete rather than collaborate. All science investments in Managing Climate Variability likely to yield fundamental data sets will be contracted to comply with Australian and New Zealand Land Information Council policies and protocols.

Equally important is making sure Australia's climate-related data sets are continually upgraded to support the rapidly increasing knowledge of climate variability, and climate change. This needs to conform to international standards formulated through the World Meteorological Organisation. It is also important that, to the extent possible, systems and practices adhere to the principles for long-term climate monitoring.

What does success look like?

Australian climate-related data:

- Conforms to international standards
- Adheres to the principles of long-term climate monitoring
- Is documented and quality-assured
- May fill gaps in existing important datasets
- Has a high likelihood of future continuity and long-term maintenance
- Is supported by metadata, which assists in its interpretation
- Is accessible to all researchers and other users, preferably at the cost of transfer
- Is within a data management system or interlinked series of data warehouses that are themselves continually upgraded to deliver the functionality required by researchers

Key development questions

- Where would investment in datasets best assist the overall outcome of improved climate risk management?
- What data, such as climate change data, can be added to existing datasets to improve the benefits of using such datasets?
- What is the potential for the development of datasets or indices that have value in monitoring or predicting commodity production or natural resource condition?
- Are there any existing research datasets that require investment to guarantee their accessibility or ongoing management and security?
- How can this data be more effectively shared and maintained?

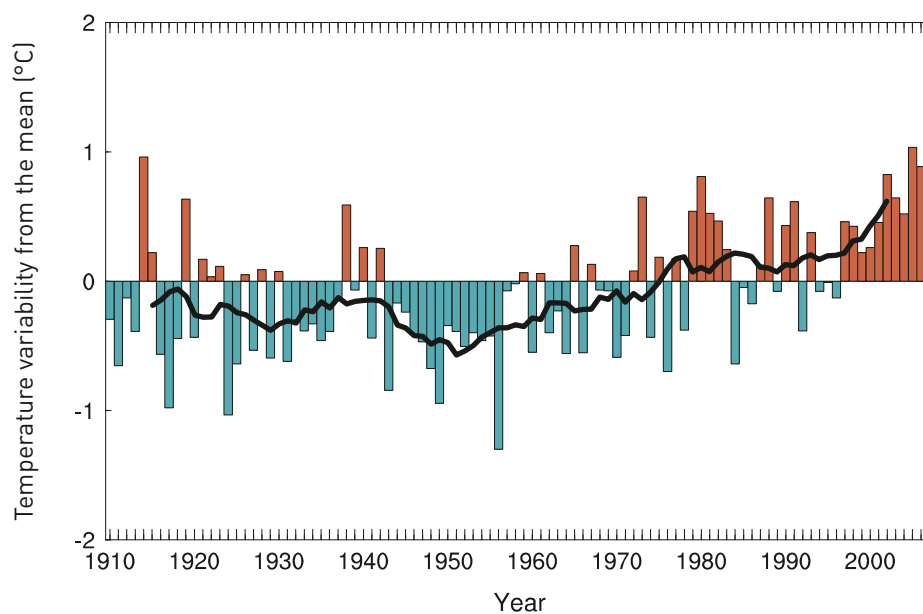


Likely major investments

- Investment in filling data gaps and providing data that characterises climate change and is relevant to production and natural resource systems
- Investment in datasets which:
 - o Support decision making in a risk management context
 - o Have high incremental value by adding to existing datasets
 - o Provide indices for monitoring or prediction
 - o Ensure monitoring adheres to data management standards and guidelines, data accessibility and metadata standards as part of overall science program management



Murray Darling Basin temperature variability from the mean (baseline period: 1961-90)



A hotter Murray Darling Basin will reduce plant-available moisture and runoff, making improved forecasting essential.

Delivering Managing Climate Variability

Managing Climate Variability is a collaborative program between the Grains, Rural Industries and Sugar Research and Development Corporations; the Department of Agriculture, Fisheries and Forestry; Dairy Australia; Meat & Livestock Australia; and Land & Water Australia.

All phases of investment have been managed by Land & Water Australia on behalf of the investors. Funding from the investors is at least matched by in-kind contributions through partnerships with research institutions and other organisations.

As the Program Manager, Land & Water Australia provides governance, management, administration and oversight.

Managing Climate Variability is overseen by a Program Management Committee composed of key investors. It is advised by a Technical Advisory Committee of independent experts representing Australian science providers.

Managing knowledge

We apply the following principles to our investments to make sure they are meeting the needs of users—especially farmers and natural resource managers. We:

- Encourage participatory research projects involving resource users and managers working with researchers
- Facilitate interaction between researchers and the community, including primary industry organisations, water corporations, agribusiness and extension providers
- Work with existing institutions, industries and communities
- Work with the extension networks of partner organisations
- Provide communication products and services based on users' needs

We integrate the findings of each of the research themes into practical understanding and advice for reducing exposure to risk from climate. This includes:

- Delivery of key products across projects, such as decision support tools, in ways that are easily accessible and relevant for farmers and resource managers
- Support for regional natural resource management bodies to include project outputs into management plans and strategies
- Building capacity in industries and regions across Australia so that local knowledge and experience can be complemented with scientific approaches
- Evaluating investments so that further research priorities can be developed to support further work
- Building capacity in Australia's research community
- Supporting workshops and conferences to promote interaction, communication and adoption



Outback flood
Photo: Bureau of Meteorology

Monitoring and evaluation

We evaluate our performance according to:

- The extent to which we are generating relevant and adoptable knowledge
- The extent to which our research outputs are being scientifically published
- The estimated improvements in profitability and resource condition that can reasonably be attributed to the uptake of improved climate risk management

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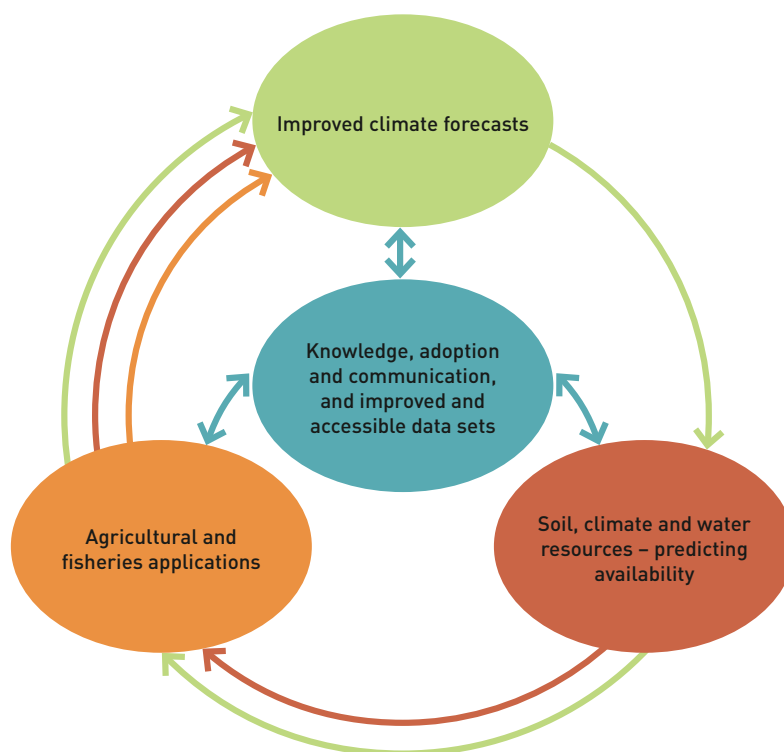
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Country	River	Ratio between maximum and minimum annual flows
Brazil	Amazon	1.3
Switzerland	Rhine	1.9
China	Yangtze	2
Sudan	White Nile	2.4
USA	Potomac	4
South Africa	Orange	17
Australia	Murray	30
Australia	Hunter	54
Australia	Darling	4700

Australia has the most variable climate of all agricultural producing countries.

Goal To help farmers and natural resource managers manage risks and exploit opportunities given Australia's variable and changing climate

- By**
- Improving forecasting accuracy, lead-time and ease of use
 - Providing tools and services for managing climate risk
 - Increasing adoption of climate risk management



Theme	Outcomes
Improved climate forecasts	More certainty in climate forecasts for monthly, seasonal, annual, and inter-annual to decadal timescales
Soil, climate and water resources – predicting availability	Australians have the knowledge to predict key attributes—for example soil moisture, frost, catchment runoff, wet season duration—over time and across landscapes as our climate varies and changes
Agricultural and fisheries applications	Climate variability related commodity-specific decision support tools that identify benefits and opportunities for increased profitability and sustainability
Knowledge, adoption and communication	Increased understanding and uptake of climate-related opportunities that benefit agriculture and Australia's natural resource condition
Improved and accessible datasets	Improved, quality assured, and readily available fundamental data sets



Australian Government

Department of Agriculture,
Fisheries and Forestry

Land & Water Australia

Rural Industries Research and
Development Corporation

Sugar Research and
Development Corporation

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