



Australian Government

National Climate Resilience and Adaptation Strategy

2015

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This work must be attributed as: “Commonwealth of Australia, ‘National Climate Resilience and Adaptation Strategy’.”

References and endnotes for the *National Climate Resilience and Adaptation Strategy* are available from the Department of the Environment website at www.environment.gov.au.

Acknowledgement of traditional owners and country

The Australian Government acknowledges the traditional owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.

As this *Strategy* shares knowledge, teaching, learning and research practices, we also pay respect to the knowledge and traditions of this country’s traditional owners and custodians.

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We act together to support prosperity and wellbeing in Australia and beyond by building the resilience of communities, the economy and the environment to a variable and changing climate.

About this Strategy

The Australian Government has developed this *National Climate Resilience and Adaptation Strategy* to articulate how Australia is managing the risks of a variable and changing climate. The *Strategy* affirms a set of principles to guide effective adaptation practice and resilience building, looks at leading practice nationally, and considers areas for future review, consultation and action.

In 2007, the Council of Australian Governments agreed on a *National Climate Change Adaptation Framework*. This Framework established priorities for action and a significant evidence base, national climate change science and adaptation research capacity and institutions, and a wide range of resilience-building initiatives. The Framework continues to anchor and guide resilience action by Australian governments.

Effective responses to climate change are context-specific, and often addressed best at the local and regional levels. The Australian Government works to ensure that its own actions and policies

do not undermine the incentives for, or capacity of, the private sector and the states and territories to manage risk. To this end, the *Strategy* highlights adaptation action by both public and private individuals and organisations across the Australian community, as well as in Asia and the Pacific. Australia is one of the developed countries most vulnerable to climate change and we are situated within a region with many highly vulnerable neighbours. Maintaining resilience in a changing climate requires the informed engagement of people and institutions at all levels and across our region.

Climate change poses significant risks to our economies, communities and the natural environment. That said, the Australian environment has always required us to be innovative in managing and adjusting to climate extremes, variability and events. The *Strategy* is another step in that journey. It highlights how Australia is employing ingenuity and sound climate risk management to meet the climate challenges of the future.

A vision for climate resilience in Australia

Our climate is changing and this will affect most of us in some way during our lifetimes. A climate-resilient Australia is one where:

We act together to support prosperity and wellbeing in Australia and beyond by building the resilience of communities, the economy and the environment to a variable and changing climate.



Governments, business, communities and individuals have an important role to play in building our resilience to climate change (© Tony McDonough / Raw Image)

Governments at all levels, businesses, communities and individuals have complementary but different roles. Individuals and businesses, for example, are generally best placed to manage the climate risks associated with their homes and commercial assets.

Governments—on behalf of the community—are responsible for managing risks to public goods and assets (including the environment), government service delivery, and creating the institutional, market and regulatory environment that supports and promotes private resilience and action.

One of the most important roles of governments in adaptation is ensuring that others within society can make informed decisions and adjust their behaviour in response to climate risks, by providing authoritative climate information. The Australian Government plays a major part in providing this climate science and information.

The Australian Government maintains a strong, flexible economy and well-targeted safety net to ensure that climate change does not disproportionately affect vulnerable groups, effective natural resource management across land, water, marine and coral reef systems, and considers the economy-wide implications of actions determined at local and regional levels. It must look to the security of its assets, investments and infrastructure, and ensure that it delivers critical government services without interruption. Beyond our borders, Australia helps developing countries, particularly in Asia and the Pacific, with effective disaster risk management, climate change science, adaptation planning and capacity building.

As the effects of climate change vary across different parts of Australia, the information and actions required will also vary across the nation. State and territory governments have the leading role in adaptation actions, primarily through their planning laws and investments in public infrastructure.

State and territory governments focus on ensuring appropriate regulatory and market frameworks are in place, providing accurate and regionally appropriate information and delivering an adaptation response in those areas of policy and regulation within their jurisdiction. This includes key areas of service delivery and infrastructure, such as emergency services, environmental protection, planning and transport. For example, building regulations updated since the 1980s have improved disaster resilience, resulting in less building damage from tropical cyclones in northern Australia.¹

Local governments are on the frontline in dealing with the impacts of climate change. They have an essential role to play in ensuring that particular local circumstances are adequately considered in the overall adaptation response and in involving the local community directly in efforts to facilitate effective change. They are well positioned to

inform state and federal governments about the on-the-ground needs of local and regional communities, to communicate directly with those communities, and to respond to local changes.

There is broad agreement between Australian jurisdictions on respective adaptation roles and responsibilities, and we continue to work together to understand the cost-benefits, optimal timing and appropriate scale for adaptation actions.

Climate change as a business risk and an opportunity

Building resilience to the physical impacts of climate change and extreme weather events is vital for the long-term sustainable growth of a business. As the interface between aviation and ground transport, airports have a key role to play in climate change. Adelaide Airport is the international and domestic aviation gateway to South Australia for 7.8 million passengers a year (2014-15).

Adelaide Airport Ltd (AAL) is the airport lessee company operating both Adelaide Airport and Parafield Airports. As an owner of significant infrastructure AAL recognises its responsibility to ensure that its assets are designed and maintained to withstand future climatic conditions, so that the organisation can continue to deliver excellence in service into the future.

AAL sees climate change as both a business risk and an opportunity for sustainable development. It can affect airport infrastructure and operations in a variety of ways from physical and service impacts to financial implications. During an extreme weather event, for example, an airport may provide local shelter and support for aviation in disaster relief. When airports in one state or country deal with a climate risk, many other airports, both nationally and globally, are affected.

In its first climate change adaptation plan, due for release shortly, AAL has used the latest available climate science and projections from the Intergovernmental Panel on Climate Change (IPCC) and the Australian Government's national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO). It has identified key climate risks and, where the existing comprehensive controls and operational plans required additional mitigation actions, these have been specified and will be integrated into key business documents and guidance. For example, treatments for heat-related risks include integration of appropriate actions within various asset management plans.

Consultation on the plan has taken place with all levels of government. As critical infrastructure for the state, Adelaide Airport has consulted with the South Australian Government on this Plan and has taken part in the state-wide and regional consultation to help inform the development of a new Climate Change Strategy for South Australia.

Emissions reduction has been ongoing for many years and Adelaide Airport is accredited to Level 3 of Airports Council International's Airport Carbon Accreditation Scheme. AAL also considers tackling climate change impacts early to be a good business decision from the perspectives of risk management, meeting policy requirements and ensuring the resilience of its assets.

Principles of effective resilience and adaptation

As we pursue our vision of a climate-resilient Australia, we base our action on principles that underpin resilience and adaptation.

SHARED RESPONSIBILITY

Governments at all levels, businesses, communities and individuals each have different but complementary and important roles to play in managing climate risks.

FACTORING CLIMATE RISKS INTO DECISION MAKING

We achieve climate resilience when short, medium and long-term decision making considers current climate risks and a changing climate. Consideration of climate risk means that decisions are informed by an understanding of current costs and benefits as well as risks and opportunities that may arise, and that they are made without passing risks on to future Australians.

We take measures that deal with the risks that are unacceptable in the current climate, for example, our current vulnerability to inland flooding, bushfires and drought in some regions. We take measures that yield benefits even without further climate change, like enhancing energy efficiency or replanting riparian vegetation along creeks. In addition, we consider climate change when making decisions with long-term consequences, such as in planning new suburbs or making decisions about long-lived infrastructure like ports.

AN EVIDENCE-BASED, RISK MANAGEMENT APPROACH

We ensure our decisions are sound by applying leading physical, economic and social science in decision making, but which do not defer adaptation planning or action because of a lack of perfect information about the future. We use risk management tools and approaches, and



Our coastal zones have important economic, social and environmental characteristics and frequently overlapping governance arrangements (© Phalinn Ooi, <https://creativecommons.org/licenses/by/2.0/>)

consider both the magnitude and likelihood of climate risks and capacity to respond to those risks. Continued investment in the science, technology and innovation, adaptation information and skills, helps us to manage climate risks and find emerging opportunities.

HELPING THE VULNERABLE

We support those who may be vulnerable to climate-related impacts, or who have limited capacity to respond. We do this through our policy design choices and the social welfare system.

COLLABORATIVE, VALUES-BASED CHOICES

We recognise that different circumstances and locations require different approaches to adaptation. There is no single approach to reducing risks that will be appropriate across all settings.

To identify action that will be appropriate and effective, decision makers should seek to understand and respect the knowledge and experience of those affected, and actively involve them in decision-making processes whenever possible. Innovative and effective adaptation relies on governments, businesses and individuals understanding the wider social and economic context in which they make important decisions.

Indigenous, local and traditional knowledge systems and practices, including Indigenous peoples' views of community and environment, are an important resource for adapting to climate change. For example, fire is a significant part of Indigenous cultures, and skilful burning of landscapes by Indigenous peoples has informed early season bushfire management, reducing the damage caused by large intense bushfires.

REVISITING DECISIONS AND OUTCOMES OVER TIME

The climate is a dynamic system and the risks it poses will change over time, as will community views, values, knowledge, resources and capacity. Adaptive management embeds this dynamism by taking changing circumstances or improved science into account. Regularly reassessing actions and incorporating flexibility into longer-term decisions will help ensure choices remain appropriate, and we capture emerging opportunities. We can engage widely across institutions and communities to encourage the social learning that supports resilience; and foster the trans-disciplinary skills we will need to manage complexity across temporal and spatial scales.

The climate change challenge

Some global warming has already occurred—Australia has warmed by 0.9°C, mostly since 1950²—and we have experienced the effects of this warming, including:

- ▶ a reduction in cool season rainfall and runoff in southern areas, and an increase in summer rainfall in the north
- ▶ increased frequency of hot, compared to cold, days
- ▶ increases in extreme weather including longer and more severe heatwaves, increased bushfire weather, increased intensity of extreme rainfall events
- ▶ detectable rises in sea level regionally and globally
- ▶ southern and eastern Australia is projected to experience more extreme fire-related weather (high confidence)
- ▶ the time in drought is projected to increase over southern Australia (high confidence), with a greater frequency of extreme droughts (medium confidence)
- ▶ sea levels will continue to rise throughout the 21st century (very high confidence), with increased frequency of storm surge events
- ▶ oceans around Australia will warm and become more acidic (very high confidence).

Some further warming is unavoidable, locked into the climate system due to past greenhouse gas emissions, even if global emissions stabilised immediately. Climate projections released by Australia's CSIRO and Bureau of Meteorology in 2015 indicate that under all future emissions scenarios:

- ▶ average temperatures will continue to increase (very high confidence in this outcome) and Australia will experience more heat extremes (very high confidence) and fewer frosty days (high confidence)
- ▶ extreme rainfall events are likely to become more intense (high confidence)
- ▶ the number of tropical cyclones is projected to become less frequent with a greater proportion of high intensity storms (medium confidence) and a greater proportion extending beyond the southern latitude of 25 degrees (low confidence)

The world has committed to limit global average warming to below 2°C. There is concerted international action towards this goal, but even a 2°C change requires Australia and the region to manage substantial adaptation challenges. This underscores the importance of pursuing actions to both reduce emissions and build resilience and adaptive capacity—they are both essential and complementary responses to climate change.

Effective climate policy aimed at reducing the risks of climate change to natural and human systems involves a portfolio of diverse adaptation and mitigation actions.

Intergovernmental Panel on Climate Change³

Effective emissions reductions efforts and climate change adaptation together will bring important benefits: social, environmental and economic impacts will be lower; new opportunities can be fully exploited; and fresh thinking about climate risks will stimulate innovation in other fields. According to recent analysis by the CSIRO, ecological pressures can be reversed while the population grows and living standards improve. In the right circumstances, economic and environmental outcomes can be decoupled.⁴

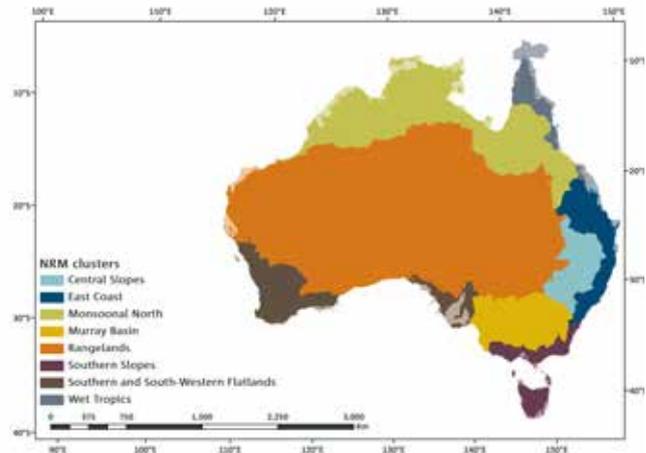
Australia's future climate

The [Climate Change in Australia](#) website hosts the 2015 climate change projections for Australia.

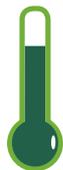
The projections, funded by the Australian Government Department of the Environment, CSIRO and the Bureau of Meteorology, are presented in regional 'clusters' designed to align with natural resource management boundaries that consider past climatic conditions, biophysical factors and expected broad patterns of climate change.

The website allows people to understand and access the projections like never before. Users have access to projections datasets, interactive tools for exploring future climates and guidance for using and understanding the projections.

The projections are based on the latest generation of global climate models. These regional projections represent the most comprehensive analysis of Australia's future climate ever undertaken. They provide a nationally important resource for decision making over the coming century, for four time periods (centred on 2030, 2050, 2070 and 2090) and four emissions scenarios. Climate change projections are available for each of the regional clusters pictured above at www.climatechangeinaustralia.gov.au and application-ready datasets are available for individual sites and on a 5 km grid for selected climate variables.



The climate has already changed. More change is unavoidable as it is locked in to the climate system from past emissions.



0.9°C

increase in average surface temperature in Australia since 1910

0.19m



increase in global average sea level between 1901 and 2010



There has been an observed decrease in rainfall in south-west Australia since 1970s

MANAGING A CHANGING CLIMATE REQUIRES A DUAL APPROACH

CLIMATE CHANGE MITIGATION WORKS TO AVOID THE RISKS

of a changing climate by reducing the emission of greenhouse gases and preventing more severe climate change.



CLIMATE CHANGE ADAPTATION WORKS TO MANAGE THE RISKS

caused by climate change already locked in and from the potential for more severe changes in the future.



Climate change mitigation and adaptation actions are complementary approaches to addressing climate risk

Key elements of climate resilience

Australia's national climate resilience has three elements: global action to reduce emissions; effective adaptation research, planning and action at the national and sub-national levels; and programmes to limit or remove other human pressures on systems affected by climate change.

The best mix of climate change adaptation, resilience-building and emissions reduction policies varies from country to country depending on emissions intensity, the cost of reducing emissions, vulnerability to climate change impacts and tolerance for risk.

The Australian Government's broad suite of climate change policies is designed to:

- ▶ reduce emissions while improving productivity
- ▶ reduce and manage the risks of extreme weather events and climate change
- ▶ reduce costs and the regulatory burden
- ▶ create jobs, and boost innovation and competitiveness
- ▶ deliver positive environmental outcomes.

Reducing emissions

Our ability to find climate-resilient pathways for development and growth for Australia and our region is dependent on what the world accomplishes with greenhouse gas emissions reduction. Effective emissions reduction reduces the *rate* as well as the *magnitude* of warming, increasing the time available for us to adapt to a particular level of climate change, and reducing the chance of dangerous climate change that would exceed adaptive capacity.

Climate change is a global challenge, and all countries must work together to address it. Australia has a strong track record in addressing the challenge of climate change, and as a prosperous nation we have the capacity to do our fair share. Acting in concert with others to reduce greenhouse gas emissions will limit the magnitude of future climate change, while we protect our economy and jobs, health and wellbeing, and maintain the benefits that clean water, land and air, and our rich biodiversity can offer.

Australia is on track to meet its 2020 target of a 5 per cent reduction on 2000 greenhouse gas emissions levels—equivalent to a 13 per cent reduction on 2005 levels. In 2015, the Australian Government agreed on a target to reduce national emissions to 26–28 per cent below 2005 levels by 2030. This target builds on Australia's strong performance and commitments to date, and was set after wide public consultation and consideration of Australia's national circumstances.

Australia has a strong policy framework in place to achieve the 2030 target, with the Emissions Reduction Fund and its Safeguard Mechanism at the centre. Australia will undertake a detailed review of the policy framework in 2017 to investigate whether any further policy action is required. In the interim, the Government will continue to consult on and implement initiatives that will achieve low-cost emissions reductions and other co-benefits. These include working with Council of Australian Governments' Energy Ministers to develop a National Energy Productivity Plan, improving the efficiency of vehicles, phasing down potent hydrofluorocarbons, delivering the Renewable Energy Target and developing a strategy to improve the use of solar power and other renewables, and developing a low emissions technology roadmap.

Climate change mitigation means reducing or avoiding greenhouse gas emissions to minimise the rate and magnitude of climate change.

Climate change adaptation means taking steps to prepare and respond to the effects of the changing climate.

SOME MITIGATION ACTIONS ARE:



ENHANCING ENERGY EFFICIENCY:
89% of Australians took steps to limit their personal electricity use in 2011-12.



INCREASED UPTAKE OF RENEWABLE ENERGY:
13.45% of Australia's electricity came from renewable sources in 2014.



IMPROVEMENTS IN INDUSTRIAL PROCESSES:
For example, improved maintenance and operation of boilers can reduce energy use by up to 5% in steam, hot water and process heating systems.



INCREASED UPTAKE OF SUSTAINABLE TRANSPORT:
16% of Australians normally travelled to work or full-time study by public transport in March 2012.



ENHANCING CARBON SINKS:
A carbon sink is anything that absorbs more carbon than it releases. Forests, soils, oceans and the atmosphere can act as carbon sinks.



Environmentally-responsible building design.



mangrove reforestation, tree planting, restoration of water catchments



Water conservation



Urban greening

SOME ADAPTATION ACTIONS ARE:

CHANGING THE USE OF LAND:
Can protect buildings and infrastructure from existing and new hazards and can allow for changes in the landscape.



UPGRADING OR HARDENING THE DESIGN OF BUILDINGS AND INFRASTRUCTURE:
CSIRO work on wind design standards for all new housing can reduce the risk of damage from wind by 50-80%.



ADJUSTING ACTIVITIES AND LIFESTYLE:
To prevent negative impacts on wine grape crops, some wineries are reducing water consumption, deviating from traditional harvest times or even shifting locations.



EMERGENCY AND BUSINESS CONTINUITY PLANNING:
Even without factoring in climate change, the total economic cost of natural disasters in Australia is forecast to rise to \$23 billion annually by 2050.



INCREASING COMMUNITY UNDERSTANDING OF CLIMATE RISKS:
To build capacity in the community to adapt to the changing climate.



Some actions can have mitigation and adaptation benefits.

The relationship between adaptation and emissions reduction

Adaptation and resilience

Climate change adaptation helps individuals, communities, organisations and natural systems deal with those consequences of climate change that emissions reduction cannot help us avoid. Adaptation can involve gradual transformation with many small steps over time, or major transformation with rapid change.

Adaptation captures a wide range of possible policies, actions and choices, including:

- ▶ policies and regulations such as building codes or environmental protection legislation
- ▶ strategic investment in built infrastructure such as seawalls and levees, and the protection of natural infrastructure such as sand dunes and mangroves
- ▶ education and information that changes behaviour, for example online information providing residential building resilience ratings for home buyers, or autonomous adjustment of market prices (such as insurance premiums) to reflect and communicate changing levels of risk⁵
- ▶ changes in business management practices, such as shifting planting dates and introducing new plant varieties, or in helping mining communities and operational staff prepare for heat waves.

Actions directly related to other developmental or economic goals, including alleviating poverty or supporting sustainable livelihoods, could also be effective in reducing the effects of climate change.

Resilience building can encapsulate a wide range of actions, such as limiting or removing other human pressures on natural systems, like land clearing or pollution, or ensuring that vulnerable communities have reliable access to information and essential services.

Just as cities like Melbourne and Sydney are building their resilience to future shocks, the Australian Department of the Environment looks for opportunities to work with others to prepare Australia's heritage for future pressures or shocks. Pressures on natural heritage, for example, arise from climate change through altered fire regimes, shifting ecosystems and severe natural disasters. Climate change can exacerbate other threats and human interventions—such as land clearing and urban development, the introduction of pests and weeds, pollution and land-based runoff, as well as overfishing. Addressing these effectively (by building their resilience) can help ecosystems and ecological communities adjust to the expected climate and its effects. Examples include setting aside and protecting habitat, undertaking rehabilitation and revegetation activities, applying Indigenous knowledge and stewardship approaches, and enhancing monitoring activities.



Understanding resilience: Resilient Melbourne

The Rockefeller Foundation's 100 Resilient Cities initiative (100RC) aims to help cities around the world become more resilient to the physical, social and economic challenges that are a growing part of the 21st century.

100RC defines urban resilience as 'the capacity of individuals, communities, businesses and systems in a city to survive, adapt and grow, no matter what chronic stresses and acute shocks they experience'.

Melbourne was selected to be among the first wave of 33 cities to join the 100RC network. It is home to some 4.3 million people and spans nearly 10,000 km². Although consistently rated as one of the world's most liveable cities, Melbourne is nevertheless vulnerable to a range of stresses that weaken the fabric of communities, including unemployment and diminishing housing affordability. It is vulnerable to acute events such as heat waves, bushfires and flooding, all of which are expected to worsen and become more frequent as a result of climate change.

In a city administered by 32 local governments, these shocks and stresses cannot be dealt with comprehensively by a single agency, or by each local council acting independently. The Resilient Melbourne project takes a collaborative approach. After talking with leaders in the government, academic, business, infrastructure, emergency management, environment, community and health sectors, the project identified five areas of focus that have been refined with the support of senior council executives and mayors across Melbourne:

- *a stronger society* – how can Melbourne support individuals and communities to take more responsibility for their own and each other's health, wellbeing and safety?
- *a better-connected society* – how does Melbourne create and sustain places where its buildings, infrastructure and activities promote social cohesion, equality and health?
- *a competitive metropolis* – how does Melbourne create diverse local employment opportunities that support an agile workforce, prepared for the jobs of the future?
- *a healthier environment* – how does Melbourne preserve and strengthen its natural assets and ecosystems alongside a growing population?
- *integrated plans and actions* – how can existing and emerging policies and practices help make Melbourne more resilient?

The metropolitan municipalities and other participants from a wide range of disciplines are considering these focus areas in detail, through in-depth analysis, broad engagement and developing targeted plans. The plans will form the Resilient Melbourne Strategy, which will be implemented from 2016.

Foundations of our approach

Australia's policies, laws, institutions and investments in research provide a strong foundation for building long-lasting climate resilience and adaptation.

A national framework for action

In April 2007, the Council of Australian Governments agreed to a *National Climate Change Adaptation Framework*. The Framework covers a range of cooperative actions between Australia's national and sub-national governments, addressing demands from business and the community for information on climate change impacts and adaptation options. The Framework has guided action over subsequent years to generate the adaptation information and tools needed by decision makers.

The Framework has two priorities: to build national adaptation understanding and capacity,

and to identify and reduce the vulnerability of, and build adaptive capacity in, regions (like the Murray-Darling Basin) and a number of priority sectors such as water resources, coastal regions, biodiversity, agriculture, fisheries and forestry, human health, tourism, settlements, infrastructure and planning, and natural disaster management.

The Framework has catalysed a wide range of projects, initiatives, institutions and outcomes, including:

- ▶ creation of a significant climate change adaptation research capability within the CSIRO; and the investment of \$126 million over five years in a Climate Change Adaptation Programme, through which the Australian Government funded a number of projects, including the establishment of the National Climate Change Adaptation Research Facility (NCCARF)

Learning to Adapt

The Environment Institute of Australia and New Zealand (EIANZ) is building capacity in climate change adaptation through its *Learning to Adapt* professional development programme.

The course, currently running over three days, builds the necessary skills for climate change adaptation projects, including applying climate change science, assessing and managing climate change risks, and implementing and communicating adaptation actions. *Learning to Adapt* has had over 400 attendees since its inception in 2010, and has instigated 16 adaptation projects, including one for the Brisbane Airport Corporation.

The training supports practitioner certification (Certified Environmental Practitioner Climate Change Specialist), a world first, providing assurance that those practitioners are competent to work and advise on climate change adaptation issues.

The New South Wales division of EIANZ originally developed the course with assistance from the Australian and NSW governments, but it has since expanded to Victoria and Queensland with the assistance of the Australian Government. EIANZ has plans to roll out the programme across Australia and New Zealand. *Learning to Adapt* has become the most continuous and longest running course relating to climate change in Australia and continues to evolve with the profession.

For further information visit: <http://www.eianz.org/institute-programs/learning-to-adapt>

- ▶ programmes across a wide range of portfolios to support adaptation such as the Australia's Farming Future initiative in the agricultural sector, and the Climate Change Skills for Professionals Programme enabling tertiary education and professional associations to create professional development and accreditation programmes for architects, planners, engineers and natural resource managers.

The Framework has established an institutional, research and evidence base that did not previously exist, and improved understanding of the need and options for climate adaptation across the Australian community.

This Strategy sets out many of the actions undertaken under the Framework across key sectors and identifies key future challenges. Community consultation and ongoing collaboration with the states and territories will ensure that the Framework continues to meet our needs in the future. The following priorities will guide these future discussions:

PRIORITY 1: UNDERSTAND AND COMMUNICATE

Improving our understanding and communication of the risks from a changing climate, and capitalising on research to drive innovation

PRIORITY 2: PLAN AND ACT

Develop and implement coordinated responses to climate risk, where needed

PRIORITY 3: CHECK AND REASSESS

Evaluate progress towards building resilience and adaptation to climate change and review our plans and actions

Review our plans, actions and outcomes regularly

PRIORITY 4: COLLABORATE AND LEARN

Work together to identify emerging risks and interdependencies, and share learning and successes.

Strong scientific institutions and capability

Science and research capacity is crucial to help us understand Australia's climate—what it will be like in the future, and how best to prepare for expected changes. Australia has a proud history of climate science excellence. This has delivered national preparedness for Australia, information needed to inform decision-making, and a capability to track how and why the climate is changing. Effective resilience and adaptation hinge on high quality information about the climate, and the current and future risks posed by it.

Australia's scientists and researchers have made significant contributions to climate change science and adaptation knowledge nationally and internationally, including through Australia's work in Antarctica and the Pacific. Australian scientists continue to be engaged in key national and international leadership roles—for example, as coordinating or lead authors within the Intergovernmental Panel on Climate Change (IPCC), contributing to an objective and authoritative analysis and synthesis of climate information.

The CSIRO has undertaken extensive adaptation research within the past decade focused on four themes: positioning Australia with information and guidelines to deal effectively with climate change, sustainable cities and coasts, managing species and ecosystems in a changing climate, adaptive primary industries, enterprises and communities. For example, CSIRO work on wind design standards for all new housing has shown how reducing the risk of



CSIRO and the Bushfire Cooperative Research Centre conducting research at Kinglake after the 2009 Black Saturday bushfires in Victoria (© Nick Pitsas)

damage by 50–80 per cent would lead to avoided present value of damage costs exceeding \$1 billion in Brisbane alone.⁶ CSIRO has also invested in understanding how and why the climate is changing and in providing credible and authoritative projections of Australia's future climates.

Weather, climate and water information and intelligence is critical to informing adaptation and promoting resilience. This is true not just for meeting the challenges posed by changes in average weather and climate conditions, but particularly the expected increase in a number of weather and climate extremes. The Bureau of Meteorology, as Australia's national weather, climate and water information agency, provides a wide range of products and services to support informed decision making by governments, emergency services, industry and the community. The Bureau

supports disaster risk reduction, for example, by issuing forecasts and warnings and providing advice to emergency services on severe weather such as bush fires, storms and tropical cyclones.

Advances in technology and data, including the Bureau's new supercomputer funded by the Australian Government, will enable more granular and real-time information that improve our response to and management of climate extremes, variability and natural disasters.

In 2007, the Australian Government established the National Climate Change Adaptation Research Facility (NCCARF). The Government created NCCARF to lead the research community in a national interdisciplinary effort to generate the information needed by decision-makers in government, business and in vulnerable sectors

The Bureau of Meteorology's new supercomputer used to run the ACCESS climate model (© Bureau of Meteorology)



Modelling the climate

Climate models are important in understanding past, present and future weather and climate. Models are mathematical representations of the climate system, based on physical laws and tested with observations, requiring powerful computers to run.

The Australian Community Climate Change and Earth System Simulator (ACCESS) was developed jointly by the Bureau of Meteorology, CSIRO and Australian universities to provide a national capability to model the Earth system on time scales from hours to centuries.

ACCESS is a global model that includes all elements of the climate system affecting Australia's weather, including the oceans, atmosphere, sea ice and land surface (plants, soils and hydrology).

Evaluation of this model via international benchmarking found that its performance ranks in the upper levels of models internationally. ACCESS delivers climate change simulations to the Australian and international science community, including for the IPCC Fifth Assessment Report.

Development and refinement of ACCESS continues so that it will meet the climate and weather information needs of government, industry and the community into the future.

and communities to manage the risk of climate change impacts. In its first phase, NCCARF successfully completed more than 140 research projects. NCCARF and its adaptation networks form a strong interface between stakeholders and the research sector in Australia. They have helped to build capacity of stakeholders in government, business and industry, by providing summary documents and guidance documents that simplify detailed research outputs.

In 2014, the Australian Government committed further funding of \$9 million to NCCARF for a second phase of work, focused on supporting sound decision-making and practical action, particularly in the coastal zone. NCCARF will deliver an online tool in 2017 enabling access to the best available science and advice on coastal climate risks and regional sea-level rise projections.

Climate science programmes

The science conducted by the Australian Climate Change Science Programme (1989-2016) and the current National Environmental Science Programme is vital to understanding the causes and consequences of climate change in the southern hemisphere.

Led by the Department of the Environment, the Bureau of Meteorology and CSIRO, in collaboration with researchers from Australia's research agencies and universities, the Australian Climate Change Science Programme has many significant achievements, including creation of ACCESS (see case study).

Work funded under the National Environmental Science Programme builds on the work of the Australian Climate Change Science Programme. The National Environmental Science Programme is a \$142.5 million programme delivered through six research hubs. One of these, the \$23.9 million Earth Systems and Climate Change Hub, led by CSIRO, is furthering our understanding of how the climate system is changing, improving our observations and understanding of past and current climate and enhancing the utility of climate change information. Other hubs, including the Tropical Water Quality and Clean Air and Urban Landscape hubs, are also supporting research into climate change adaptation.

Investments by state and territory governments and universities in climate change science complement those of the Australian Government. For example, the NSW and ACT governments, with the University of New South Wales, have produced NARClIM, an ensemble of climate change projections in high temporal and spatial resolution for southeast Australia, for use in impacts and adaptation research and local decision making.

Australian researchers work closely with international scientists on climate science, including monitoring of the atmosphere, biosphere and oceans, climate modelling and improving our understanding of climate processes. Australia has taken a pivotal role in undertaking research on the Southern Hemisphere climate, which is helping to deliver more robust information on the timing, extent and nature of likely changes to temperatures, rainfall, water availability, sea-level rise and extreme climatic events.

Cape Grim baseline air pollution station

Cape Grim is a facility run by the Bureau of Meteorology in north-western Tasmania, with a science programme run jointly with CSIRO. In over 40 years of operation Cape Grim has provided critical observations of the changing levels of greenhouse gases—for the Southern Ocean region and for the globe. Cape Grim is one of the top CO₂ observing stations in the world—similar and of equal stature to Mauna Loa in Hawaii. It has played a critical role in tracking climate change, and will continue to do so as the international community implements policies to reduce greenhouse gas emissions.

Climate research through the Australian Antarctic Science Programme investigates the role of Antarctica and the Southern Ocean in the global climate system, building on more than 50 years of climate research in Antarctica. Ice-core research at Law Dome in Antarctica led by researchers from the Australian Antarctic Division of the Department of the Environment and Antarctic Climate and Ecosystems Cooperative Research Centre, has significantly increased our knowledge of pre-instrumental climate.

This information is relevant not only to Australia but also to our Southern Hemisphere neighbours, and contributing this knowledge to the international effort will help to inform global solutions to climate change.

Australian resilience: risks, actions and future challenges



Australian resilience: risks, actions and future challenges

In the following chapters, the *Strategy* looks at national action in priority policy areas or sectors that Australian governments collectively identified after considering the economic, social and environmental magnitude of potential climate change impacts, their likely timing and the relative importance of early action to manage the risks.

The sectors and policy areas considered are:

- ▶ coasts
- ▶ cities and the built environment
- ▶ agriculture, fisheries and forestry
- ▶ water resources
- ▶ natural ecosystems
- ▶ health and wellbeing
- ▶ disaster risk management
- ▶ a secure and resilient region.

Each sector is responding to different trends and challenges in addition to climate change—whether structural, economic, demographic or social changes. In its [Fifth Assessment Report](#), the IPCC found that Australia’s capacity to manage climate change risks to built assets and human activities is generally high, but can still be costly, while natural systems have limited capacity to adapt to the rate of climate change. According to the IPCC, the major risks for Australia are:

- ▶ increased frequency and intensity of flood damage to housing, roads and other infrastructure

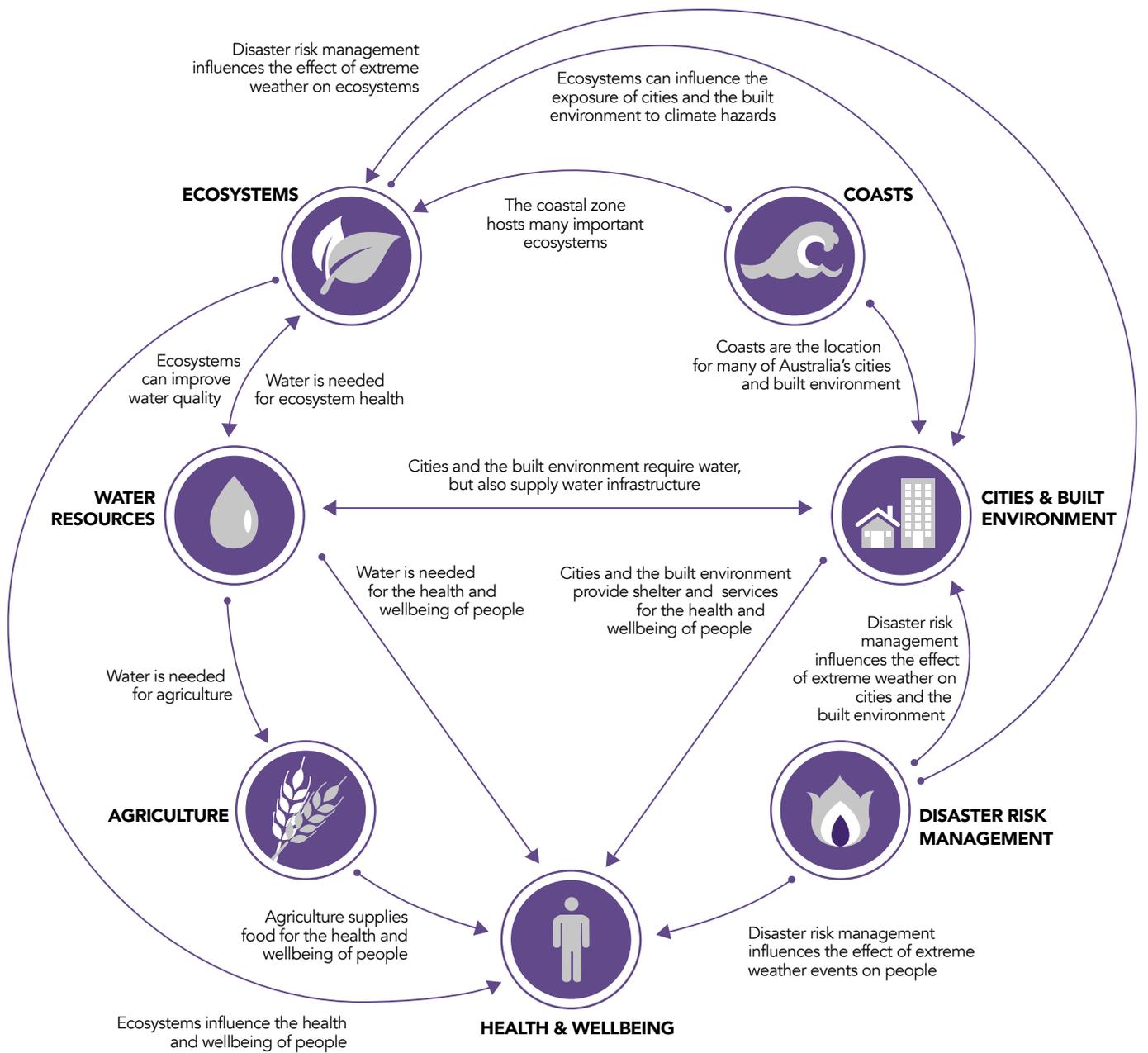
Images from the previous page
(1) Coastline (© Gregory Heath).
(2) Vineyard (© Australian Government Department of Agriculture and Water)

- ▶ increased illness, death and infrastructure damages during heat waves
- ▶ constraints on water resources in southern Australia
- ▶ significant reduction in agricultural production in the Murray-Darling Basin and far south-eastern and south-western Australia if scenarios of severe drying are realised
- ▶ increasing risks to coastal infrastructure and low-lying ecosystems from continued sea-level rise
- ▶ increased damages to ecosystems and human settlements, infrastructure, economic losses and risks to human life from bushfires in most of southern Australia
- ▶ significant change in the ecological community composition and structure of coral reef systems
- ▶ loss of mountain ecosystems and some native species.

Some sectors have experienced greater adaptation success to date than others, some need only consider incremental change—and others require more transformative responses.

Of course, actions undertaken in each sector also have implications for the others, both positive and negative, and synergies can be found when those crosscutting impacts are considered together.

Australia’s coastal zone exemplifies this complex set of interdependencies. Australia’s coastal settlements are characterised by the convergence of the natural and built environments and human systems to a high degree, a broad range of natural hazards and climate change impacts from tropical cyclones to sea-level rise, a governance system involving all



Key interdependencies between priority sectors

three levels of government, and risk ownership spread across all the actors, public and private.⁷

The IPCC gives the example of links between water, land and energy as emergent risks:

“Human management of water, land, and energy interacts with climate change and its impacts, to profoundly affect risks to the amount of carbon that can be stored in terrestrial ecosystems, the amount of water available for use by humans and ecosystems, and the viability of adaptation plans for cities or protected areas. Failure to manage land, water, and energy in a synergistic fashion can exacerbate climate change impacts globally producing emergent risks... For example, the use of water by the energy sector, by thermo-electric power generation, hydropower, and geothermal energy, or biofuel production, can contribute to water stress in arid regions. In

irrigated agriculture, climate, crop choice, and yields determine water requirements per unit of produced crop, and in areas where water must be pumped or treated, energy must be provided.”⁸

Coordination, collaboration and information sharing across a wide range of political, legal and institutional settings will help Australia to understand and manage these interdependencies.

Coasts



Coasts

Australia's coastline and beautiful beaches are etched in our national identity. They have been, and will continue to be, shaped by the climate.

The coast holds enormous economic, cultural, social and environmental significance for Australia. Most of Australia's urban population is located in the coastal zone, and coastal regions generate most of the country's economic activity. Beaches are part of our identity, as are our highly valued coastal and marine ecosystems.

What are the risks from a changing climate?

The Australian coastal zone has largely been developed with the expectation that the shoreline will remain stable, extreme events will occur within a range defined by historical experience, and sea levels will not change. This means that many coastal assets are vulnerable to future climate changes depending on their location and design.

Climatically, coastal areas are exposed to sea-level fluctuations, coastal inundation and river flooding from short-term weather cycles and episodes of extreme events, even without climate change. These pose risks to households and settlements, businesses, infrastructure and essential services (water and energy), and industry (such as fishing, oil and gas and tourism). Natural and built assets located a number of kilometres inland but within flood-prone areas also face 'coastal zone' risks.

Projected climate change will exacerbate the coast's current climate risks and create new risks:

- ▶ global and regional sea level rises are already occurring and future rises will be determined by global emissions
- ▶ rising sea levels will increase the impact of storm surge when it occurs.⁹ Storm surge is responsible for damage experienced during

large coastal storms, and can destroy buildings, wash away roads and run boats aground. This in turn will exacerbate coastal erosion, which presents problems at a number of points around the Australian coastline, with the risk of damage to coastal infrastructure, removal of sediment from beaches and loss of land

- ▶ current and planned coastal settlements and infrastructure may be affected by flooding, particularly in low-lying communities. Rising sea levels, combined with extreme events (such as river flooding), could result in further damage
- ▶ coastal assets are at risk from a number of other variables and hazards, such as ocean acidification, warmer sea surface temperatures, bushfires, increased wind speeds, and the increased frequency and intensity of heatwaves.

Adaptation for marine water quality, resources and biodiversity, including aquaculture, fisheries, conservation and tourism, can be enhanced by land-based climate change adaptation decisions, particularly those in the coastal zone.

Various studies show that early action anticipating coastal inundation hazard, mainly influenced by storm surge and rising sea level, can have great returns by avoiding later damages. For example, according to work by the CSIRO, proactive adaptation nationally could have a net present value of at least \$3.2 billion compared to a reactive approach that only adapts after damage to coastal residential buildings has occurred.¹⁰

What are we doing to improve the resilience of the coastal zone?

Most land-use planning decisions are made by local governments operating within regulatory and policy frameworks established by their relevant state or territory government. A range

of organisations, such as energy retailers, port authorities and the insurance industry also have an interest in coastal zone management.

Local councils, industry, business, non-government organisations, communities and individuals all play a role in implementing coastal adaptation actions. They are affected to varying degrees by the decisions of governments and each other. In coastal zones, in particular, decisions by private individuals can have significant and long-term impacts on public goods. For example, the construction of a seawall to protect private property from sea-level rise could result in the loss of beaches and associated loss of amenity and opportunity for public recreation in those areas.

Governments are increasingly working with affected communities and organisations, acknowledging that the coast presents opportunities for regional coordination. Although the states and local governments have responsibility for most on-ground action and decision making, the Australian

Government provides scientific data and technical information and guidance. This provides essential information for those making decisions about managing climate risks.

Over the past decade, the Australian Government has helped integrate climate change into coastal planning through a number of initiatives, including:

- ▶ investments in datasets, methodologies and visualisation tools
- ▶ projects to develop new approaches to decision-making that can cope with uncertainty, manage asset risk cost-effectively, and build adaptive capacity
- ▶ the *Climate Change Risks to Australia's Coast* report, which was Australia's first national coastal vulnerability risk assessment.

One of the Australian Government's principal contributions to climate adaptation information and



Storm surge on Queensland's Gold Coast (© Bruce Miller)

guidance is the funding of the National Climate Change Adaptation Research Facility at Griffith University on the Gold Coast in Queensland.

State and territory governments make decisions about climate risks to their own assets, such as roads and airports. An approach taken by a number of Australian state governments in the past to managing coastal climate risk has been to use sea-level rise projections to 2100 to create setback benchmarks for coastal development. This approach, where development is not approved within a certain proximity to the sea, has experienced wavering popularity in recent years.

In November 2015 the NSW Government announced a coastal management reform package for public consultation. The package includes a draft Coastal Management Bill, proposals for a Coastal Management State Environmental Planning Policy and an outline for a new coastal management manual. The aim of the new package is to establish a contemporary regulatory framework for coastal management and better support coastal council decision making. The package will equip coastal councils to more effectively identify and assess coastal hazards, and select and fund affordable coastal management programmes.

The economic and social implications for those responding to climate change, particularly local governments, can be significant. There is considerable variation in the way that local councils across Australia are responding to coastal climate risks. A number of councils have gained enormous experience proactively managing their specific risks, and there are opportunities to share these leading practices with councils at a less advanced stage of preparedness. There are significant benefits when local councils engage in a partnership approach, by bringing in other local councils and/or businesses and community groups. Working together, local councils can achieve economies of scale, share information and pool resources.



CoastAdapt: a coastal risk management framework

The National Climate Change Adaptation Research Facility is focused on delivering practical, hands-on tools and information to help governments, businesses and communities manage climate risks, particularly in the coastal zone.

The Facility is working closely with state and local governments, and other stakeholders around Australia to create an online coastal risk management framework, CoastAdapt, to assist organisations understand and manage the risks associated from sea-level rise, storm surges and other coastal hazards.

CoastAdapt will make use of national data sets and research outputs developed over the past five years by Australian research organisations. Informed by extensive consultation with potential users, CoastAdapt will include clear guidance on all aspects of adaptation planning in the coastal zone including community engagement, risk assessment and adaptation options. It will provide guidance, tools, case studies and worked examples.

CoastAdapt will be available online in late 2017.



Sydney seawalls

Legacy seawalls and other protective structures exist at many locations that come under the administration of Sydney coastal councils. Their construction details are sometimes unknown, and the capacity of the structures to withstand storm and inundation events is not always well understood. If communities identify coastal protection as an adaptation option, the state of existing seawalls and other protection structures is an important consideration.

Seawall asset owners and managers must consider development applications in areas protected by structures of unknown quality and origin (including those that are approved and those that are not). These decisions can generate conflict between the coastal managers and the community, which has varying impressions of their effectiveness. This emphasises the need to take a partnership approach to share concerns and ideas.

As part of the Coastal Adaptation Decision Pathways programme funded by the Australian Government, the Sydney seawalls project assisted local governments to evaluate the robustness of existing small seawalls against projections of coastal climate change. This information could then be used to develop options for further upgrades.

Under a partnership between the Sydney Coastal Councils Group, Coastal Environment Pty Ltd, Griffith University Centre for Coastal Management, the Water Research Laboratory (University of NSW), and WorleyParsons, the project developed an Assessment and Decision Framework for Seawall Structures. The widely applicable Framework comprises elements for assessing seawall suitability, monitoring and maintenance, and criteria for investigating and evaluating coastal seawalls using a cost-benefit analysis approach. The project used case studies to apply the developed methodology. For example, a detailed assessment was undertaken for each of the four seawalls at Bilgola Beach, resulting in evaluations of the effectiveness of seawalls prior to their exposure to a storm event likely to cause structural failure.

The relatively high degree of shared ownership, management and regulatory oversight of coastal assets often requires governments, businesses and individuals to take a coordinated approach. The unique geographical characteristics of the coastal zone, which often extend beyond governing borders, require governments to cooperate in planning and implementing adaptation actions. For example, many natural coastal processes (such as the shifting of sand accumulation) cross local (or even state) government boundaries.

Like individuals and businesses, the Australian Government manages risks to public goods and assets they steward on behalf of the community, including an extensive land and property holding managed by the Department of Defence, much of which lies in the coastal zone.



Department of Defence taking action

The Department of Defence has the most extensive land and property holding in Australia, comprising more than 3 million hectares of land and 25,000 buildings, with a replacement value in excess of \$32 billion. The Department also has large training areas and bases close to the coastline.

It is likely that Defence capability will be affected by changes in sea-level rise, storm surge and king tides. While these risks may develop over a long period, an assessment of the potential risks to Defence establishments is prudent to enable appropriate planning and expenditure on the Defence estate.

Recognising the challenges posed by climate change, Defence conducted a study to determine the impact of sea-level rise, flooding, storm surge and coastal erosion on selected bases. The report detailed physical infrastructure mitigation strategies to assist in reducing climate change impacts on these sites, and is being used to guide redevelopment and maintenance projects on the subject bases.

Defence is now undertaking a similar study to quantify the impact of these climate change factors on training areas and the effect that these changes may have on the generation of Defence capability using these training areas. The second study will again look at mitigation and remediation measures to ensure that the Defence training estate stays one step ahead of climate change.

The Department of Defence is taking concrete steps to address the risks of a variable and changing climate. On Australia's largest Royal Australian Navy base—HMAS Stirling in Western Australia—extreme heat, wind and wave events threaten the supply of power and water over the Garden Island causeway. Recognising the need to diversify power and water resources the Department, in partnership with Carnegie Wave Energy, has overseen the installation of three CETO 5 wave energy units with 240kW peak capacity to feed electricity to the HMAS Stirling grid, providing up to 5 per cent of the base's electricity supply, and a new wave powered desalination plant with the capacity to provide up to 30 per cent of Stirling's water needs.

Carnegie's Perth Wave Energy Project at Garden Island is a world-first example of wave-powered electricity and fresh water production. The project was funded with more than \$20 million in Carnegie equity, \$13 million of Australian Government funding through the Australian Renewable Energy Agency, and \$10 million from the Western Australian Government. The Australian Government is investing a further \$13 million for Carnegie's CETO 6 Project, which is in its preliminary design phase, and will further expand the capacity of the project.

There are many examples of governments working together to boost the resilience of Australia's coastal ecosystems. Action to protect and build the resilience of the Great Barrier Reef provides a prime example of innovative Australian action. The World Heritage-listed Great Barrier Reef is one of the world's greatest natural assets, and the Australian Government has taken action to improve the Reef's resilience through the Reef 2050 Plan. In collaboration with the Queensland government, the Plan sets out a long-term strategy and targets for managing pressures on the Reef, including invasive species, run-off and development.

Coastal climate risks in Australia can vary significantly: geographical location, local and seasonal climate variations and community capacity all play a part in defining the particular climate resilience challenge. This is well-illustrated in the Torres Strait, whose communities are now recognised to be at the frontline of climate change impacts due to their remoteness, often low topography and limited capacity to respond to the social, financial and ecological stresses that climate variability brings. The Australian and Queensland governments have collaborated with the Torres Strait Regional Authority, several research organisations and relevant local councils and community representatives, to develop management plans and construct coastal defences in highly exposed communities.

What do we need to do in the future?

Australia's coastline has always been a dynamic place and governments and communities are continually developing innovative ways to manage the impacts of climate variability. As coastal climate risks increase, Australia is facing new challenges in finding ways to minimise current risks and avoid future exposure. Early planning can help to ensure a more measured and cost-effective approach to managing coastal climate change, which in turn allows coastal communities and businesses to adjust positively and take advantage of opportunities.

There is further work to do to understand a range of critical questions, such as the most effective ways to preserve coastal environments from sea-level rise, the engineering, technical and natural solutions that will reduce risks to tourism infrastructure from increased weather severity, and estuarine systems' vulnerability to the coincidence of river flooding and coastal storm surge.

Continuing to build on extensive integrated coastal planning, risk assessment (including legal risk) and scientific understanding of coastal and climate processes developed to date will ensure that this work is progressed collaboratively across jurisdictions and tiers of government. The important frameworks and institutions are now in place to continue this effort.

Cities and the built environment



Cities and the built environment

Australia's cities are drivers of the national economy and home to the majority of our population but they face many challenges, including climate change.

Australian cities already rank among the best in the world in many measures of liveability. Stepping up to meet the many challenges they now face will ensure they retain this reputation and remain great places to live for current and future generations of Australians.

Climate change and natural disasters will impact on the location and design of our cities and the built environment, and the way we manage the precious natural resources that support human settlements.

What are the risks to cities and the built environment?

Climate change will pose challenges to a range of publicly and privately-owned and managed assets. Key climate risks to Australian cities include:

- ▶ challenges to often-ageing publicly and privately-owned and managed assets and infrastructure systems, including commercial and residential buildings, energy, water and communications utilities, and transport systems, both from gradual impacts like sea-level and temperature rise, and from extreme events like floods, heatwaves and bushfires
- ▶ greater risk of human injury, disease and death, and interrupted labour force productivity, due to hotter, drier conditions, increasing the bushfire risk to lives and private property and the incidence of heatwaves
- ▶ in the coastal zone—where most of Australia's urban infrastructure and population is located—more intense storms and cyclones and rising sea levels could worsen storm surge, coastal inundation and erosion

- ▶ damage to biodiversity and ecosystems that support social wellbeing, provide services that are fundamental to our health like clean air and fresh water, and offer protection from natural disasters
- ▶ negative impacts on Government budgets, including growing costs to the Australian Government to cover its contingent liability for natural disasters, and constraining existing Government capital for new investments and the need to rebuild or harden existing infrastructure
- ▶ failure in one part of a city's social, economic or infrastructure networks which may have cascading or unanticipated effects elsewhere, as demonstrated in Melbourne in 2009 when a heatwave-induced blackout shut down the city's rail and tram networks, forced thousands of businesses to close, and crippled internet services nationwide.¹¹ These interdependencies are local, national and global.

Population trends, urbanisation and residential shifts to high risk areas will intersect with climate change to increase Australia's exposure to natural hazards as a whole.



Ports are affected, not only directly by higher temperatures, sea-level rise, severe storms and increased rainfall, but by social, economic or physical effects of climate change around the globe. (© Arthur Mostead)

What are we doing to improve the resilience of cities and the built environment?

Because climate and weather-related risks have always been present, governments and private parties have fairly well established institutional, governance and policy frameworks to manage these risks.

Nationally, the government provides comprehensive and nationally consistent exposure information relating to residential, commercial and industrial buildings, public institutions and infrastructure assets through the National Exposure Information System (NEXIS).

The *Critical Infrastructure Resilience Strategy*¹² sets out the Australian Government's approach to ensuring that critical infrastructure is resilient, and the *Enhancing Disaster Resilience in the Built Environment: Roadmap* sets out the activities required to achieve broader disaster resilience in the built environment. The *Roadmap* focuses on: integrating legislation; developing comprehensive data and mapping; enhancing collaborative vendor disclosure; governance partnerships; lifelong education and training; and inter-jurisdictional coordination.

A range of codes, standards, and rating schemes exist to ensure that new building stock will be robust to a changing climate. Standards Australia has developed the first Australian Standard to incorporate a systematic approach to planning the adaptation of communities and infrastructure based on a risk management process. The Australian Government is working with states and territories and Austroads to update the National Guidelines for Transport System Management which will be called the *Australian Transport Assessment and Planning Guidelines*. These guidelines will cover public, road and rail transport, and include appropriate guidance on climate change adaptation for transport planning and project appraisal.



Climate risks should be taken into account in road project identification, formulation and execution, to minimise the potential impacts of extreme weather on the movement of people, goods and access to services. (© Willem van Aken)

State, territory and local governments own and manage more assets and deliver more services than the Australian Government, and share a greater responsibility for responding directly to climate change and natural disasters that affect publicly and privately-owned built assets. They have a range of sophisticated legislative, policy and regulatory frameworks and tools that help minimise exposure to potential climate and disaster risk.

The Western Australian Government's *Standard and Technical Guide on Addressing Climate Change in Road and Traffic Engineering*, for example, is helping planners, designers and managers identify climate change risks relevant to construction of roads and bridges.

Maintaining and improving our urban spaces' safety, amenity and productivity depends upon planning, designing and building them to consider possible climate change and extreme weather impacts.

WA Main Roads— Building climate resilient road networks

WA Main Roads is responsible for the delivery and management of a safe and efficient main road network in Western Australia. In order to manage risks to roadways from the combined impacts of inundation and shoreline recession from sea-level rise, WA Main Roads is integrating climate change considerations into design standards and road upgrades across the State – including the Great Eastern Highway (Kooyong Road to Tonkin Highway) and Great Northern Highway (Port Headland Realignment).

WA Main Roads has made it a requirement that the implications of a 300mm sea-level rise (450mm for structures) be considered as part of planning, design and construction considerations for all rehabilitation and expansion projects near coastal areas. Other WA Main Roads initiatives include: introducing climate change risk assessments into project planning; working with government and non-government stakeholders to address shared climate change risks; and educating employees and contractors on the impacts of climate change and ways to adapt assets over time.

People living in large cities can be more susceptible than non-urban dwellers to the effects of heatwaves because of the urban heat island effect, caused by the prevalence of heat-absorbing materials such as dark coloured pavements and roofs, concrete, urban canyons trapping hot air, and a lack of shade and green space in dense urban environments. The increasing intensity and frequency of heat waves, combined with the urban heat island effect, could have serious implications for human health. Some local councils have put in place measures to address this, such as the City of Melbourne's Urban Forest Strategy, which aims to increase canopy cover from 22 to 40 per cent by 2040 which could help reduce urban temperatures.¹³ Urban forests and greening also provide habitat for biodiversity, improve wellbeing, support management of stormwater run-off and improve air and water quality.

Natural assets provide important services to cities beyond urban greening, including protection of water catchments and recreational amenities for local communities. This was demonstrated by a series of floods in Queensland where Brisbane residents were faced with the prospect of running out of drinking water when silt from the Lockyer Valley threatened the Mt Crosby plant, which supplies 40 per cent of the region's drinking water. The *Southeast Queensland Resilient Rivers Initiative* is the resulting partnership between the Southeast Queensland Council of Mayors, the Queensland Government, water utilities, regional organisations and the community to improve the health of the region's waterways and help to safeguard future water supply.

Major infrastructure and assets in cities are often privately-owned, and peak bodies and sectoral representative bodies are providing private asset owners with targeted guidance. The Australian Green Infrastructure Council has developed *Climate Change Adaptation Guidelines* to help industry address climate change risks and opportunities for



Sydney skyline: the Minister for Cities and the Built Environment is focussed on improving the liveability, efficiency and productivity of our cities and the built environment (© Flickr/Marc Dalmulder)

new infrastructure projects or existing assets, and the Infrastructure Sustainability Council of Australia's sustainability rating scheme covers the design, construction and operation of transport, water, and energy and communications infrastructure.

What do we need to do in the future?

Climate change adaptation planning is common in Australia at the local or city level. Many Australian cities are participating in global resilience programmes, businesses are considering longer-term sustainability issues, urban utilities are considering climate risks to assets that deliver critical services, and health and non-government organisations are helping households manage extreme weather events.

We know that our settlements and the infrastructure that supports them are interconnected. Better integration of our planning systems, coordination, information sharing and risk disclosure will help business, communities and governments more effectively manage their exposure to climate change and natural disasters.

The resilience of our cities could be further increased through the land-use planning process, including by considering current and future disaster risks in planning decisions (including

approval of developments and location of infrastructure). Being smart about where, when and how we build is key to ensuring the climate resilience of our settlements and infrastructure over time. To deliver that resilience, planning policies need to be robust across a range of climate change outcomes and responsive to new information. Construction codes and standards that explicitly consider future climate change will help us design, build, maintain and retrofit more resilient infrastructure.

The recent announcement of Australia's first national Minister for Cities and the Built Environment flags the Australian Government's interest in finding opportunities to strengthen the climate resilience and liveability of our cities and built infrastructure. One of the roles of the new Minister will be a focus on improving the greening and sustainability of Australia's cities.

A significant opportunity exists in cities to both adapt to climate change and reduce greenhouse gas emissions through the use of passive microclimate control—the use of greenspace to offset additional urban heating, both as an adaptive measure as described above, and to reduce energy costs through reduced consumption and emissions.

Cities building resilience to climate change and extremes will benefit from improved energy productivity. Under the National Energy Productivity Plan, which includes a target to improve energy productivity by 40 per cent between 2015 and 2030, energy choices will become easier and the efficiency of appliances, equipment, buildings and transport improved. Through the CSIRO's Energy Flagship, the Australian Government is also supporting a dedicated research programme exploring new energy technologies for Australia.

If we want households and communities to understand the risks they must manage, and empower them to increase their preparedness, then all levels of government should be engaged in communicating disaster and climate risk information. The community should be involved in a conversation around 'acceptable levels of risk' and ensuring that risk ownership is clear.

Agriculture, forestry and fisheries



Agriculture, forestry and fisheries

Australia's primary industries are in a strong position to manage climate risks.

The agriculture, forestry and fisheries sectors are significant contributors to the Australian economy. They provide the quantity and quality of food that is enjoyed both nationally and internationally on a daily basis and play an important role in maintaining our health and wellbeing.

What are the risks from a changing climate?

Primary industries are highly sensitive to weather extremes and variations in climate. Climate variability is not new for Australian agriculture and many producers have adapted to the highly variable and challenging climate. Climate change is presenting new challenges in some locations and industries, while presenting new opportunities in others. Over the coming decades, projected climate changes are likely to increase productivity risks for agriculture, forestry and fisheries in different ways.¹⁴ For example:

- ▶ the increased frequency of drought conditions in southern Australia has the potential to affect agricultural yields, which can contribute to increases in food prices
- ▶ increasing temperatures and more frequent extreme heat events are likely to place livestock at greater risk of heat stress, reducing livestock productivity and reproductive rates
- ▶ rising water temperatures, changing currents and acidification of the ocean are likely to affect Australia's fishing industry
- ▶ forestry is facing an increased risk of declining productivity and tree mortality as a result of reduced rainfall, increased temperatures, natural disasters and water loss

- ▶ crops and horticulture are facing changes in growing seasons and changed frequency and intensity of heatwaves and storms
- ▶ changing temperature and rainfall patterns can affect the biosecurity risk posed by pests, diseases and weeds.

Water is fundamental to agriculture—including for growing crops and feed, and providing drinking water for livestock. Water availability is already a significant factor in the sector, particularly in irrigation areas. While the effects of the changing climate will vary across sectors, regions and production systems, the continued variability and shifting patterns of rainfall are likely to pose significant challenges, particularly to agriculture and forestry.

What are we doing to improve the resilience of agriculture, forestry and fisheries?

Individuals, industries and governments share the responsibility for managing climate risks to primary industries.

Farmers, like other business owners, plan for the future and make appropriate decisions based on their different situations. This means that farmers may choose to alter their crop management and breeding practices or take more substantial changes such as changing crops, agricultural products or locations.

Governments at all levels have a role in understanding and managing risks to public good and assets, and creating the right conditions and incentives for farmers and businesses to manage risks. State, territory and local governments play a key role in enabling and facilitating direct adaptation action, from giving farmers guidance about crop futures, to land use planning and regulation.

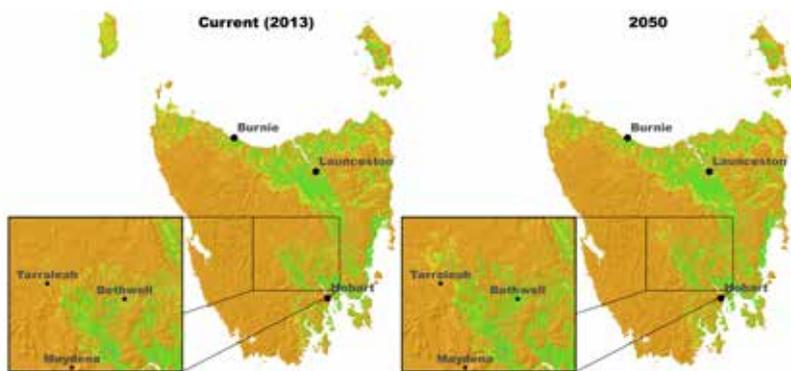
Supporting the adoption of agricultural opportunities in Tasmania

The Tasmanian Government is helping inform farmers and investors by identifying how five crops could be grown under different climate futures, specifically poppies, wheat, potatoes, wine grapes (sparkling and table wine) and barley.

Land is classified into “Well suited”, “Suitable”, “Marginally suitable” or “Unsuitable” classifications that are determined from mapped soil and climate parameters guided by established crop rules.

Farmers or investors can use this tool to identify emerging agricultural opportunities as the climate changes in regions across the state. This helps them to understand the likely risks or impediments of shifting agricultural businesses to different locations.

Visit <http://dpiwve.tas.gov.au/agriculture/investing-in-irrigation/enterprise-suitability-toolkit> for further information.



Sample map from Enterprise Suitability Mapping project (Land suitability change for Barley, Tasmania, comparing current estimations to projected change at 2050. Projections are based on Climate Futures for Tasmania simulations under a high (A)2 emissions scenario. Inset boxes display areas of greatest change) (© Tasmanian Department of Premier and Cabinet)

The Australian Government helps to build Australia's agricultural capacity to deal with a changing climate by:

- ▶ providing climate and weather information to support farmers' decision-making across daily, seasonal and longer time frames
- ▶ investing in agricultural research and development
- ▶ contributing to Australia's biosecurity system
- ▶ building drought resilience and preparedness
- ▶ investing to support sustainable and profitable agriculture.

Climate and weather information support decision making

The Bureau of Meteorology supports decision making by farmers, governments, industries and communities through its seasonal forecasts.

Seasonal forecasts provide information about the expected temperature, rainfall and streamflow conditions for the upcoming month, and three months, with insights into the further future.

This information helps a variety of individuals and organisations adapt to Australia's changing and highly variable climate. It allows farmers to prepare and build their resilience for events, such as the hot and dry conditions associated often with an El Niño event.

The seasonal outlook continues to improve in response to the needs of users, particularly agricultural communities. By 2017, the Bureau of Meteorology expects to improve seasonal forecast accuracy and to release multi-week forecasts.

Visit <http://www.bom.gov.au/climate/outlooks/#/overview/summary/>

Planning for the future and ensuring Australian farmers have access to advanced and appropriate farming technologies and practices are vital in maintaining the competitive edge of primary industries. Research and development provides farmers with options for dealing with future risks and opportunities. The Australian Government

and industry together invest around \$550 million annually through Australia's rural research and development corporations. The Australian Government boosted this investment with \$200 million over eight years to 2021–22 to fund collaborative research projects that deliver cutting-edge technologies, applied research and on-farm adoption. This is occurring through the Rural Research and Development for Profit Programme.

The Australian Government has made a significant investment in the Climate Change Research Programme and, more recently, in *Filling the Research Gap*, which includes \$7.9 million for adaptation research projects in the agriculture sector. This work includes projects exploring practices to increase livestock tolerance to heat stress during extreme weather events while increasing productivity and improving animal welfare.

In an international context, Australia participates in the Global Research Alliance on Agricultural Greenhouse Gases, working with more than 40 member countries to encourage collaboration on climate change research, including assisting developing nations in identifying more resilient agricultural systems.

Climate change is a factor, along with changing land use, trade and travel patterns that can affect the biosecurity risk posed by pests, diseases and weeds. Adaptive land management strategies—such as new crops and agricultural areas (as in Northern Australia)—will change risk pathways as industries respond to a more variable or extreme climate.

The Australian Government has implemented formal biosecurity emergency response agreements and collaborative arrangements for the collection and sharing of information with states, territories and industries. These arrangements contribute to timely and effective identification and reaction to new or emerging pests, diseases or weeds that could result from climate change.

Over the coming decades, time in drought is projected to increase across southern Australia, with a greater frequency of severe droughts.¹⁵ If this were to eventuate, it would present a major challenge for Australian farmers. The Australian Government is committed to helping position farm businesses to prepare for, manage through and recover from drought.

The Australian Government works closely with state and territory governments to implement a range of measures under the Intergovernmental Agreement (IGA) on National Drought Programme Reform. The IGA aims to refocus government support to encourage farmers to prepare for droughts and to manage their business risks proactively. The measures encourage farmers to improve their preparedness and resilience, so that they are better able to manage through and recover from periods of drought.

The *Agricultural Competitiveness White Paper* provides significant measures to help farmers manage climate variability. It makes available \$2.97 billion to support farmers and rural communities in drought, and to strengthen their drought preparedness and risk management. For example, farm businesses can claim an immediate tax deduction for new water facilities and depreciate new on-farm fodder storage assets over three years from May 2015.



The Australian Government is keen to ensure, through improved management of our natural resources, that environmental and agricultural outcomes are appropriately balanced. For example, under the National Landcare Programme regional stream, \$450 million is being provided to Australia's 56 regional natural resource management organisations for natural resource management activities, including identifying the best ways to achieve local sustainable agriculture priorities.

To assist industries respond and adapt to changes in water availability, a national Water Use in *Agriculture Research, Development and Extension Strategy* has been developed to increase water-use efficiency in agriculture.

What do we need to do into the future?

Past and present investments made by Australian governments, the innovation and research capacity of our scientific institutions, and the decisions made by individual farmers and businesses are improving the resilience of agriculture, forestry and fisheries to the changing climate.

Adaptation will continue to be increasingly important into the future. Building further flexibility into our agricultural system will support a range of adaptation actions—ranging from small changes to larger, more transformational change appropriate to different sectors, regions and production systems. There will need to be a continued focus on ensuring agriculture, fisheries and forestry stakeholders have access to the best available climate information, advice and support to manage risk to their business.

Water resources



Water resources

Australia's experience managing scarce water resources in a variable climate has put it in a strong position to manage emerging climate risks.

Water is a vital component of our society and economy, and for sustaining the healthy environment in which we live. Apart from drinking water and household use, Australians rely on water as an input to almost every industry in the nation's economy, particularly agriculture.¹⁶

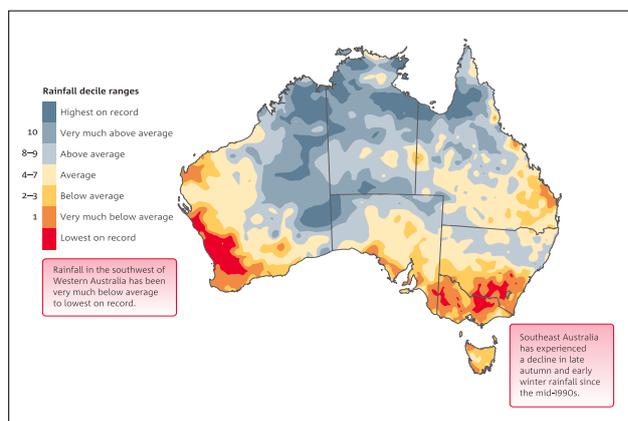
Australia's water availability is influenced by factors including seasonal and yearly variability in rainfall, which is affected by climate drivers such as the El Niño Southern Oscillation and the Indian Ocean Dipole. Australia experiences low surface flows of water due to high rates of evaporation and mountains that are relatively low by world standards.¹⁷ Non-climate influences that affect water management in Australia include a growing population, ageing water infrastructure, competition for water, energy prices and changing water consumption patterns.

Water resource management in Australia is broadly categorised into urban and rural water sectors. The urban water sector focuses on providing a continued reliable supply of water for households along with the maintenance of different services, such as sanitation. The rural water sector focuses on supporting agriculture and ecosystems.

What are the risks from a changing climate?

At a continental scale, rainfall average over Australia has slightly increased since 1900, but there is considerable variability in where and how that rain has fallen across Australia. Northwest Australia has experienced a significant increase in the frequency of heavy rainfall events, consistent with the observed increase in total annual rainfall since 1970.¹⁸

In comparison, much of southern Australia is becoming significantly drier. Rainfall has declined since 1970 in the southwest, dominated by reduced winter rainfall. Autumn and early winter rainfall has mostly been below average in the southeast since 1990.¹⁹ The reduction in rainfall is amplified in the water flow into our rivers and streams. In the far southwest, streamflow has declined by more than 50 per cent since the mid-1970s.



Southern wet season (April–November) rainfall has declined since 1996 (© Bureau of Meteorology and CSIRO 2014)

Observed changes have already detected an increase in the risk to the services which rely on water. For example, Perth's water supply has seen a reduction in streamflow into the dams from an average of 338 gigalitres a year between 1911 and 1974, to 65.8 gigalitres a year between 2006 and 2013.²⁰

In the future, cool season rainfall is likely to decline further in southern Australia, but changes elsewhere are uncertain. When changes in rainfall are combined with expected increases in potential evaporation, decreases in soil moisture are expected across Australia. Extreme rainfall events are projected to increase in intensity, but time in drought is also projected to increase in southern Australia, with more frequent severe droughts.²¹

Groundwater is vulnerable to climate change and climate variability. Potential climate risks for groundwater include reduced groundwater recharge and groundwater supplies, seawater intrusion to coastal aquifers, reduction of freshwater availability on small islands, and increased demand.

Supply from surface and groundwater is not the only risk to our water resources. Increased extreme weather events, such as bushfires and floods, can affect water quality and the infrastructure on which our water resources rely. Increasing temperatures may also increase the risk of bacterial contamination in water supplies, blue-green algal outbreaks and acid-sulphate soil issues. Rising sea levels may pose a flood risk to low-lying coastal assets and may lead to saltwater intrusion into groundwater resources. More extreme hot days could pose a risk to worker safety and productivity, and disrupt electricity supplies leading to service failure.²²

What are we doing to improve the resilience of the water resources sector?

Water authorities and utilities ensure the supply, quality and quantity of water resources and services in the urban environment. Utilities are taking steps to build resilience to a changing climate, including initiatives to reduce household water demand, diversifying water supply, creating interconnected water supply grids or systems, reducing loss from irrigation channels, building redundancy into sewerage systems to cater for increase peak flows and building understanding of other potential impacts on infrastructure—such as odour and corrosion of pipes.²³

For example, the goal for the Water Corporation in WA is to reduce water use by 15 per cent through water saving programmes, smart metering of water use and promoting water efficiency.²⁴ At

the same time, the Water Corporation is investing in climate-independent water sources, including desalination and groundwater replenishment, and water recycling for non-drinking uses.²⁵



Aerial view of the Cataract Dam and Reservoir, New South Wales (© Gregory Heath)

Water utilities are looking to manage the consequences of climate change for their infrastructure and the services that they provide. For example, SydneyWater has partnered with Climate Risk Pty Ltd, the Water Services Association of Australia, the Australian Government, MelbourneWater, City West Water, SA Water, Queensland Urban Utilities and the Water Corporation to develop the AdaptWater™ tool. This quantifies the risk associated with climate change and extreme weather events to water utility assets. The tool performs cost-benefit analyses on proposed adaptation options to inform planning and investment decisions.

High-quality and accessible water data and information is available to help inform policy, planning and water management decisions in both the urban and rural water sectors in Australia. For example, the Bureau of Meteorology collects and publishes data on climate change, climate variability and on rainfall, groundwater, and streamflow, as well as water market information.

The Murray-Darling Basin supports significant biodiversity
(© Murray-Darling Basin Authority/Keith Ward)



A changing climate and the Murray-Darling Basin Plan

The Murray-Darling Basin Plan (2012) established a whole-of-Basin approach to water planning and management across five jurisdictions and sets a sustainable limit on the use of Basin water resources. The Basin Plan limits water use at environmentally sustainable levels by determining long-term average Sustainable Diversion Limits for both surface and groundwater resources. It is an adaptive framework that will be rolled out over seven years to 2019.²⁶

The Murray-Darling Basin Authority was established to develop and implement the Basin Plan. The federal government adopted the plan with strong bipartisan support. All Basin governments have committed to the plan and are implementing it through their legislative and management frameworks.

The Plan builds on existing arrangements developed over the past century for the management of water resources in Australia's highly variable climate, including seasonally adjusted water allocations in the Murray-Darling Basin and the capacity to trade water.

The highly variable climate of the Basin provides significant challenges to water managers, which will be exacerbated by a changing climate. The *Water Act 2007* required the Authority to consider climate change in the development of the Basin Plan and to develop strategies to manage the risks to the availability of water resources arising from the effects of climate change.²⁷

The Plan included climate change considerations in its high-level objectives and through various provisions implemented within an adaptive management framework. Some existing actions and arrangements which help build resilience have been strengthened. For example, water trading has been improved by applying a set of updated trade rules consistently across the Basin and removing barriers to the trade.

The Plan aims to buffer the system from stress, for instance by providing additional water to ecosystems. The Commonwealth Environmental Water Holder oversees the management and use of a portfolio of water to protect and restore rivers, wetlands and floodplains, in the interest of sustaining productive river communities throughout the Murray-Darling Basin. Commonwealth water holdings are the result of government purchases of entitlements and a substantial investment in more efficient water infrastructure in the Basin.

Other measures explicitly address elements of climate change, such as improving knowledge about the impact of climate change on the water. Finally, the Plan includes actions that allow adaptive responses to climate change over multiple timescales. There is a ten-year review interval for the Basin Plan and a five-year review interval for the complementary Environmental Watering Plan and the Water Quality and Salinity Management Plan.²⁸

The Water Efficiency Labelling Scheme (WELS) is the national program for encouraging more efficient domestic water use. The scheme labels domestic water products with their consumption information, influencing purchasing decisions and driving both reductions in demand for water and competition amongst suppliers. After a decade of implementation, the WELS scheme is estimated to be saving at least 100 gigalitres of water each year in our major cities and towns, along with achieving major energy savings.

The 1994 Council of Australian Governments Water Reform Framework, and the 2004 Intergovernmental Agreement on the National Water Initiative (NWI), set out the foundations for the management of water resources. National, state and territory governance mechanisms supplement the Framework and the NWI and operationalise many of their principles. In some cases, where catchment areas extend across multiple jurisdictions, cooperative management has been developed, such as the Murray-Darling Basin Plan (see case study).

NWI implementation is well advanced in the Murray-Darling Basin, but is still being implemented in other major basins such as the Lake Eyre Basin and Great Artesian Basin, and some northern catchments where development is still underway.

The NWI represents a shared commitment by governments to manage water resources in a way that optimises economic, social and environmental outcomes through a range of regulatory and planning reforms. The NWI has been recognised internationally as a model for effective and efficient water management that addresses the challenges of cross-jurisdictional management of shared water resources and enables greater certainty for investment in new water resource developments.

The NWI explicitly recognises climate change as a potential constraint on future water allocations. In particular, the NWI identifies water entitlement holders as responsible for bearing the risks of any reduction in the amount and reliability of water allocations because of seasonal or long-term changes in climate. This approach aligns with a key driver for good adaptation—the clear allocation of climate risks to those best placed to manage them.

More broadly, the reforms set out in the NWI help position water managers to respond to changing water availability. Under the NWI, water resources are managed by each state and territory having in place water plans and water access entitlements that provide long-term security of access by water users to their share of the available water resource. These plans are the primary mechanism for addressing risks to water security resulting from inter-connectivity between surface and groundwater systems, interception activities, and climate variability and long-term change.

Identifying a sustainable limit for water extractions is one of the fundamental principles of the NWI. Caps must be informed by robust scientific analysis of water resources and an appreciation of trade-offs between environmental considerations and social and economic needs. To determine sustainable limits over the long term, it is essential to understand the implications of climate change for water availability.

Water markets allow water users to adapt to changes in water availability. Water markets place a cost value on water, a value which varies according to demand and supply. In times of water scarcity, water markets can move water to more productive and efficient uses. The principles embedded in the NWI provide essential prerequisites for water market development, including:



Chicks in Barmah Forest in the Murray-Darling Basin (© Murray-Darling Basin Authority/Keith Ward)

- ▶ setting an effective cap on total sustainable water extractions
- ▶ statutory-based water plans and secure water access entitlements that provide long term security of access to water
- ▶ sound regulatory and governance frameworks within which water trading can take place
- ▶ good water management such as metering and water accounting.

The Australian Government is working with the governments of the Australian Capital Territory, New South Wales, Queensland, South Australia and Victoria to protect and restore water-dependent ecosystems in the Murray-Darling Basin. Guided by the Murray-Darling Basin Plan, governments' objectives include ensuring water-dependent ecosystems are resilient to climate change.

What do we need to do into the future?

Past and ongoing investments by water utilities and reform leading to the formation of a nationally coordinated system of water management have produced benefits. Water-dependent goods and services are more resilient to increasing rainfall variability and a changing climate. More effective water management has placed Australia in a strong position to manage emerging climate risks.

Continued action by governments, water utilities, businesses and communities will ensure we manage climate risks that are still emerging. This may include introducing more efficient technology for household water use right through to agricultural and industrial scales. This could include supporting the diversification of water supplies or smart metering of household water use. Options for managing risks to water resources vary extensively according to the location, the actor, and the goods and services the water is providing.

Natural ecosystems



Natural ecosystems

Australia's biodiversity and ecosystems are diverse and unique. There are limits to the capacity of natural systems to adapt to the impacts of climate change.

Australia—home to almost one tenth of all species on earth—is one of the most biologically diverse parts of the planet.²⁹ Many of Australia's species are found nowhere else in the world. This biodiversity is essential for our existence, and intrinsically valuable in its own right. It provides services that are fundamental to our health like clean air and fresh water, products such as timber, protection from natural disasters, as well as cultural and spiritual values.

What are the risks to ecosystems from a changing climate?

Australia's unique biodiversity and the ecosystems that support it are under significant pressure from threats that include habitat fragmentation, invasive species and altered fire regimes. Many species and ecological communities are threatened and at risk of extinction or vulnerable to collapse. Over the last 200 years, Australia has suffered the largest documented decline in biodiversity of any continent.³⁰

Climate change, particularly rising temperatures, will exacerbate many of these existing pressures and will significantly affect biodiversity and ecosystems.³¹ These existing pressures interfere with the natural responses to climate change that native species have relied on in the past, undermining their resilience.³² Scientists expect climate change to cause changes to the abundance and geographic range of many species, restrict or alter species movement and interfere with their life cycles (such as the timing of germination). Climate change presents

a biosecurity risk for Australia's ecosystems by altering the distribution of pest and weed species.

Ecosystems have a limited capacity to manage these multiple pressures compared to human systems. Rates of climate change, together with other pressures, limit the capacity of species to adapt *in situ* or migrate to more climatically suitable areas, where such areas exist.³³ Indeed, climate change is already posing risks to Australia's ecosystems, and some impacts will be difficult to avoid.³⁴ A number of Australia's unique and fragile ecosystems are at risk from current climate conditions, including the Great Barrier Reef, Queensland's wet tropics and the Australian Alps. These ecosystems are unlikely to survive in their current form if global temperatures rise by more than 2°C above pre-industrial levels.³⁵

How are we improving the resilience of our ecosystems?

Australia has a long history of effective action to protect ecosystems, manage external threats and address biodiversity decline. These actions help to maintain natural levels of biodiversity and improve the overall health of ecosystems. Healthy ecosystems are more resilient to the impacts of climate change. Governments, the private sector and communities all play a significant role in environmental management.

Australia is a party to international agreements designed to protect biodiversity, such as the *Convention on Biological Diversity*, which form the constitutional basis for the Commonwealth to take action to protect biodiversity.

At the national level, the Australian Government provides funding for scientific activities, provides information to the public, manages Commonwealth lands and marine areas, provides funding for conservation and natural resource management activities, and plans, recovers and manages

Images from the previous page

(1) Yellow-footed rock wallaby (© Flickr/Roger Smith)

(2) Flowering gum. (© Flickr/Denisbin)

Climate change in the marine environment

Climate change is causing the sea surface temperatures to rise and is increasing ocean acidification, which will have impacts on the marine environment, particularly in coral reef systems. In its latest report, the IPCC observes that the ability of coral reef species to adapt to these changes is limited.

Marine protected areas are an important tool for marine ecosystem resilience and adaptation in response to climate change. At more than 3 million square kilometres, Australia's National Representative System of Marine Protected Areas is the largest marine protected areas system in the world. Marine protected areas provide an important contribution to Australia's ability to manage the effects climate change. For example, they provide refuge for species as their ranges shift in response to climate change. They also represent important sites for monitoring the effects of climate change.

The Australian and Queensland Governments are driving the implementation of the *Reef 2050 Long-Term Sustainability Plan*—a 35-year blueprint for the management and protection of the Reef. Developing ecosystem resilience in the face of a variable and changing climate is a key principle of the Plan.

Overall investment by governments in the Reef exceeds \$2 billion over the next decade, including \$140 million for the Reef Trust, which provides targeted funding for improved water quality, restoring coastal ecosystem health and enhancing species protection.

water for the environment in the Murray-Darling Basin. The Australian Government administers the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which protects matters of national environmental significance, including listed threatened species and ecological communities. The Act recognises that climate change presents a key threat to biodiversity by restricting the habitat of species and ecosystems.

Australia's Biodiversity Conservation Strategy 2010–2030 (ABCS), approved by each of the state and territory governments and the Australian Government, aims to reduce the impacts of climate change on biodiversity. The Biodiversity Conservation Strategy forms the overarching framework for more specific policies such as the

Strategy for Australia's National Reserve System 2009–2030, which provides national guidance for improving the coordination of the National Reserve System. The National Reserve System — Australia's network of protected areas that covers over 10,000 properties across more than 17 per cent of Australia's landmass—is Australia's primary landscape-scale solution to help biodiversity adapt to a changing climate while protecting healthy ecosystems. It does this by:

- ▶ improving the resilience of the landscape to withstand and recover from climate change impacts by conserving a diversity of species and habitat

- ▶ providing opportunities for species and ecosystems to move, adapt and reorganise in response to changing climatic conditions
- ▶ protecting critical habitat refugia to which species can move in times of environmental stress such as drought events
- ▶ reducing the direct damage costs and severity of natural disasters (for example, wetlands storing water during flood)
- ▶ drawing on Indigenous and traditional knowledge systems and practices, particularly through Indigenous Protected Areas which make up over 40 per cent of the reserve network.

The Australian Government is investing more than \$2 billion to help communities take practical action towards rebuilding and protecting our precious natural resources and build ecosystem resilience to climate change. These investments are administered through the Green Army Programme and the National Landcare Programme (including the 20 Million Trees programme), the Reef 2050 Plan and Working on Country programme. These investments are in addition to substantial government contributions to managing water resources.

Under the National Landcare Programme many natural resource management organisations drawing on Indigenous and traditional knowledge systems and practices through on-ground activities and employment opportunities, such as traditional burning practices, rehabilitation and management of high-value ecological communities and management of threatened species. The Green Army Programme supports projects that improve and extend habitat for threatened species and therefore their resilience to climate change. For example, the Big Scrub Rainforest Landcare Group is hosting Green Army teams to work together with the New South Wales Parks and

Wildlife Service to improve the condition, extent and connectivity of the critically endangered ecological community lowland rainforest of subtropical Australia in northern New South Wales. These projects will improve the resilience of this ecological community through weed treatment, seed collection and propagation and revegetation.

The Australian Government is working with the governments of the ACT, New South Wales, Queensland, South Australia and Victoria to protect and restore water-dependent ecosystems in the Murray-Darling Basin. Guided by the Basin Plan (see Water Resources), the governments' objectives include ensuring water-dependent ecosystems are resilient to climate change through activities like those of the Commonwealth Environmental Water Holder and The Living Murray Initiative (see Water Resources).

Protecting Australia's threatened species

The Australian Government's *Threatened Species Strategy* outlines a new, action-based approach to protecting and recovering our threatened plants and animals. The strategy provides a more prioritised, targeted and coordinated approach to managing threats to Australia's native species, which in turn will help to improve the resilience of ecosystems to climate change.

Australia's first Threatened Species Commissioner, appointed by the Minister for the Environment in July 2014, brings a new national focus to conservation efforts and is helping to address the growing number of native flora and fauna in Australia facing extinction.

Revegetation provides a range of environmental services



Revegetation helps to protect water catchments in South Australia

SA Water is owned by the South Australian Government and delivers safe and affordable water services to more than 1.5 million South Australians. As part of their land management, SA Water uses native species in revegetation across historically cleared parts of their water catchments to protect water quality, encourage biodiversity, and to increase carbon sequestration.

To ensure the resilience of revegetation plantings in a drier future climate, SA Water and its partners have redesigned their revegetation strategy to use an alternate seed collection protocol termed 'composite provenancing'. Supported by research, this protocol combines locally-sourced seeds with seeds sourced from drier parts of a species' range in a way that mimics the dynamics of the natural gene flow that would have existed before land clearing and fragmentation.

Ongoing research has demonstrated that trees grown from seeds sourced from drier parts of a local species range perform better in revegetation than those grown from seed sourced from the immediate surrounds. Integrating this new approach into land management activities will help to maintain the co-benefits from native revegetation into the future.

In addition, the Australian Government's \$145 million National Environmental Science Programme (NESP) is assisting decision-makers to understand, manage and conserve Australia's environment by funding world-class biodiversity and climate science. The Australia Government has also funded AdaptNRM, a national initiative which brings together a diverse group of scientists and researchers from CSIRO and NCCARF to work with natural resource management practitioners. The project aims to support these regional organisations to update their natural resource management plans to incorporate climate change and adaptation approaches, and guide planning for climate change impacts on the land.

State and territory governments have primary responsibility for managing land, water and biodiversity within their jurisdictions. States and territories use a combination of legislation, policies, strategic planning frameworks and

management approaches to manage and protect biodiversity. Many of these include considerations of climate change.

For example, the New South Wales Government has developed a Statement of Intent in response to the listing of climate change as a key threatening process under the NSW *Threatened Species Conservation Act 1995*. The Statement identifies priorities to support biodiversity to adapt to the impacts of climate change. In the ACT, the *Nature Conservation Strategy 2013-2023* provides a coordinated and integrated approach to nature conservation. The Strategy recognises that assisting the ACT's biodiversity to adapt to a changing climate requires new conservation approaches, including a whole-of-landscape planning approach and a stronger focus on protection for threatened species by enhancing ecosystem resilience.

Across Australia, the Regional Natural Resource Management Planning for Climate Change Fund is helping regional natural resource management organisations incorporate climate change mitigation and adaptation measures into existing regional natural resource management plans. Regional natural resource management organisations are updating existing plans to identify where in the landscape climate adaptation and mitigation activities should be undertaken. Regional-level information about the impacts of climate change (water, temperature, storms) is now available to assist planning (see ‘Australia’s Future Climate’ in *The climate change challenge*).

Local governments provide a valuable and ongoing contribution to efforts to conserve biodiversity through their role in local and regional planning, environmental management, monitoring and reporting and adapting to the impacts of climate change. Some local governments are taking actions to increase the resilience of ecological assets, threatened habitats and species to damage from extreme weather events. They include climate change in planning and decision-making.

What do we need to do in the future?

Climate change will drive a great deal of change in our biodiversity and ecosystems. Australia is taking action at many levels to ensure our ecosystems are healthy and resilient to this future challenge.

Many conservation approaches will continue to be effective under climate change, particularly where climate change impacts are expected to be relatively small and knowledge and capacity are high.³⁷ Improving ecosystem resilience and the connectivity of fragmented ecosystems, supporting the National Reserve System, protecting important refugia and reducing invasive species and other pressures on ecosystems will remain important to conserve biodiversity regardless of future climate change impacts.

Tasmanian Midlandscapes and the Midlands Conservation Fund

The Midlandscapes project aims to respond to threats to biodiversity—including the projected effects of climate change such as increased temperatures, prolonged drought and heavy rainfall events—by protecting up to 64,000 hectares of important conservation areas in the Midlands of Tasmania and building landscape connectivity.

Enhancing connectivity is one of the most effective tools available for conserving biodiversity and preparing landscapes for climate change. Wildlife corridors can help ensure against climatic uncertainty by providing alternative pathways for species’ movement and adaptation.

Located in the Tasmanian Midlands in an area that supports cropping and broad-acre grazing, the project is supported by the Midlands Conservation Fund, which offers stewardship payments to landholders for protecting threatened natural landscapes. By reducing threats such as over-grazing and weed invasion, and conserving native species such as perennial deep-rooted grasses, landholders are helping to build resilience against climate change. Many landholders are actively involved in revegetation projects to reduce fragmentation of native vegetation and improve connectivity for populations of mammals and birds that have become isolated due to land clearing.

In time, some ecological systems occurring across the continent are likely to be markedly different from the current systems. To minimise biodiversity loss, some conservation approaches will need to adapt to a future with potentially significant differences in biodiversity and its distribution, along with a limited knowledge of the magnitude and extent of future ecological changes. If we want to maximise opportunities for species to find suitable habitat, our approaches will need to focus on reducing the impacts of climate change on ecosystems, and maintaining or improving their capacity to adapt while remaining relevant and feasible under a range of possible future trajectories of ecological change.³⁸

Building our knowledge about how biodiversity and ecosystems respond to climate change will ensure our management interventions are more effective. This ongoing investment, as well as improved institutional arrangements for sharing research and other forms of knowledge among conservation practitioners and decision makers, will deliver refined biodiversity management strategies that can help the ecosystems on which we depend for so many services cope with climate change.



Poa grassland on the property of a Midlands Conservation Fund landholder, near Campbell Town (© Matt Appleby)

Health and wellbeing



Health and wellbeing

Climate change is influencing health outcomes

Good health is the foundation of our way of life, and ultimately the state of the wider society and economy. The health sector is facing a range of challenges, including a growing and ageing population, the rising costs of treatment and basic services, increasing urbanisation and lifestyles that are more sedentary.

While the greatest health threats to Australians are from chronic diseases, (such as cancer, cardiovascular disease,³⁹ diabetes and mental health issues), climate change poses challenges to the health of Australians through stresses such as heatwaves, droughts and an increase risk of food and water borne diseases.

Yet Australia is in a good position to adapt to climate change from a health perspective. We have high levels of education, access to technology and a strong public health system. We are working to address chronic diseases, such as cardiovascular disease and diabetes. We already respond effectively to environmental threats to human health including heat waves, bushfires, flooding, disease outbreaks and declines in air and water quality. We learn from events, and revise our actions accordingly.

What are the risks from a changing climate?

Human health is intimately linked with the environment, and environmental factors such as temperature and air and water quality are important determinants of health. The changing climate is altering the environment in multiple and far-reaching ways, with the greatest health threats expected to come from extreme weather events (such as heat waves), rising temperatures and the changing variability of rainfall. The full range of risks to human health from climate change is mostly foreseeable based on our knowledge of

how natural variations in climate and weather have affected rates of illness, disease and death.

The increasing incidence of heat waves is leading to a greater risk of injury, disease and death.⁴⁰ The core body temperature for humans needs to remain around 37°C.⁴¹ If the body absorbs more heat (for example, from outside temperatures) than it can release, the core body temperature will rise. With a core body temperature of 38°C, the body can suffer heat exhaustion and reduced mental and physical capacity.⁴² At 42°C, serious heatstroke or death can occur.⁴³



Those most at risk during heatwave events include the elderly, children, some workers, Indigenous Australians and those already suffering from chronic disease.

Heat waves have caused more loss of life than any other natural hazard in Australia over the past 100 years.⁴⁴ The severe Melbourne heatwave in early 2009 that preceded the Black Saturday bushfire led to an estimated 374 more deaths than would normally be expected at that time of year.⁴⁵ The more recent, 2014 January heatwave resulted in 167 more deaths than expected in Victoria alone.⁴⁶ The week of the 2014 heatwave saw a 25 per

cent increase in Ambulance Victoria's emergency caseload in the metropolitan region, along with a five-fold increase in heat-related presentations to public hospital emergency departments and a three-fold increase in heat-related calls to the Nurse-On-Call service.⁴⁷ Those most at risk during heatwave events are the elderly, children, particular categories of workers and those already suffering from chronic disease.⁴⁸

The increasing frequency and intensity of other extreme weather events also pose risks to human health, including injuries, disease and death and disruption to health services. Extreme weather events have flow-on effects for basic human services (including increasing risks to food and water security and the provision of basic sanitation) and place increased demands on hospitals, aged-care facilities, local governments, community organisations and service providers.

Drought has been linked to decreased mental health, particularly in rural communities.⁴⁹ The experience of droughts and their impacts, such as loss of income as well as changes to social roles, are often associated with stress, anxiety and sometimes suicide.⁵⁰

Changes in temperature, rainfall and humidity create risks to our health more indirectly. For example, the climate affects agricultural production systems and therefore the affordability and availability of foods, especially fresh fruit and vegetables, which are an important part of a healthy diet. The changing climate may also boost the prevalence of bacteria, parasites and viruses, which in turn could increase the risk of food and water contamination.⁵¹ Decreasing water levels in dams, for example, increases the concentration of pollutants and increasing water temperatures, and encourages the growth of blue-green algae.⁵²

What are we doing to maintain national wellbeing in a changing climate?

Reducing the health risks from the changing climate means taking action across multiple sectors (such as agriculture, water resources and infrastructure) and considering climate in health service planning. A well-adapted health system is flexible and robust, with resources strategically allocated to manage climate (and other) risks.

Australia is responding to the health effects of climate change within the overall context of existing health services and the preventive health mechanisms that help provide a healthy and safe environment—for example, clean water and air, safe food and housing, and protection from pollutants and the spread of disease.

State and territory governments play a crucial role in delivering health services across Australia. For example, state governments are responsible for primary healthcare, public health and response strategies along with the maintenance of essential services—including hospitals and health services, electricity and transport networks as well as water infrastructure.

The Heatwave Plan for Victoria contributed to the decrease in estimated excess deaths observed during the 2014 heatwave event compared to the 2009 event
(© Victorian Department of Health and Human Services)



Managing the impact of heat waves on human health in Victoria

The severe Melbourne heatwave in January 2009 led to an estimated 374 more deaths (or 62 per cent increase) than would be normally expected at that time of year.⁵³ In response, the former Victorian Government developed the 'Heatwave Plan for Victoria'⁵⁴ which has since been updated as the 'Heat health plan for Victoria' for the 2015–16 summer season.

The Plan outlines the response to extreme heat and heat waves across the Victorian Department of Health and Human Services, local governments, community organisations and individuals. It provides a clear understanding of the actions and systems in place to support Victorians, particularly those most at risk from extreme heat. The Plan sets out a range of actions to reduce health impacts, including issuing a heat health alert when conditions meet certain thresholds, to help prepare government agencies and the wider public for forecast extreme heat.

The Plan sets out to inform and educate Victorians about the risks to human health posed by heat waves and the actions available to minimise these risks.

The January 2014 heatwave, which had comparable intensity to the 2009 heatwave, resulted in far fewer excess deaths (an estimated 167 excess deaths compared with 374 respectively).⁵⁵ This is despite the fact that the 2014 heatwave was a four-day period of prolonged heat, compared to the three-day period in 2009. The Victorian Government believes that the continued implementation of the 'Heatwave Plan for Victoria' contributed to the decrease in estimated excess mortality observed in 2014.⁵⁶

Local governments run health promotion and community services, in addition to other activities that support good health such as food safety, sporting and recreational facilities and looking after the local environment. Community organisations and health businesses provide some health services, such as meals-on-wheels and caring and support services and first aid and emergency food and shelters in extreme weather events. They support health outcomes through education and outreach.

The Australian Government leads and shapes Australia's health system to ensure affordable, accessible, efficient and high quality services

that create better health outcomes and reduce inequalities across the nation. It collaborates with state and territory governments to ensure the existence and effectiveness of appropriate public health programmes.

In addition, the Australian Government can help communities and individuals to manage their health and wellbeing through the provision of information and early warning systems. For example, the Bureau of Meteorology provides a heatwave warning service to help communities and individuals prepare for and take precautions during heatwaves. The Heatwave Service is a set of maps showing colour-coded heatwave severity

for the previous two three-day periods, and the next five three-day periods.

While there are no national programmes specifically targeting the health effects of climate change, health impacts are canvassed in scientific research into climate change in Australia, which is often publicly funded. These include the Australian Institute of Health and Welfare and the National Health and Medical Research Council. The Australian Government also funds the National Climate Change Adaptation Research Facility (NCCARF) to maintain an adaptation network focused on vulnerable communities and human health, linking researchers with decision makers.

What do we need to do into the future?

We all play a vital role in ensuring our own health and that of our families, friends and communities. This means adhering to public health warnings, engaging in health-related behaviours that lower the risk of chronic disease, making plans to manage severe weather events and supporting

others to manage climate risks, like helping to prepare elderly relatives for heatwave events.

To maintain Australia's high standards of wellbeing in the future we will need to:

- ▶ consider the risks of climate change across our health services, from a national to a local level
- ▶ address climate risks in our workplaces and, in particular, consider heat-related illnesses in the design and organisation of our work
- ▶ support adaptation in other sectors that provide services that improve our health and wellbeing, such as agriculture, water resources, emergency services and infrastructure.

The Australian Government will continue its work to make the health system more sustainable and adaptable, so that it can plan for the future provision of services in the face of a range of challenges, including the changing climate.



Disaster risk management



Disaster risk management

Australia's long history with natural hazards means that we have built systems, science, institutions and collaborations to help us prepare, respond and recover.

Natural hazards—including cyclones, floods and bushfires—influence, shape and modify human behaviour, changing the way people live with and respond to the environment. They become natural disasters when they significantly and negatively affect the community.⁵⁷

Natural disasters can hit all sectors and industries and result in substantial social and economic costs for Australia. The Queensland floods of 2010/11 are estimated to have cost in excess of \$5 billion.⁵⁸ The same event killed 33 people, with another three still missing, and affected more than 78 per cent of Queensland. Climate change has the potential to alter the frequency, magnitude and distribution of extreme weather and further increase Australia's exposure to natural disasters. In addition to climate change, population trends, urbanisation and residential shifts to high-risk areas will increase Australia's exposure to natural hazards.

Australia has a long history of natural hazards and is experienced at dealing with them. We have developed robust science and early warning systems, institutions that focus specifically on emergency management and disaster resilience, and strong collaboration between the Australian Government and states, territories and local authorities during disasters. Other countries often call upon our experience in emergency management and disaster resilience in times of crisis.

What are the risks from a changing climate?

The costs of extreme weather events are wide reaching and range from environmental impacts and financial costs incurred by governments, businesses and households to the impacts on the physical and psychological health of individuals. Although Australia is experienced at preparing for and responding to natural disasters, the influence of climate change on extreme weather could reduce our resilience to these events.

For example, the changing frequency, magnitude and distribution of extreme weather may result in natural disasters occurring in areas where they have not previously occurred and where emergency management experience is limited. Furthermore, natural disasters could increasingly occur in close succession, limiting the time available for a community to recover between events. Despite Australia's robust emergency management procedures, these changes to the nature of extreme weather challenge existing emergency management processes.

The Australian community is financially exposed to the impacts of natural disasters, and this risk is increasing. Through changing temperatures, precipitation and sea levels, among other factors, climate change is already modifying hazard levels and exacerbating disaster risks. The total economic cost of natural disasters in Australia for 2012 exceeded \$6 billion. These costs are predicted to double by 2030 and reach \$23 billion in real terms by 2050 without accounting for climate change.⁵⁹ That said, evidence is growing to show that every \$1 invested well in building resilience delivers at least \$10 in eventual savings.⁶⁰ The costs of natural disasters could reduce if we are proactive about adaptation and preparedness activities.

The insurance industry plays a critical role in disaster risk management, by providing a mechanism for individuals, businesses and governments to transfer their risks. The price and availability of insurance provides signals to the community about the level of risk from a range of hazards and provides some encouragement for disaster risk mitigation and reduced vulnerability to loss. Increases in insurance premiums can result in a reduction in insurance coverage, leading to under-insurance or non-insurance in some circumstances. A reduction in private

insurance coverage has the potential impact of shifting the costs of repair and reconstruction following an extreme weather event from private insurers to individuals and to governments, by way of assistance packages and payments. This in turn can have the perverse effect of further discouraging households from insuring their property, as they believe they will receive financial assistance from the government if they are affected by a natural disaster.⁶¹



The impacts of flooding have substantial economic consequences in Australia

Natural disasters and insurance

As the climate changes and extreme weather events become more frequent and severe there will be an increasing reliance on insurance to support the community and economy to recover.

A recent report released by the Investor Group on Climate Change, *Assessing Climate Change Risks and Opportunities for Investors*, states that insurance costs from extreme weather events have risen in Australia since 2000. This is leading to increases in insurance premiums, and even a withdrawal of some insurers from high exposure regions.

Business is responding to increased insurance premiums by improving the resilience of their operations and assets and ensuring they are well placed to respond to climate change. The Insurance Council of Australia (ICA) has been using its knowledge of insured loss in the built environment to promote resilience in Australian communities. For example, the ICA is funding the development of a Building Resilience Rating Tool that aims to stimulate best-practice resilience in residential buildings across Australia, including the production of more resilient building materials.

In northern Australia, an important climate adaptation is building housing that is more resilient to cyclones. On average, cyclones cause more than \$630 million in damages per year, and this is likely to increase into the future. Learning from past experiences, the insurer Suncorp has partnered with James Cook University to analyse insurance claim data to better understand cyclone vulnerabilities in homes, and what can be done to address them. This research shows that simple, low-cost disaster mitigation can pay for itself after just one cyclone. Using Cyclone Yasi as a case study, low cost strapping upgrades to the roof at a cost of around \$3,000 achieved a Benefit Cost Ratio of 1.5 for pre-1960 homes and a Benefit Cost Ratio of 1.4 for 1960-1980 homes.⁶² These findings are particularly important considering up to 100,000 homes in north Queensland may not meet current standards.

Following extensive floods in Queensland during 2010-11, insurance premiums increased substantially and insurance companies refused to offer new insurance policies for flood damage in Roma and Emerald. The insurance companies were not satisfied that the existing flood infrastructure was sufficient to protect those communities from future flood events. A joint agreement between the Australian and Queensland governments resulted in the construction of a 4.9 km flood levee in Roma (\$20 million) and the upgrading of flood defences in Ipswich (\$10 million).

To avoid similar issues in the future, local land use planning needs to consider the future impacts of climate change to ensure communities are not exposed to increasing risks associated with extreme weather. Importantly, improved planning and investment in disaster resilient infrastructure can help to lower disaster risks, and therefore insurance premiums for the community. For example, since the construction of the flood levee in Roma together with targeted house-raising, average premiums have been reduced by around 30 per cent for a \$300,000 home, and by up to 80 per cent for the highest flood risk properties.

While natural disasters affect all Australians, regardless of background or status, they do not affect us all equally. People facing disadvantage, such as those in poverty, migrants, refugees, children, older people, people with disabilities, people who are homeless or transient, and people living in poor quality housing, are more vulnerable at all stages of a disaster—before, during, and after it strikes.

Natural disasters can cause significant impacts to natural ecosystems, including biodiversity and water resources. They disrupt ecosystem services which are important for Australian communities, including the provision of food and water, regulating floods, disease control, supporting nutrient cycling and providing health, recreational and cultural benefits. It is important to note, however, that although they can disturb ecosystems, some natural disasters such as bushfires and flooding are important for triggering growth and breeding events and are essential for ecosystem function. The economic and social costs arising from natural disaster impacts on ecosystems are not well understood or quantified.

Environmental degradation increases the risk that extreme weather events will lead to disaster for vulnerable communities. While the protection of ecosystems alone cannot halt the occurrence of natural hazards or extreme events, there is increasing evidence that large, healthy and functioning ecosystems are likely to be more resistant to the impacts of such events and reduce the likelihood of ecological and humanitarian disasters. Investing in the protection, restoration and maintenance of natural habitats (also known as green or natural infrastructure) may be more cost effective for reducing disaster risk than investing in hard infrastructure alone.

What are we doing to improve our disaster resilience?

Disaster resilience is a shared responsibility. When natural disasters occur, the resilience of Australian communities is a result of how well all stakeholders have worked to prevent, prepare, respond and recover from these disasters.

Under Australia's constitutional arrangements, state and territory governments have primary responsibility for emergency management within their jurisdictions. The Australian Emergency Management Arrangements are based on partnerships between the Australian, state, territory and local governments, businesses and industry, non-government organisations, community groups, emergency management volunteer organisations, and the community.

To enhance Australia's capacity to withstand and recover from emergencies and disasters the Council of Australian Governments (COAG) endorsed the *National Strategy for Disaster Resilience* in February 2011. The Strategy represents a whole-of-nation resilience based approach to disaster management, which recognises that our resilience is the shared responsibility of governments, communities, business and individuals. A significant body of work has occurred since the Strategy's endorsement that delivers against the Strategy's priority outcomes to build disaster resilient communities.

The Australian Government funds a number of disaster prevention and preparedness programmes. The Natural Disaster Resilience Programme (NDRP) is the key funding mechanism through which the Australian Government supports states and territories in implementing the *National Strategy for Disaster Resilience*. The Australian Government contributes around \$26 million annually to the NDRP, which is matched by the states and territories through funding or in-kind resources.



Emergency management needs close partnerships between governments, non-government organisations, volunteers and the community (© Shoalhaven City Council)

The NDRP framework allows the Government to support important projects at the local level, while recognising the primacy of state and territory governments in managing natural disasters. Projects are led by state and territory agencies, local councils, non-government organisations, volunteer organisations and researchers. Specific outcomes of projects can be wide reaching and varied, and include flood and bushfire mitigation infrastructure, volunteer development programmes, hazard mapping, public awareness campaigns, and research across all hazards.

In addition, the Australian Government has committed to provide substantial funding for disaster resilience, including:

- ▶ \$15 million over three years to state and territory governments for a National Bushfire Mitigation Programme to implement long-term bushfire mitigation strategies and improved fuel reduction programmes
- ▶ \$12 million in funding to Geoscience Australia over four years (2012-16) to deliver the National Flood Risk Information Portal to

provide a single access point to existing flood hazard data, and to develop national guidelines covering the collection, comparability and reporting of flood information

- ▶ \$47 million (2014-22) to the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC), with state and territory governments, research institutions and non-government organisations providing matched support
- ▶ establishment of the Australian Institute for Disaster Resilience to pool resources and knowledge from the Australasian Fire and Emergency Services Authorities Council, the Australian Red Cross, the Bushfire and Natural Hazards Cooperative Research Centre and the Attorney-General's Department, and deliver products and services that have been developed by, and for, the emergency management sector.

The National Emergency Management Projects (NEMP) grants programme, established in 2009, provides approximately \$3.6 million a year to fund

projects of national significance. The Resilient Australia Awards is a national awards programme to recognise and promote initiatives that strengthen community disaster resilience across the nation.

The National Disaster Relief and Recovery Arrangements (NDRRA) are the primary mechanism through which the Australian Government shares the recovery costs of natural disasters with the states. The NDRRA provides partial reimbursement to the states and territories for expenditure on certain relief and recovery measures, such as personal hardship and distress assistance, restoration or replacement of essential public assets, and loans, subsidies and grants for affected communities, small businesses and primary producers. Through the NDRRA, the Australian Government has spent approximately \$8 billion over the past decade, and another \$5.7 billion over the forward estimates for past natural disaster events.

The Australian Government's Green Army programme helps to support natural disaster recovery by carrying out environmental cleanup and rehabilitation works in communities affected by natural disaster and severe storm damage. In the 2015 Natural Disaster Recovery Round, Green Army projects were approved that tackle disaster recovery efforts in New South Wales, Queensland and Victoria, including the removal of flood debris and invasive weeds from the Kooragang Ramsar wetland in the Hunter Valley. These projects will restore habitat in sensitive riparian zones and improve resilience to future extreme weather events.

The Australian Government provides a range of weather services and scientific information to support disaster resilience building. Through monitoring, forecasting and issuing warnings, the Bureau of Meteorology assists Australians in dealing with drought, floods, fires, storms, tsunami and tropical cyclones." CSIRO's Oceans and Atmosphere Flagship provides Australian governments, industries and communities with the knowledge, tools and integrated approaches to predict and respond to weather, climate and ocean variability and change, and extreme events, and to manage their expanding coastal footprint.

Further afield, natural disasters in Asia and the Pacific prevent millions of people from breaking out of poverty. Reducing risk and building resilience to disasters is a priority not only to save lives, but to achieve sustainable economic growth. Australia is recognised globally for our disaster risk management expertise in governance, preparedness, hazard identification and technological innovation. We share this expertise internationally through global forums and our aid programme, and in particular helping to protect development gains in the Pacific, the world's most disaster-prone region.

What do we need to do into the future?

Although we have come a long way in building Australia's disaster resilience, continued effort is required to further reduce and manage our risks and to deliver a sustainable, coordinated national approach.

In 2014, the Productivity Commission undertook an inquiry into natural disaster funding arrangements. The inquiry found that Australian governments are over-investing in post-disaster recovery and under-investing in disaster mitigation and insurance. The report recommended that the Australian Government take a greater role in disaster mitigation, with disaster funding

The Gayndah Mundubbera Road is an example of 'building back better'. Picture (1) is the damage to the road post Tropical Cyclone Oswald in 2013. Picture (2) is the rebuilt road through the Queensland betterment fund. Picture (3) is Gayndah Mundubbera Road after Tropical Cyclone Marcia in 2015 (© Queensland Department of Environment and Heritage Protection)



Queensland betterment fund— building back better

The Australian and Queensland governments jointly funded the Queensland Betterment Fund under the NDRRA in 2013 following Tropical Cyclone Oswald. Oswald caused \$2.1 billion damage to many public assets that had been repeatedly affected and restored after earlier disasters in 2011 and 2012. Under the Fund, \$80 million was approved to allow local government assets to be rebuilt to a more disaster resilient standard, reducing risk to the community and reconstruction costs from future events.



A key test for the Betterment programme is whether it leaves infrastructure and communities less vulnerable to the future natural hazards of Queensland's climate. The Gayndah Mundubbera Road was damaged in 2011 and rebuilt at a cost of \$800,000, only to suffer \$6.8 million in damages again in 2013. The road is an essential freight and transport link for the North Burnett region, connecting the highly productive agricultural towns of Gayndah and Mundubbera.



The Betterment project has rebuilt and increased the resilience of the two-kilometre section of road adjacent to the Burnett River that was washed out by relocating it uphill by up to 11 metres and installing concrete lined channels, culverts and scour protection.

Following Tropical Cyclone Marcia in early 2015, the Gayndah Mundubbera Road was re-opened within three hours of the flood waters receding, with only minor expenditure required to clean up and remove debris. The local council advised at the time that the cost to re-open the road in 2015 was about \$1,500. This compares with the road's closure for more than three months in 2013 and a repair cost of almost \$6.8 million.

arrangements to be significantly reformed. The Australian Government is consulting with states and territories on proposed reforms to disaster funding arrangements.

Australian governments will continue to work together to improve measurement, evaluation and strategic priority setting for disaster risk management; improve cross-sectoral

partnerships; improve community engagement; enhance resilience in the built and natural environment; ensure better disaster risk awareness and mitigation; and improve capabilities for disaster resilience.

A resilient and secure region



A resilient and secure region

Australia is working with less developed countries to create a resilient and secure region.

Climate change does not stop at country borders. The effects of climate change are being felt in Asia and the Pacific, with implications for Australia's trade, migration, development and national security. Like Australia, our neighbours in the region have long demonstrated resilience in the face of challenging climatic conditions. Asian and Pacific island governments, regional organisations and communities are actively planning for and responding to the challenges of a variable and changing climate.⁶³

Australia supports these efforts through its bilateral engagement with individual countries, as well as through contributions to regional and multilateral organisations and funds, including the Green Climate Fund. Australia is partnering with its neighbours in the region to build resilience to climate change and natural disasters, to enhance regional stability, and to promote sustainable development for present and future generations.

What risks does a changing climate pose to the region?

Predicted changes to the climate in Asia and the Pacific over the coming decades will have significant implications for lives and livelihoods,⁶⁴ and exacerbate existing developmental challenges.

Many settlements and infrastructure assets in the Pacific, for example, will be increasingly at risk from more frequent and severe coastal inundation or river flooding, and more intense tropical storms—potentially affecting the movement of people, goods, and wealth-generating industries such as tourism and international trade. Terrestrial and marine climate-induced ecosystem changes will have serious economic and social

consequences for countries and communities that have traditionally relied on subsistence agriculture and fishing for their livelihoods. Climate change may also exacerbate existing water security challenges faced by countries dependent on rainfall, or with groundwater resources currently under threat from saltwater intrusion and increasing demand—with cascading impacts for food security and human health.



Ambo Village, Kiribati: Workers from the Public Utilities Board in Kiribati working to prevent damage to water pipes during high tides (©Copyright, Australian Government Department of Foreign Affairs and Trade)

The regional effects of climate change could have consequences for Australia's national security. Exacerbation of existing hardships—including current strains on food and water security, health and safety—has the potential to reshape the region's security environment if critical tipping points are reached, and could increase calls for outside help in maintaining regional stability.⁶⁵

How are we helping to improve the resilience of Asia and the Pacific?

Australia is working to deliver an effective global outcome on climate change that will require all countries, including all major emitters, to play a role in limiting global temperature rise to below 2°C relative to the pre-industrial era. Alongside this effort, Australia is directly supporting its neighbours in the face of climate variability, climate change and the impacts of natural disasters. We do this by:

- ▶ building the capacity of researchers, national meteorological services, policy makers and communities across Asia and the Pacific to better understand and communicate the effects of climate variability and change, and integrate this knowledge into resilience and preparedness activities
- ▶ providing support for practical adaptation and resilience measures that align with regional and national priorities; and safeguarding investments by building resilience considerations into the overseas development assistance we provide (such as climate proofing critical infrastructure)
- ▶ facilitating improved coordination through regional organisations and frameworks and partnering with our neighbours in the region to prepare for, and respond to, disasters and extreme weather events.

Australia's aid policy, *Australian aid: Promoting prosperity, reducing poverty, enhancing stability* strengthens our focus on the Indo-Pacific region, affirms Australia's role as a partner for development in the region, and highlights opportunities for private sector collaboration in building resilience to climate-related shocks. Over 90 per cent of country programme aid is directed to Asia and the Pacific region. This investment represents a significant commitment to reducing

poverty and lifting living standards in the face of variable and changing climate.

National capacity building and practical support

The Australian Government's investments through the Pacific Climate Change Science Programme (PCCSP) and Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) programme have enhanced regional climate science and adaptation planning capacity through a number of activities—for example, through training and mentoring programmes to help national meteorological services provide climate change science and critical information to stakeholders, and by formulating the first ever country-scale projections for the western tropical Pacific region for atmospheric and oceanic variables.

New science knowledge has informed the work of many national governments, building the information base for effective international negotiation and the development of national climate resilience plans and strategies. Pacific island countries use this information in sectoral planning at national and sub-national levels, and to educate and raise community awareness of



Apia Bay, Samoa: Samoa Meteorology Division, COSPPac and the Electricity Power Corporation are working together to produce a water storage outlook model. The model seeks the most efficient use of current and future water supplies, by combining key elements of Samoa's seasonal rainfall outlooks with projected energy generation (© Flickr/Johannes Zielcke)

climate change risks and effects. Regional and national meteorological service capacity continues to be built through the Climate and Oceans Support Programme in the Pacific (COSPPac), which is helping 14 Pacific national meteorological services make seasonal forecasts, undertake sea-level rise monitoring, and turn this climate science into accessible information useful to their governments and communities. This information supports critical adaptation planning and decision-making in the agriculture, water, health and renewable energy sectors.

The Australian Government provides practical support to Pacific island governments to manage climate and disaster risk. For example Australia funds the Pacific Risk Resilience Programme (PRRP), a large-scale risk governance programme working in four countries—Fiji, Solomon Islands, Tonga and Vanuatu—to strengthen disaster risk governance at national, sub-national and community levels across key sectors like finance and planning, education, and food security.⁶⁶



Discussing masterplan concepts for a possible new capital in Choiseul Bay, Solomon Islands (© Simon Albert)

In the Solomon Islands' Choiseul Province, Australia has supported the government and local community to address issues constraining long-term sustainable development. This included planning controls to guide future development on Taro and Supizae islands, and the site of a possible new provincial capital on the mainland.

We are building Tuvalu's resilience to climate shocks including by constructing new school facilities that take into account potential climate change impacts and are supporting the new integrated climate change and disaster management unit in the Prime Minister's Office following the devastation caused by Tropical Cyclone Pam.

In Vanuatu—where Tropical Cyclone Pam impacted most heavily—Australia is helping to restore access to more resilient infrastructure and services for women, men, boys and girls; and providing a greater range of more resilient livelihoods opportunities. The recovery package is supported by our *Vanuatu Aid Investment Plan*, which aims to address the economic and social challenges posed by climate change and frequent natural disasters.

Australia is supporting Griffith University and the Secretariat of the Pacific Regional Environment Programme in implementing a regional approach to climate change data and information management throughout the Pacific. The *Pacific iCLIM* project will allow regional and national stakeholders to more easily discover, store and access priority climate change information and data that will help to inform and support resilience and adaptation planning activities into the future.

Multilateral engagement and improved coordination

Australia is supporting improved coordination of mitigation and adaptation efforts at both the international and regional levels. This includes Australia's \$200 million commitment to the Green Climate Fund, to assist developing countries to reduce their greenhouse gas emissions and to adapt to the impacts of climate change.⁶⁷

At the regional level, Australia supports improved regional governance and climate change coordination through the Council of Regional Organisations in the Pacific. This includes regional groups like the Secretariat of the Pacific Regional

Environment Programme and the Secretariat of the Pacific Community, whose work addresses a range of important climate, environment and sustainable development issues. We are supporting the Pacific Women Shaping Pacific Development programme —working with Pacific governments, civil society organisations, the private sector, and multilateral and regional agencies to improve the political, economic and social opportunities of women in 14 Pacific Island countries.⁶⁸

In both the Indian and Pacific Ocean regions, Australia supports regional economic development and climate change resilience through integrated

oceans governance—including through the *Pacific Oceanscape Framework*. Australia is a strong contributor to United Nations negotiations for a new treaty to address the conservation and sustainable use of marine biodiversity, and actively supports the *Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security*.

Australia stands ready to provide hands-on assistance and humanitarian relief following natural disasters in the region, as it did earlier this year when Tropical Cyclone Pam struck Vanuatu.

Case study: Tropical Cyclone Pam

Australia is Vanuatu's largest development partner. In recent years, our aid has comprised more than 60 per cent of the total Official Development Assistance (ODA) to Vanuatu.

In March 2015, Tropical Cyclone Pam struck Vanuatu as a category five cyclone, causing eleven deaths and severe damage to infrastructure. The cyclone affected the livelihoods of around 195,000 people across four disaster-affected provinces—Tafea, Shefa, Malampa and Penama. Vanuatu's key industries of tourism and agriculture were also affected.

Australian personnel arrived in Vanuatu within 36 hours of the cyclone's impact. In consultation with the Government of Vanuatu, Australia deployed Australian Defence Force assets, urban search and rescue and medical teams, and more than 500 personnel to repair key infrastructure, restore basic services, and deliver emergency relief supplies. Australia has been the largest international contributor to the cyclone response so far, committing \$50 million in support for humanitarian and early and long-term recovery needs. This is in addition to the \$41.8 million Australia provided in ODA to Vanuatu in 2014/2015.

Significant investment through the PACCSAP programme also assisted in the immediate aftermath. LiDAR data and aerial imagery captured in Vanuatu was used to develop the web-based *TC Pam Crisis Map*. The *TC Pam Crisis Map* was widely used at the Emergency Operation Centre in Vanuatu. The Australian Bureau of Meteorology dispatched expert staff to assess Vanuatu's post-Pam response. This work will assist the Vanuatu Meteorological Services, Vanuatu authorities and their partners develop measures to improve hazard monitoring, early warning, and understanding of the impacts of tropical cyclones on the population.



The Secretariat of the Pacific Community (SPC) survey team prepare an aerial drone for disaster mapping after Tropical Cyclone Pam (© SPC)

Recognising the potential for climate change to worsen the impacts of disaster-induced population displacement, Australia supports the Nansen Initiative—an international, state-led consultative process that aims to build consensus among states on key principles and elements of a protection agenda, and encourage better management of this issue at a domestic, regional and global level.⁶⁹

Australia advocates for strong global disaster risk reduction and was one of the first of 168 United Nations Member States to sign the Hyogo Framework for Action 2005-2015. Australia works to support partner countries and agencies implement the United Nations Office for Disaster Risk Reduction's (UNISDR) Sendai Framework for Disaster Risk Reduction 2015-2030.

What future action is needed?

Australia recognises the challenges that climate change poses to countries in Asia and the Pacific—and especially to atoll states. That is why Australia is working to deliver an effective outcome on climate change to limit global temperature rise to below 2°C.

We have a clear interest in ensuring that support to the region results in measurable adaptation outcomes—ones that improve livelihoods and wellbeing, and deliver infrastructure and development that are robust to climate change. Our aid programme promotes Australia's national interests and those of our neighbours by contributing to sustainable economic growth and poverty reduction in the region. Through the aid programme, we will continue to provide core support to regional organisations to deliver technical services to member countries. Our bilateral resilience investments will continue



to operate across a range of sectors in partner countries. We will continue to invest in programmes and activities that can help countries better prepare for, and respond to, the impacts of natural disasters and extreme weather. Australia will continue to provide humanitarian assistance and disaster response capabilities and will work closely with our regional partners to strengthen shared capacity to respond quickly and effectively to extreme weather events.

Economic resilience is important across all levels of government, business and the community. Financial instruments, tailored to regional and national contexts and supported by appropriate regulatory and governance frameworks, can help deliver financially sustainable responses to climate change and natural disasters. The resilience of communities—and particularly women—can be improved through better access to reliable and adequate sources of income. A resilient private sector will be able to better recover from shocks, and introduce additional sources of finance. Australia has strengths and experience at all levels, and plays an influential role in multilateral forums such as through the International Monetary Fund and Multilateral Development Banks. We proactively support countries in our region to effectively use this finance and enhance private sector engagement and innovation.

Australia has delivered a long-term investment in climate change science and data, meteorological capability, and adaptation information and planning for the Pacific. We will continue to support the development of a credible evidence base to underpin adaptation planning in the Pacific and share Australia's adaptation planning experience, including by building better networks between regional and Australian climate change adaptation practitioners—and translating climate data and science into practical guidance, applications and resilience-building activities.

Australia has been active in the Green Climate Fund (GCF) since its inception, and uses its seat on the GCF Board to advocate for our region's interests. We are working with the GCF, the GCF's accredited entities and with partners to ensure that our region has access to the Fund's resources and other sources of multilateral funding to build resilience to the impacts of climate change. The Australian Government will continue to support successful funding applications to the GCF that result in positive adaptation outcomes and emissions reductions for the region.

National Climate Resilience and Adaptation Strategy Summary

SCOPE AND PURPOSE

Highlight resilience-building by governments, businesses and communities in Australia and our region; guide effective climate change adaptation with a set of principles; and establish priority areas for future consultation and action.

VISION

We act together to support prosperity and wellbeing in Australia and beyond by building the resilience of communities, the economy and the environment to a variable and changing climate.

GUIDING PRINCIPLES

Shared responsibility

Governments at all levels, businesses, communities and individuals all have important roles to play

Factor climate risk into decisions

Consider the current climate and future change in all our decisions

Assist the vulnerable

Support those who are vulnerable to disaster risk and climate change

Evidence-based, risk management approach

Apply the best available science

Collaborative, values-based choices

Respect the knowledge and experience of those affected, and involve them in decision-making

Revisit decisions and outcomes over time

Review actions regularly, look for flexible choices and opportunities

PRIORITIES FOR NATIONAL ENGAGEMENT

Priority 1

Understand and communicate

Improve our understanding and communication of the risks from a changing climate.

Priority 2

Plan and act

Develop and implement coordinated responses to climate risk, as appropriate.

Priority 3

Check and reassess

Evaluate progress towards building resilience and adaptation to climate change and review our plans and actions.

Priority 4

Collaborate and learn

Work together to identify emerging risks and interdependencies, and share learning and successes.





