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Australian Greenhouse Office

Climate Change
Risk and Vulnerability

Promoting an efficient adaptation response in Australia

Final Report

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Report to the Australian Greenhouse Office, Department of the Environment and Heritage

By the Allen Consulting Group

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Preface

This report was commissioned by the Australian Greenhouse Office, which is now part of the Department of the Environment and Heritage, as the first step in identifying priorities for the National Climate Change Adaptation Programme.

Whereas climate change has been recognised as an important challenge since at least 1987, it was only with the publication, in 2001, of the Third Assessment Report of the Intergovernmental Panel on Climate Change that the need to plan for adaptation to climate change received broad recognition. This prompted initial work by the Australian Government on adaptation, particularly through the Australian Climate Change Science Programme to gain a better understanding of likely impacts in Australia. Given the novelty of the issue, regional variation and uncertainty in likely impacts of climate change and the breadth of interests potentially affected, work on adaptation remains at an early stage all around the world.

The National Climate Change Adaptation Programme, announced in the May 2004 Budget is an initiative of the Australian Government to commence preparing Australian governments and vulnerable industries and communities for the unavoidable impacts of climate change. Consultations conducted in the course of preparing this report suggest that this national leadership will be generally welcomed.

The report takes a risk management approach to identifying the sectors and regions that might have the highest priority for adaptation planning. It is important to consider how effectively key systems will respond to climate change in coming years, and the development of policies that align the direction and extent of adaptation actions with social objectives and values.

While effective action to reduce greenhouse gas emissions requires a coordinated global response, in which Australia will play its part, adaptation can be effectively advanced at a local scale. Adaptation and mitigation are related, because our success in mitigating greenhouse gas emissions will determine the magnitude (and possibly the nature) of changes to which we must adapt. Greenhouse gas emissions since the industrial revolution make some climate change inevitable, but adaptation is likely to be a progressively imperfect substitute for reducing global greenhouse gas emissions because the more greenhouse gas concentrations in the atmosphere rise, the greater the risk of 'dangerous' anthropogenic interference with the world's climate system that cannot be readily absorbed or prepared for.

This report explores the risks to Australia from the impacts of climate change over the next 30 to 50 years. Within this, an analysis of comparative risks will be important for identifying priorities for adaptation action and planning.

Acknowledgments

The Allen Consulting Group wishes to acknowledge the efforts of a wide range of individuals and agencies in the development of this study.

Roundtable discussions in each State and Territory capital city were a key source of information for this report, and would not have been possible without the generous contribution of time and expertise by the participants (government and non–government) in each of these jurisdictions.

The cooperation and logistical support of a variety of State and Territory government agencies was also a significant contributor to the success of these meetings and other discussions. For providing venues, facilities and coordination for the roundtable discussions, particular thanks go to:

- NSW Greenhouse Office;
- South Australian Office of Sustainability;
- Northern Territory Greenhouse Unit;
- Tasmanian Department of Primary Industries, Water and Environment;
- Victorian Department of Sustainability and Environment;
- Queensland Environment Protection Agency;
- Western Australian Department of Environment;
- Environment ACT; and
- Bureau of Meteorology.

The assistance provided by the Australian Greenhouse Office (AGO) also needs to be acknowledged. AGO sponsored the project, but has also been generous in the provision of additional support in the form of meeting rooms, technical advice, administrative input and documentation.

All these contributions added to the insights and analysis reflected within.

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Executive summary

What climate change is possible for Australia?

There is little doubt that Australia will face some degree of climate change over the next 30 to 50 years irrespective of global or local efforts to reduce greenhouse emissions. The scale of that change, and the way it will be manifested in different regions is less certain, but climate models can illustrate possible effects. Applying a range of these models to Australia for the range of global emissions scenarios generated by the Intergovernmental Panel on Climate Change (IPCC) for its Third Assessment Report, CSIRO has identified a number of possible outcomes:

- an increase in annual national average temperatures of between 0.4° and 2.0°C by 2030 and of between 1.0° and 6.0°C by 2070 — with significantly larger changes in some regions by each date;
- more heatwaves and fewer frosts;
- possibly more frequent El Nino Southern Oscillation (ENSO) events — resulting in a more pronounced cycle of prolonged drought and heavy rains;
- possible reductions in average rainfall and run–off in Southern and much of Eastern Australia with rainfall increases across much of the Tropical North — as much as a further 20 per cent reduction in rainfall in Southwest Australia, and up to a 20 per cent reduction in run–off in the Murray Darling Basin by 2030;
- more severe wind speeds in cyclones, associated with storm surges being progressively amplified by rising sea levels;
- an increase in severe weather events — including storms and high bushfire propensity days; and
- a change in ocean currents, possibly affecting our coastal waters, towards the end of this period.

Of these possible results, the most likely are for temperature change (including heatwaves and reductions in frosts), sea level rises and increases in cyclonic wind intensity. This does not mean that the results of the models for other possible dimensions of change — rainfall, run–off, non–cyclonic severe weather events — should be disregarded, as they still provide a useful basis on which to test the sensitivity of different systems — natural and human — to the possible scale of change. They should not, however, be regarded as forecasts but rather as indications of possible directions and scale of change. The wisest approach is to use these projections as ‘thought experiments’ to assess the additional risk — the potential exposure to hazards to life, biodiversity, or economic interests — that changes on this scale could pose.

The period through to 2030, and to a lesser extent 2050, is the one that is most relevant today for decisions about adaptation strategies. This is because most decisions that could be affected by climate risks involve assets and business systems whose economic life falls within or near this time horizon.

Why have an adaptation strategy?

Over the past decade or more the national and international focus has predominantly been on strategies to reduce greenhouse emissions. There has been, in many countries and in the international negotiations on climate change, an unwillingness to devote serious attention to adaptation strategies.

Some level of climate change is inevitable irrespective of emission reduction strategies. This inevitability is reflected in the conclusion of the IPCC in their 2001 Assessment Report that adaptation is now a necessary strategy to complement emission mitigation efforts. The Australian Government's decision to fund the development of an adaptation strategy is therefore an important step forward. Policymakers and investors daily make decisions that have far–reaching and sometimes irreversible effects on the environment, economy and society. These decisions will sometimes be sensitive to assumptions about future climate conditions. Frequently, expectations of future climate are implicitly, or explicitly, based on a continuation of *past* patterns. This could be costly. Some sectors, like insurance and re–insurance, are already including climate risk in their decision making. Governments will need to consider the issues around the distribution of losses in the community arising from the possibility of either a withdrawal of insurance from covering some risks, a huge increase in costs, or the failure of one or more major companies. An adaptation strategy will aim to increase the resilience of human and natural systems to possible changes in climate conditions where this is likely to be feasible and cost effective, and takes account of the social dimensions of distributing losses. It is a framework for managing future climate risk. It offers the potential of reducing future economic, social, and environmental costs as well as protecting life.

An adaptation strategy, to be effective, must result in climate risk being considered as a normal part of decision-making, allowing governments, businesses and individuals to reflect their risk preferences just as they would for other risk assessments. In this sense, adaptation strategies will fail if they continue in the long run to be seen in a 'silo' separate from other dimensions of strategic planning and risk management. To reach this point, however, is going to require a period of awareness raising, development of the science, and development of techniques for applying it in practical situations. This is a common path in developing public policy in 'new' fields. The first step is to identify priorities.

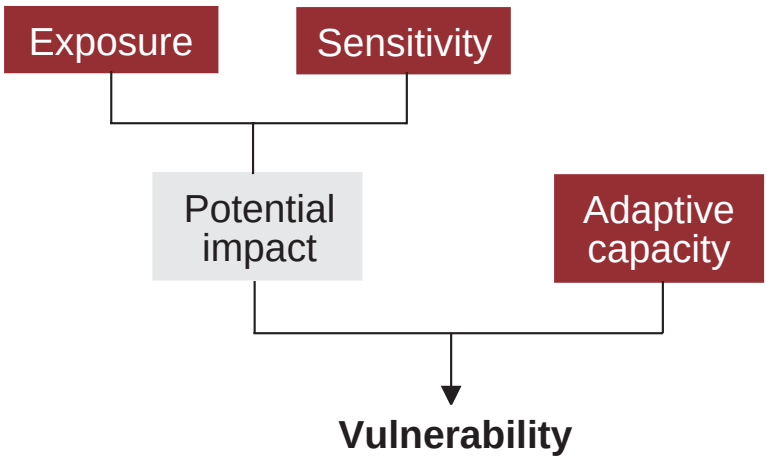
Identifying priorities

Many of our human and natural systems are strongly influenced by climate. All of our natural ecosystems have evolved in variable, but generally slowly changing climate patterns. Industries and communities are also affected by climate factors. Climate can influence productivity and reliability of supply. The community also expects that our cities and infrastructure will cope with severe weather events efficiently and safely. Improved technical knowledge and modern communications are tending to increase understanding of the relationship between climate exposure and national welfare.

Prioritising adaptation action requires the identification of vulnerable systems — human and natural — the costs if these fail, the scope to reduce this risk, and the ability to capture any potential benefits. Vulnerability is a function of exposure to climate factors, sensitivity to change and capacity to adapt to that change. Systems that are highly exposed, sensitive and less able to adapt are vulnerable. This is illustrated in Figure ES.1 below. Adaptation strategies therefore involve the identification of sectors/systems/regions vulnerable to change and an examination of the scope to increase the coping capacity of those systems — their resilience — which in turn will decrease that vulnerability. Prioritisation will also depend on identifying vulnerable systems or regions whose failure or reduction is likely to carry the most significant consequences. Our framework for assessing comparative risk thus incorporates system vulnerability, the consequences of system failure or reduction, and the scope to improve likely outcomes through planned adaptation.

Figure ES.1

VULNERABILITY AND ITS COMPONENTS



Source: Adapted from D. Schroter and the ATEAM consortium 2004, *Global change vulnerability — assessing the European human–environment system*, Potsdam Institute for Climate Impact Research.

There is some debate about the 'realism' of the IPCC scenarios for temperature change through to 2100 on which some of the CSIRO climate projections rest. In recent time this has focused on the projections of emissions over the century. Some economists have suggested that the IPCC methodology overestimates real income growth in developing countries, implying emissions growth rates that are also too high. There is considerable debate amongst economists about whether this is the case. This is a worthy issue for debate, but it is not materially relevant for the 30 to 50 year time frame which is the focus of this study.

Much of the climate change likely to be observed over the next few decades will be driven by the action of greenhouse gases already accumulated in the atmosphere. The period through to 2030, and to a lesser extent 2050, is the one that is most relevant for early decisions about adaptation strategies. Replacement and refurbishment decisions for most of the assets within the economy will be made within this time frame, together with design decisions on longer lived assets — some of which may well face significantly increased climate stresses in the future. Planning now for climate change, and its potential risks, can help ensure Australian industries and communities are well placed to deal with climate conditions in the future.

Better information on regional climate change and potential outcomes is a key requirement. Regional climate is determined largely by the nature of the large–scale meteorological features such as the ENSO pattern and the Southern Annular Mode, and understanding changes in these systems is a major part of understanding climate change at a regional level.

Any climate change signal will be overlaid on an Australian climate that is already highly variable and where there is more work to do in identifying and attributing such changes as have already happened. However, recent climate events, such as the drought conditions affecting Australia, heatwaves, bushfires, storms and the hurricane events of Florida and the Caribbean can help illustrate the nature of key stresses that might be placed on natural and human systems by a climate driven by progressively warmer temperatures.

Priority vulnerable systems and regions

On the basis of the application of this framework to possible priority sectors and regions identified through a review of the literature and meetings with key stakeholders in all capital cities, The Allen Consulting Group has identified the following priority vulnerable systems and associated regions. These reflect considerations of climate vulnerability, the significance of the systems at risk and the likely need for government intervention to encourage a timely and efficient adaptation response.

Ecosystems and biodiversity

- alpine regions;
- reef systems (such as Ningaloo and the Great Barrier Reef);
- tropical rainforest areas;
- heathland systems in southwest Western Australia;
- coastal mangrove and wetland systems (such as Kakadu); and
- rangelands.

Within this group, particular priority should be given to World Heritage listed systems. Such systems and areas have properties of uniqueness and ecological importance that have been confirmed against an international yardstick. However, there is a need to face the prospect that, in some cases, the may be little that can be done. Climate change might overwhelm some fragile species and remnant habitats (such as those in alpine regions) that literally have nowhere else to go, or for which effective options for supplementing their natural adaptive and coping capacities — through actions such as relocation, developing migratory corridors or relieving other environmental pressures — are extremely limited.

Biological systems are likely to come under significant pressure from climate change, which is likely to proceed at a rate that will exceed their natural adaptive capacities. In some cases there may be scope to assist the adaptation of vulnerable systems and species, and work should proceed on identifying the most effective options. The threat from climate change should be explicitly factored into planning and actions undertaken under a range of existing initiatives such as the National Heritage Trust, world heritage management and the National Reserve System, and the preparation of recovery and threat abatement plans under the Environment Protection and Biodiversity Conservation Act 1999. The findings of this report should also give further impetus to the National Action Plan for Biodiversity and Climate Change. However, it is likely policymakers will need to adopt a triage approach — aimed at investing effort where the benefits to biodiversity and important ecosystems are likely to be greatest.

Agriculture

Agricultural systems have shown considerable capacity to adapt to the climate — changes in land management practices, crop and cultivar choice and selection of animal species and technologies to increase efficiency of water use have all been used to change the geographic and climate spread of our agricultural activities. All of these activities could and will be deployed by farmers to respond to climate change, although as the degree of climate change increases the limits of this adaptive capacity may be tested. There may be some gains in some regions emerging from low levels of climate change as a result of longer growing seasons, fewer frosts, higher rainfall (northern Australia) and CO_2 fertilisation.

The agri–business units and regions most at risk will be:

- those already stressed — economically or biophysically, as a result of land degradation, salination and loss of biodiversity;
- those at the edge of their climate tolerance; and
- those where large and long lived investments are being made — such as in dedicated irrigation systems, slow growing cultivars and processing facilities.

Adaptation strategies to increase resilience of the agricultural sector could include research on cultivars that are capable of handling temperature stress and drought, selection and development of livestock for temperature and pest resistance, and better information on climate risk parameters for those making long term investments so that they can be weighed along with other risks. Micro–economic policies for the sector — particularly under the National Water Initiative and the National Action Plan for Salinity and Water Quality — could be examined to ensure that they expose rather than suppress opportunities to adapt. There may also be a role for Australian Government programs such as 'Agriculture – Advancing Australia', which is designed to help primary production become more competitive, sustainable and profitable.

Water supply

The availability of water is essential for many industries and other natural resources. Every major mainland city faces water stress already. In many cases climate change will increase these pressures through increased temperature and possibly lower rainfall combined with more frequent ENSO events. Dams could be susceptible to extreme rainfall events if these exceed historical design standards. Dam overtopping and failure can have catastrophic short and medium term effects in terms of human and economic losses.

Adaptation options for urban water and dams could include systematic inclusion of climate risk — on both the supply and demand side — in all our major urban catchments. There is much work already progressing in this area. Multi–jurisdiction partnerships through the CRCs on catchment hydrology, freshwater ecology, and water reuse, and with the Bureau of Meteorology and CSIRO could support a more efficient deployment of collaborative research capacity and the development of robust, substantially transferable catchment models and decision support tools. Similarly, collaborative work on assessment of non–conventional water supply sources — desalination, water recycling — and on demand management could be a high priority under the National Water Initiative. The National Committee on Large Dams could also be approached to ensure that future climate risks are adequately reflected in current standards.

Settlements and emergency services

Exposure of our cities to climate patterns is high — but the sensitivity to change depends very much on the way it impacts on extreme events. Urban areas and the built environment are machines to manage and control climate. Our cities and infrastructure are built to accepted risk limits based on the expected return frequency of severe winds, heavy precipitation events, storm surges and so on. Below these thresholds, severe weather events are usually handled with relatively light damage to property and human health and life. Above the thresholds, however, damage, injury and death can accelerate in a non–linear way.

If climate change increases the energy of tropical cyclones and severe non–tropical depressions then the return frequency of severe storms (like cyclone Tracy) could reduce significantly with an associated increase in exposure. Linked with increasing sea level and hence more dangerous and extensive storm surges, this could put some of our significant population and tourist centres like Cairns, Broome, Darwin and Townsville, as well as remote communities, at considerably increased risk.

In many temperate urban and rural centres, any increase in severe weather events linked with climate change — bushfires, heavy and sustained rainfall, high winds and in particular cyclones, sustained heatwaves — could cause significant damage. This is particularly so in inner areas of older cities that have progressively increased population density and hardened surfaces above stormwater infrastructure put in place fifty or more years ago. Demographic changes could exacerbate these effects as they impact both on the volunteer base for emergency services and increase the population at risk.

Adaptation options for urban systems and emergency services would include ensuring that the current study of emergency management priorities and responses being carried out at the Council of Australian Governments' (COAG's) direction, systematically includes the additional risks posed by climate change. Action in this area should build on existing programs and responsibilities. Deliberations under the Australian Government's Disaster Mitigation Australia Package should also be informed by climate change risks. Consideration of the greater risk of heat stress and the ageing of the population might be relevant to thinking on future emergency services needs. Local Government will have an important role to play in designing and delivering adaptation options for urban systems.

There may also be merit in a specific multi–jurisdictional/multi–sector analysis of tropical centres — including remote settlements — prioritised by risk, to examine their sensitivity to increased return frequency of high intensity cyclones and progressively increased storm surges due to sea level rises. The aim would be to assess and rank possible options ranging from warning systems to emergency response capacity, through hardening key elements of infrastructure used in recovery, to changes in infrastructure, planning and building rules and possibly even the upgrading of key buildings to ensure that they meet tougher standards, or the withdrawal of populations from particularly exposed areas.

At a lower priority there could also be merit in each of our major metropolitan areas conducting multi–disciplinary studies — reflecting a partnership of Commonwealth, State and local governments — examining the inter–linkages between climate change and thresholds of sensitivity in human (urban, rural, infrastructure, economic, health and social) and natural systems. Input from key decision makers from all sectors of the community, including Indigenous communities and vulnerable groups such as the aged, could be obtained.

The Australian Government has a range of programs to strengthen regional communities, and it may be advantageous for some of these to take the likely impacts of climate change into account.

Energy

Demand for energy is temperature sensitive (increasingly so with the penetration of domestic air–conditioning) with peaks both changing from winter to summer and steepening. Electricity supply is sensitive both to extreme weather related events and in some cases temperature itself as it degrades transmission capacity. Supply sensitivity also extends to disruption to platform operations (as has happened recently in the Gulf of Mexico with direct consequences for global energy prices), transmission and distribution (including impacts of land slip and storm on very long gas pipelines and storm and bushfire on electricity distribution). Most of Australia's energy infrastructure — generation and transmission/distribution — is now at, or approaching, the point where there is little redundancy at peak periods and reduced capacity to sustain cumulative impacts. Our economic, social and household systems are now so interdependent while being simultaneously dependent on a reliable, high quality energy supply that a failure in that supply brings much higher economic and social costs than at any time in the past. Much of the sector is subject to price regulation in one form or another, and it is not clear that regulators are as yet sensitive to the pressures that might be placed on infrastructure by climate change, and hence the possible need to allow some level of redundant capacity.

Climate change risks and implications need to be factored into Australia's energy planning. Adaptation options for energy could include a program of studies of our energy systems' sensitivity to climate events — in particular sustained heatwaves and severe weather events — as an additional risk factor to those already facing the system. System stability in the face of cumulative events, including climate events, could be examined. These studies could be regionally based. They could also examine the stability of the Eastern States grid, reflecting

- *the interaction between energy sources and energy infrastructure, including between generation, transmission and distribution; and*
- *the increasing dependence of our economic and social systems on uninterrupted energy supply.*

Independent regulators could usefully be drawn into these studies.

Other areas for particular attention could include demand management and energy conservation strategies aimed particularly at temperature driven peak demand, interval pricing, minimum energy standards for air–conditioning, passive thermal design requirements in domestic accommodation (already increasingly required but in an uncoordinated way across Australia) and options for improving the performance of the existing stock of dwellings.

In addition, the recent impact of high intensity hurricanes on operations and gas and oil production infrastructure in the Gulf of Mexico suggests that a review of the adequacy of current regulatory requirements and emergency management protocols for Australia's off shore energy infrastructure against the background of possibly reduced return frequencies for severe cyclones could be merited.

Regions

Climate vulnerability also has important regional dimensions. Climate variability is inherently a phenomenon that will play out at a geographic level and put greater pressure on some regions than others. Similarly, some regions will be more vulnerable to these pressures. They may already be under significant stress, embody several climate sensitive industries or systems and have recognised national significance. Vulnerable areas (and associated communities) include:

- low lying coastal population and resort centres;
- tropical and sub–tropical population centres;
- alpine regions;
- centres with a high dependence on agricultural and/ or eco–tourism activities;
- remote Indigenous communities (particularly in the far north of Australia); and
- areas of southern Australia facing acute water shortages and supply constraints.

However, within this grouping a handful of highly vulnerable regions can be identified that should be given priority for further adaptation planning and response. These are:

- Cairns and the Great Barrier Reef;
- Murray Darling Basin; and
- south west Western Australia.

These regions exhibit a potent combination of exposure to climate change, sensitivity and need for facilitative adaptive action. An ongoing dialogue between industry, governments and the scientific community is required, aimed at addressing the threat that climate change poses for these areas.

Regional adaptation planning requires coordination across all levels of government and the involvement of industry, scientists and community leaders. It must be informed by a thorough and ongoing analysis of the climate threat and viable adaptation options, recognising the inter–linkages and dependencies of the many human and natural systems that operate at a regional level. Planners need to anticipate future climate pressures and build the capacity of systems to cope with these pressures (and/or relieve other stresses) if the adverse implications of climate change are to be minimised.

Pulling it all together

Climate change can influence, and react with, a range of macro variables. Within Australia it can be a driver of internal migration and production patterns, and interact with demographic and behavioural trends with implications for future health care and community services needs. Australia will also be influenced by overseas climate impacts and their effect on commodity prices, trade volumes and socio–economic factors, including pressures for disaster relief and migration.

The common thread in stakeholder discussions across all capital cities was a desire to build on existing effort and for strong national leadership on climate change adaptation. This was expressed by senior representatives of industry, non–government organizations, the science community as well as by State and Local Government. National leadership was seen as important in four ways:

- to confirm at the most senior level that careful thought should be given by governments at all levels, the private sector and communities to managing climate risk;
- to improve understanding of the current status of climate science, and provide a framework within which the necessarily collaborative and multi–disciplinary effort required to advance it can be structured;
- to coordinate reviews and development of strategies for identifying and managing risk in vulnerable sectors and regions with the aim of gaining economies, sharing learning and developing synergies; and
- to provide decision support tools that could assist local government, the private sector and households to integrate climate risks into key decisions.

Australian Government–State partnership

Much of the implementation of any adaptation strategy would inevitably be the responsibility of the state, territory and local governments reflecting their key roles in public infrastructure, safety, health and land use planning and control. Key adaptation issues span virtually all portfolios and governments. Building on existing effort to integrate planning and management for climate change will be important.

Climate science for adaptation

Climate science to underpin adaptation has three principal streams:

- progressive development of climate models and associated infrastructure to provide regional—scale information, based on progressively enhanced global monitoring systems;
- more sophisticated modelling of global emissions scenarios allowing for feedback loops with climate systems and probabilistic assessments as an aid to adaptation planning; and
- multi–disciplinary approaches to linking climate models to spatial models of terrestrial systems (hydrology, biodiversity, crop productivity, disease vector spread) and testing sensitivity thresholds of vulnerable human and natural systems.

The first of these streams sits within a global effort. It is characterised by large-scale systems of great complexity. The second stream also has global dimensions through the IPCC. Integrated effort across CSIRO, the Bureau of Meteorology, together with the universities and decision makers will assist in creating well-targeted and efficient use of the research dollar.

The third stream — adaptation science — is complex and has been characterised over the last 15 years by what one observer has called 'cottage industries'. It is a stream that is at its core multi–disciplinary and fully consistent with the National Research Priorities.

Coordinated cross sectoral reviews of vulnerable regions and centres

Integrated assessments of regions will be needed to better understand the vulnerabilities and the adaptation options. Vulnerability assessment does not need to await developments in climate science. System sensitivity to climate change and adaptive capacities and planned response options are equally important factors in assessing vulnerability. Early consideration of these elements will provide the maximum opportunity for a timely and effective response to climate change.

Private incentives and markets

Most climate risk management decisions will be made by decentralised decision makers in the private sector, local government and by households. The development of Australian–based decision support framework and guides will be necessary to support decision makers. There is a role for governments to work in partnership with industry and communities to increase the understanding of climate change impacts and actions to improve adaptive capacity.

Promoting incentive structures that encourage efficient resource allocation, market development and consistency of private decision making and community values is particularly important in a 'change' environment.