B Australian approaches

This appendix provides an overview of climate change adaptation policies that are currently in place in Australia. All levels of government — Australian, state, territory and local — have implemented measures to adapt to the impacts of climate change. These range from policy frameworks to research efforts, information provision, and tools for evaluating climate change threats and opportunities.

## B.1 Intergovernmental work on adaptation

In 2007, the Council of Australian Governments (COAG) agreed to a National Climate Change Adaptation Framework. The Framework outlined strategies to understand and manage climate change impacts in key sectors (such as water resources, biodiversity and health) and regions (such as the Murray–Darling Basin and the dry regions of eastern Australia) to be implemented over five to seven years (COAG 2007b). Within each sector and region, the Framework proposed potential adaptation actions, such as research programs, vulnerability assessments and amendments to existing policies to reflect climate change risks. To support these actions an implementation plan was to be developed in 2007, with biennial reports on implementation and a full review in the fourth year. Neither the biennial reports nor the implementation review were undertaken.

A Select Council on Climate Change (SCCC) was announced on 13 February 2011 as part of the new COAG system of ministerial councils. It was formally established on 18 January 2012. Broadly speaking, the aim of the SCCC is to inform nationally significant climate change policy and provide a forum for the Australian Government to work with state, territory and local governments, and New Zealand, on implementing climate change programs. This includes developing national adaptation priorities and work plans. The SCCC held its first meeting in May 2012 and released a number of documents, including a discussion paper setting out principles for allocating climate change risks and the roles and responsibilities of private parties and governments in adaptation. The paper identified three components of the role of governments.

1. Providing information to the public on climate change and adaptation options.
2. Ensuring regulatory arrangements do not distort market signals and that risks are appropriately recognised and apportioned across governments.
3. Ensuring that climate change considerations are accounted for in the Australian Government’s management of public assets, and policy development and implementation (COAG Select Council on Climate Change 2012b).

The SCCC also identified seven national priorities for adaptation action.

* Water resources.
* Coasts.
* Infrastructure.
* Natural ecosystems.
* Agriculture.
* Emergency management.
* Vulnerable communities (COAG Select Council on Climate Change 2012a).

An Adaptation Working Group will be responsible for developing work plans for these national priorities (DCCEE 2012j).

## B.2 Australian Government

### Overarching approach

The Australian Government’s climate change policy is based on three pillars.

1. Mitigation — to reduce greenhouse gas emissions.
2. Adaptation — to respond to the unavoidable effects of climate change.
3. Global solution — to help shape an international response to climate change (DCCEE 2012k).

To date, governments have focused largely on the first and third of these pillars, with relatively little focus on adaptation. In 2010, the Australian Government released the position paper *Adapting to Climate Change in Australia* (DCCEE 2010a). The paper outlined the Australian Government’s approach to adapting to climate change at the time. It noted that a key function of Australian governments would be to create ‘the right conditions and incentives for businesses and the community to make efficient investment decisions and manage the risks from climate change impacts’ (DCCEE 2010a, p. 8).

The position paper outlined broadly similar roles and responsibilities of governments in climate change adaptation to those in the SCCC’s discussion paper. It indicated that since climate change will have widespread effects on the economy and society, the Australian Government will have an important role in leading and coordinating the national adaptation effort, especially in areas that relate to national prosperity and security.

To track progress on adaptation, the position paper committed to commission a ‘Climate Futures Report’ every five years, with the first report due before the end of 2010. These reports were intended to assess ‘how well Australia is placed to deal with climate change risks and evaluate the effectiveness of policy measures taken by governments to improve resilience to climate change impacts’ (DCCEE 2010a, p. 16). The first Climate Futures Report has not yet been released.

### Roles and responsibilities

In its 2012 discussion paper, the SCCC noted that climate change adaptation is a shared responsibility and will require involvement by businesses, communities, individuals and governments at all levels (COAG Select Council on Climate Change 2012b). However, the nature of involvement will vary across these groups. In this context, the discussion paper provided some detail of the appropriate roles of each level of government in adaptation.

The SCCC considers that the main roles and responsibilities of the Australian Government are to:

* provide ‘most of’ the public‑good research and information required for effective adaptation by businesses, communities and governments
* manage Australian Government assets (including defence facilities, national parks and reserves) and programs
* lead a national adaptation reform to promote effective adaptation through collaboration with states and territories
* maintain a strong and flexible economy with an appropriate social safety net (COAG Select Council on Climate Change 2012b).

### General frameworks

In most cases, the Australian Government considers that adaptation responses will be embedded within existing policy and institutional frameworks. New frameworks will only be considered where it is demonstrated that existing frameworks are not able to manage climate change risks effectively (DCCEE 2010a).

In addition to the National Climate Change Adaptation Framework established by COAG (section B.1), a National Framework for Climate Change Science was adopted in May 2009. It endeavours ‘to bring together Australia’s climate science expertise to deliver the essential climate science needed for an effective national response to climate change’ (DCC 2009a, p. 7). The Framework includes different elements to identify future climate change science priorities, resources needed to meet forthcoming science requirements, and how to use the country’s scientific capabilities to address those priorities.

The Framework focuses on the ‘fundamental climate system science’ required to develop adaptation and mitigation strategies and does not cover ‘adaptation science’ (how human activities or the management of natural ecosystems may need to change in response to the impacts of climate change) (DCC 2009a). However, fundamental climate system science is expected to provide critical information to support how the community adapts. To this end, the Framework calls for close links between the climate change science community and the adaptation research community, in particular the CSIRO’s Climate Adaptation Flagship (box B.1) and the National Climate Change Adaptation Research Facility (box B.2).

### Current policies

The Australian Government has adopted a range of policies to support climate change adaptation. On the whole, these policies generally fall under one of the two distinct policy frameworks for adaptation (the National Climate Change Adaptation Framework and the National Framework for Climate Change Science) or address one of the national (sectoral) priority areas identified by the SCCC. However, there is considerable overlap across these areas and at times the linkages between frameworks and policies are unclear.

#### Climate change science

The Australian Government has implemented a number of initiatives supporting climate change science research, some of which fall under the National Framework for Climate Change Science. These range from broad research programs such as the CSIRO’s Climate Adaptation Flagship (box B.1) and the Australian Climate Change Science Program, to sector‑specific programs such as the Marine and Climate Super Science Initiative.

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| Box B.1 The CSIRO’s Climate Adaptation Flagship |
| The CSIRO’s Climate Adaptation Flagship was established under its National Research Flagships Program. It provides scientific information and expertise across four research themes.   1. Pathways to adaptation — provides climate information to scientists and external users. It examines the social and economic aspects of vulnerabilities and adaptation options at the regional and national levels. It also analyses the international impacts of climate change and adaptation responses. 2. Sustainable cities and coasts — helps cities and coastal regions adapt to climate change by preparing for coastal inundation and extreme weather events, understanding climate‑related health risks and managing the potential threats from climate change. 3. Managing species and natural ecosystems in a changing climate — identifies and manages the climate change threats faced by biodiversity and ecosystems. 4. Primary industries, enterprises and communities adapting to climate change — offers adaptation options to primary industries and resource sectors to help them manage climate change risks and opportunities. |
| *Source*: CSIRO (2011a). |
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The Australian Climate Change Science Program has been active since 1989 and now falls under the National Framework for Climate Change Science. It centres its activities on a number of main themes: understanding the key drivers of climate change in Australia, improving climate modelling and producing regional climate change projections, and promoting international research collaboration. Recent activities supported by the Program include monitoring the effects of climate change on marine indicators (ocean temperature, acidification and salinity), analysing climate and weather systems, and developing Australia’s climate modelling capability.

To improve research in marine and climate science, the Government allocated $387 million to the Marine and Climate Super Science Initiative (announced in 2009 with funding available until 2013). These funds will be used to improve marine infrastructure at the Australian Institute of Marine Science, upgrade Australia’s climate change computing capacity, and develop research facilities (DCCEE 2012a).

In 2011, the Government established the Climate Commission as an independent body to provide expert advice and information to the community about the science and impacts of climate change, and the effects of climate change mitigation. The Commission holds regular public forums and has released a number of reports (Climate Commission 2011a).

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| Box B.2 National Climate Change Adaptation Research Facility |
| The National Climate Change Adaptation Research Facility is a national interdisciplinary research program established in 2007 to provide decision makers with information to manage the risks of climate change. Its activities focus on nine priority themes: water resources and freshwater biodiversity; marine biodiversity and resources; terrestrial biodiversity; primary industries; settlements and infrastructure; indigenous communities; human health; emergency management; and social, economic and institutional dimensions of climate change.  The National Climate Change Adaptation Research Facility organises its activities around four key areas.   1. *Adaptation research networks* hosted by research institutions around Australia support interdisciplinary research aimed at advancing climate adaptation knowledge 2. *Thematic research* addresses the priorities identified by the National Adaptation Research Plans. These Plans identify current gaps in knowledge across the priority themes as well as priority adaptation research questions. 3. *Synthesis and integrative research* draws together and develops research capacity for ‘cross cutting’ issues and issues that are not particular to one theme. 4. *Knowledge communication and adoption* ensure that decision makers have information they need and can readily use. |
| *Source*: NCCARF (2011). |
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#### Climate change adaptation

The Climate Change Adaptation Program[[1]](#footnote-1) was established under the National Climate Change Adaptation Framework to help Australians understand the risks and potential opportunities associated with climate change. The 2007‑08 Australian Government budget provided up to $126 million over five years for the Program, with an additional $3 million provided in the 2012‑13 budget. This funding has been directed at a number of grant programs, national vulnerability assessments, and research efforts. These include:

* the National Climate Change Adaptation Research Facility (box B.2)
* national climate change risk assessments in sectors such as biodiversity and coastal management. One example is a case study examining the potential effects of climate change and sea‑level rise on the South Alligator River, located in the Kakadu National Park
* grants for local governments to undertake local risk assessments and develop adaptation action plans. These include $109 000 for the Mid‑West Regional Organisation of Councils (WA) to examine threats from droughts and sea‑level rise, and $120 000 to Towong Shire Council (Victoria), Alpine Shire Council (Victoria) and the North East Greenhouse Alliance (Victoria) for research into the impacts of climate change on the alpine region (DCC 2009c)
* a Climate Change Adaptation Skills for Professionals Program that provides funds for tertiary education institutions to revise or establish professional development and accreditation programs for architects, planners, natural resource managers and engineers.

#### Sector‑specific programs

The Government also has a range of sector‑specific programs which relate to the national priority areas identified by the SCCC (section B.1) and in the Australian Government’s 2010 position paper (DCCEE 2010a). These programs support the broad adaptation objectives established under the two previously discussed general policy frameworks. The programs are not always dedicated adaptation programs, but rather incorporate adaptation into broader sector‑specific policy arrangements. Some examples of sector‑specific programs are provided below.

##### Coastal management

The Australian Government has implemented a number of initiatives to help coastal communities prepare for and adapt to climate change. These include:

* the Caring for our Coasts policy, which involves funding for a Community Coast Care Program and the Great Barrier Reef Rescue Plan as well as consultation with coastal councils and other stakeholders on how coastal regions can address current and future climate challenges (DCCEE 2012b). Caring for our Coasts also includes a National Coastal Risk Assessment, which involved two reports on the effects of climate change on coastal areas (DCCEE 2012g)
* the Coastal Adaptation Decision Pathways Program, through which the Australian Government has provided $4.5 million to councils and alliances of councils to develop effective approaches to improve the management of future climate risks to coastal assets and communities. Projects were due for completion in June 2012 (DCCEE 2012e).

In 2009, the Australian Government established the Coasts and Climate Change Council to engage with communities on coastal climate change adaptation issues and to provide advice to the Government on the implications of coastal climate change for decision making. The Council’s initial report made a number of recommendations, including the development of a ten‑year national agenda for managing the effects of climate change in the coastal zone. The Council provided a final report to the Minister for Climate Change and Energy Efficiency in December 2011.

##### Water

The Australian Government is providing $13 billion for the Water for the Future initiative. This initiative has been described by the Government as the ‘single largest investment in climate change adaptation’ (DCCEE 2012a). It involves a wide range of policies aimed at improving the efficiency and sustainability of water use, supporting healthy rivers and wetlands, and understanding the implications of climate change for Australia’s water supply.

Water for the Future advances the implementation of the National Water Initiative, which outlines the role that all state and territory governments and the Australian Government will play in managing Australia’s water resources. It also sets the framework for urban water reform. The 2009 and the 2011 biennial assessments of the Initiative both recommended considering the impacts of climate change on water resources in future water allocation plans.

##### Agriculture

The Australian Government funds primary producers to adapt and respond to climate change under Australia’s Farming Futureinitiative. Elements of the initiative relevant to adaptation include funding for agricultural research projects and on‑farm demonstrations related to climate change adaptation (and mitigation), grants for primary producers to attend training courses in areas including managing climate change impacts, free business analysis and financial assessments, and transitional income assistance (DAFF 2011).

##### Emergency management

Following on the decision from the Ministerial Council for Police and Emergency Management that Australian emergency management should focus on community and organisational resilience, COAG adopted the National Strategy for Disaster Resilience in February 2011. The Strategy calls for a joint effort from all levels of government, businesses, individuals, the not‑for‑profit sector and the community to improve the country’s ability to resist and recover from emergencies and disasters (COAG 2011). The purpose of the Strategy is to provide guidance and direction on disaster management to individuals, organisations and governments. This covers the role that each party has to play in managing their climate change risks, collaborative approaches to increasing disaster resilience, and reducing disaster risk to communities through amendments to the planning system.

In addition to the National Strategy for Disaster Resilience, the Australian Government also works through the National Partnership Agreement on Natural Disaster Resilience to promote resilience against natural disasters in collaboration with state and territory governments. Under the financial arrangements for the Agreement, approximately $100 million of Australian Government funding is divided between the states and territories over the four years from 2009 to 2013. These funds are used for a range of disaster‑mitigation activities, such as natural disaster risk assessments, community education programs, disaster‑mitigation infrastructure and early‑warning systems (COAG 2009b).

##### International partnerships

As part of its contribution to a global response to climate change, the Australian Government is involved in a number of partnerships to support adaptation efforts in other countries. For example, Australia contributes to international programs on climate change impacts, vulnerability and adaptation through the United Nations Framework Convention on Climate Change (appendix C).

Climate change adaptation is also part of Australia’s international aid efforts to vulnerable countries in the region. In that respect, the Australian Government has contributed $328 million over five years (2008 to 2013) to the International Climate Change Adaptation Initiative. This provides technical assistance and funding to countries most vulnerable to the impacts of climate change, particularly in the Asia‑Pacific region. The main objectives of the Initiative are to improve local climate change science, better understand climate change impacts and vulnerabilities in partner countries, and support adaptation efforts (AusAID 2011b). In addition, the Australian Government participates in some United Nations Development Programme activities related to adaptation and contributes funding to the Global Environment Facility (AusAID 2011a).

#### Funding arrangements for selected adaptation measures

The Australian Government has committed substantial funding to support climate change adaptation measures. A selection of these measures and their funding arrangements is outlined in table B.1.

Table B.1 Funding arrangements for selected adaptation measures**a**

Australian Government

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| Adaptation measure | Funding arrangements |
| Australian Climate Change Science Program | Funding of $31 million to support climate change science research activities. |
| Caring for our Coasts | Includes $100 million for a five‑year Community Coast Care Program, $200 million for a five‑year Great Barrier Reef Rescue Plan, and $25 million over five years to support climate change adaptation in coastal communities. |
| Climate Change Adaptation Program | Funding of up to $126 million to help Australians better understand climate change risks and opportunities. The 2012‑13 Australian Government budget provided an additional $3 million to the Program. |
| Coastal Adaptation Decision Pathways | Funding of $4.5 million to demonstrate effective adaptation in the coastal zone. |
| Climate change adaptation measures through the Department of Climate Change and Energy Efficiency | Funding of $117 million (2008–12) in climate change adaptation initiatives and research to support the implementation of the National Climate Change Adaptation Framework. |
| Natural Resource Management (NRM) Climate Change Impacts and Adaptation Research Grants Program | Funding of $8 million available to research institutions to provide information on climate change impacts and adaptation responses that is relevant to natural resource management planning. |
| International Climate Change Adaptation Initiative | Funding of $150 million over three years from 2008‑09 to support climate change adaptation in vulnerable countries in Australia’s region. The 2010‑11 budget increased this funding by $178 million for another two years. |
| National Climate Change Adaptation Research Facility | $20 million from the Australian Government to support its main functions and Adaptation Research Networks. It also received funding of up to $30 million through the Climate Change Adaptation Research Grants Program to address priority research identified in the National Adaptation Research Plans. |
| Marine and Climate Super Science Initiative | Funding of $387 million to promote research in marine and climate science by providing funds for high‑performance computing, new observation systems and developing research facilities. |
| Water for the Future | Funding of $13 billion to manage Australia’s water supply and take action on climate change. |

a Figures in this table represent funding announced by the Australian Government and may apply over multiple years. In some cases, program funding has already ceased.

*Sources*: AusAid (2011b); DCC (2009a); DCCEE (2012a, 2012e, 2012h, 2012k); NCCARF(2010).

## B.3 State and territory governments

### Overarching approaches

Almost all Australian states and territories have overarching approaches to plan for, and adapt to, the impacts of climate change. In some states and territories, adaptation policy is integrated into general climate change policy responses (such as in Victoria and the ACT) and in others, adaptation policy is implemented through dedicated adaptation strategies (such as the ClimateSmart Adaptation 2007–12 strategy in Queensland and South Australia’s Draft Climate Change Adaptation Framework).

A number of state and territory governments have enacted climate change legislation, which guides their approach to climate change, and in some instances commits governments to report against progress (box B.3). Climate change legislation exists in Victoria, South Australia, Tasmania, and the ACT.

While progress in developing adaptation strategies differs by state and territory, there are significant commonalities in the adopted approaches. In particular, the current focus of activities has been on conducting research into climate change impacts, identifying priority sectors for action and undertaking vulnerability assessments in different sectors and regions.

### General frameworks

State and territory governments are currently in different stages of development of adaptation policy responses (box B.3).

* Queensland, Tasmania and the ACT have had climate change strategies in place for some time. Queensland and the ACT are in the process of updating these (Queensland’s ClimateSmart Adaptation plan concludes in 2012 and the ACT’s climate change Action Plan 1 concluded in 2011).
* In late 2010, South Australia released a Draft Climate Change Adaptation Framework, with a final version yet to be approved by Cabinet.
* Victoria and the Northern Territory are yet to release adaptation plans despite commitments to do so (in Victoria’s case, an Adaptation Plan is not due until 31 December 2012).
* New South Wales does not currently have an explicit adaptation strategy. It has several sector‑specific adaptation policies in place and is working through COAG on adaptation policy more broadly (NSW Government 2012a).
* While adaptation forms one of the four substantive elements of the 2004 Western Australian Greenhouse Strategy, this strategy does not set out specific adaptation actions. However, it provides support for projects to generate and communicate information regarding climate change impacts.

Development of adaptation policy has, in some cases, been affected by other ongoing policy development processes. In particular, state and territory governments’ responses to recent natural disasters have implications for adaptation policy, such as reforms enacted following the Queensland Floods Commission of Inquiry and the Victorian Bushfires Royal Commission.

To coordinate climate change issues across the whole of government, a number of state and territory governments have established dedicated climate change offices or units within Premiers’ departments or environment departments. For example, the Tasmanian Government has established an adaptation unit within the Tasmanian Climate Change Office. The Office leads efforts to respond to climate change and has the role of coordinating and facilitating climate change action across the Tasmanian Government (Tasmanian Government 2012b).

A number of state and territory governments have also established independent bodies or government advisory groups to provide advice to governments on climate change issues.

* The South Australian Premier’s Climate Change Council is an independent council that advises the Premier on climate change mitigation and adaptation issues (SA Government 2012a).
* The Tasmanian Climate Action Council provides independent advice on the Tasmanian Government’s response to climate change. The Council is required to report annually on its activities and biennially on climate change issues. In the 2008–10 biennial report the Council noted that the Government’s Draft State Coastal Policy (2008) inadequately addressed climate change and needed to be revised to incorporate adaptation goals (Tasmanian Climate Action Council 2010).
* The ACT Climate Change Council provides advice to the Minister for Environment and Sustainable Development on climate change issues, including adaptation (the first report is due in 2012) (ACT Government 2012a).

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| Box B.3 State and territory overarching adaptation responses |
| New South Wales  The NSW Government is working through COAG to identify required reforms and priority areas for adaptation policy. It has incorporated climate change adaptation in its ten‑year strategic business plan, NSW 2021. The State Government also supports initiatives relating to climate change research and vulnerability assessments.  Victoria  The *Climate Change Act 2010* (Vic) guides the Victorian Government’s actions on climate change mitigation and adaptation. It requires the Government to develop a Climate Change Adaptation Plan every four years (the first is due by 31 December 2012) and to report every two years on climate change science and emissions data. The Plan will assess the climate change risks faced by various regions in Victoria and discuss strategies to adapt to their potential impacts. The Act also requires the State Government to take climate change into account in specified areas of decision making. A review of the Act was completed in December 2011.  Queensland  ClimateSmart Adaptation 2007–12 is an action plan that provides direction for managing the impacts of climate change in government and business decision making. It identifies a number of priority sectors for adaptation action. These include water planning and services, agriculture, human settlements, natural environments and landscapes, and emergency services. To facilitate effective adaptation, the plan suggests that adaptation responses should be developed by building and sharing knowledge, considering climate change in decision making, and reducing exposure and increasing adaptive capacity.  South Australia  The *Climate Change and Greenhouse Emissions Reduction Act 2007* (SA) commits the South Australian Government to work with businesses and the community to put in place strategies to adapt to climate change. This has included the development of a Draft Climate Change Adaptation Framework for South Australia and the establishment of the Premier’s Climate Change Council. The Minister for Sustainability and Climate Change is required to report on the operation of the Act on a biennial basis.  The Framework provides overarching state‑wide objectives to guide adaptation and involves a regional approach to adaptation across 12 regions. It advocates the use of regional vulnerability assessments to understand the community’s climate change exposure and also provides guidance for regional adaptation planning. This approach also includes sectoral agreements between the State Government, industry, community and regional groups. The draft framework is currently being reviewed by the Government. |
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| Box B.3 (continued) |
| Western Australia  The State Government developed the Western Australian Greenhouse Strategy in 2004 to guide its response to climate change. One of the Strategy’s four central elements is climate change adaptation. The Strategy establishes a number of projects to undertake research on climate change in Western Australia and provide this information to affected groups to facilitate climate change adaptation.  Tasmania  The Tasmanian Framework for Action on Climate Change (Tasmanian Government 2008)sets a policy framework aimed at reducing greenhouse gas emissions, adapting to expected climate change impacts, and capturing the new opportunities resulting from climate change. To achieve its objectives relating to adaptation, the Framework proposes a number of potential actions. These involve promoting scientific research on climate change; providing adaptation information to individuals, communities and businesses; managing climate change risks to public assets and communities; and working with local governments and communities to facilitate adaptation.  Northern Territory  A $34 million Climate Change Policy released in 2009 sets out the main mitigation and adaptation policies and targets of the Territory Government. These include a commitment to develop a Territory Climate Change Adaptation Action Plan (this was scheduled for release by the end of 2011). The plan will detail the impacts and risks of climate change, develop a risk analysis model for ecosystems, and form strategies to address the health and environmental impacts of climate change. Climate change issues are also acknowledged in the Territory 2030 Strategic Plan.  Australian Capital Territory  The ACT Climate Change Strategy 2007–2025 outlines the expected impacts of climate change and sets out the Government’s approach to climate change. Action plans will be released at regular intervals throughout the duration of the Strategy, committing the Government to a number of specific actions. Action Plan 1 (covering the period 2007–11) identifies a number of actions to facilitate climate change adaptation, ranging from vulnerability assessments to climate change research, information provision and protection of biodiversity. The *Climate Change Greenhouse Gas Reduction Act 2010* (ACT)established the ACT Climate Change Council and requires the Minister for Environment and Sustainable Development to report annually against the requirements of the Act. |
| *Sources*: ACT Government (2007); NSW Government (2012a); NT Government (2009); Queensland Government (2007); SA Government (2010a, 2012b); Tasmanian Government (2008, 2012a); Victorian Government (2012b); WA Greenhouse Task Force (2004). |
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### Roles and responsibilities

The SCCC considers that state and territory governments will have a large role in direct adaptation action for a number of reasons.

* They deliver a broad range of services and manage a large number of assets. State services that may be affected by climate change include protection against flooding and sea‑level rise, emergency management, public health and environmental protection. Assets exposed to climate change risk include national parks and reserves.
* They are responsible for most of the regulation that may influence the ability of businesses and communities to adapt to a changing climate. This may include building codes, land‑use planning and environmental legislation (COAG Select Council on Climate Change 2012b).

The SCCC indicates that, in principle, state and territory governments will:

* provide local and regional science and information — by collaborating with other tiers of government to provide climate change projections, assess climate risks and understand the costs and benefits of adaptation
* be responsible for state and territory assets and programs — by managing climate change impacts on public assets (for example, natural assets and electricity networks) and services (for example, emergency management, health services and land‑use planning)
* work with the Australian Government to implement a national adaptation reform — by collaborating on a consistent approach to adaptation, managing national adaptation priorities, and monitoring and evaluating arrangements to ensure adaptation responses are effective and well targeted.
* implement measures to enhance adaptive capacity — by encouraging the public to consider climate change risks and ensure that state and territory legislation and policy do not hinder effective adaptation (COAG Select Council on Climate Change 2012b).

State and territory governments have outlined their roles in the adaptation process in a number of policy documents. While differences exist across jurisdictions, the general view of state and territory governments is fairly consistent with the SCCC’s vision. They believe that their roles and responsibilities can be broadly categorised as:

* encouraging climate change research and providing relevant information on climate change science and potential adaptation strategies to businesses, communities and individuals
* using regulatory and policy instruments such as land‑use planning and building codes to reduce exposure to climate change risks
* managing potential climate change impacts on public assets and services
* promoting a collaborative approach to manage climate change risks and respond to climate change
* taking primary responsibility for coastal planning and management (with the exception of the ACT) (ACT Government 2007; NT Government 2009; Queensland Government 2007; SA Government 2010a).

### Current policies

State and territory governments have implemented a range of policies relating to climate change adaptation. In most cases, they focus on climate change research, information provision on climate change impacts and adaptation, and vulnerability assessments. In other cases, to address the priority areas identified by some state and territory governments, policies examine sectoral climate change and adaptation issues in areas such as land‑use planning, water provision, protection of the natural environment and emergency management. Some examples of these policies are provided below.

#### Research and information provision

Providing relevant information on climate change science and adaptation can help governments, businesses, communities and individuals make better informed decisions about how to respond to climate change (chapter 7). State and territory governments have implemented a range of measures to generate information relevant to climate change and adaptation and disseminate this information to stakeholders.

Climate change science initiatives generally focus on undertaking specialised research and delivering climate science information to inform state or territory responses to climate change. In some cases, these initiatives involve working in collaboration with local or international partners to generate climate science information regarding the expected state‑wide effects of climate change. For example, the Queensland Climate Change Centre of Excellence focuses on climate science research to support the Queensland Government’s response to climate change, climate variability and climate extremes. Its research is undertaken through internal research projects as well as in partnership with a range of national and international groups. Other similar initiatives include the Indian Ocean Climate Initiative, the South East Australian Climate Initiative and the Climate Futures for Tasmaniaproject.

State and territory governments also have a number of initiatives in place to provide general information to local governments and communities about the potential impacts of climate change and how to adapt to these impacts. In many cases, these initiatives are part of state or territory general adaptation responses and may involve vulnerability assessments, reports detailing regional climate change impacts, or action plans on adaptation.

As part of their role in working with other levels of government, state and territory governments provide information to local governments to help them identify and manage their climate change risks (annex). Such guidance can be in the form of vulnerability assessments, published reports and guidance manuals. For example, the NSW Government has published a guide to climate change risk assessment for local governments which aims to support councils undertaking climate change risk assessments and generate information to develop adaptation strategies.

Other information provision initiatives examine the impacts of climate change on particular areas such as health, agriculture and the natural environment, and inform government bodies on potential adaptation responses that can be undertaken. Western Australia’s Climate Change Response Strategy (focusing on the agricultural sector) and the Victorian Climate Change Strategy for Fisheries and Aquaculture 2008–2012 are two examples of such initiatives.

#### Environmental protection

In addition to Acts of legislation which protect and manage natural systems and wildlife, state and territory governments have also released a number of policy documents setting out actions and commitments to help manage the natural environment in a changing climate.

These government initiatives focus on areas such as ecosystems and species, and natural resource management. For example, the NSW Biodiversity and Climate Change Adaptation Framework (established under the 2005 Greenhouse Plan) and the SA Government’s Regional Climate Change Decision Framework for Natural Resource Management were both implemented to identify natural resource systems vulnerable to climate change and guide responses to climate change.

Other initiatives relate to natural landmarks and coastal environments. One example is Queensland’s Reef Water Quality Protection Plan which was endorsed in 2003 and builds on existing government and community initiatives to improve water quality, including the Australian Government’s Reef Rescue program. The plan outlines a number of actions to improve water quality in the Great Barrier Reef and reduce contaminants in runoff from land, so as to increase the Reef’s resilience to climate change related impacts. Another example is the SA Government’s Living Coast Strategy which outlines a range of initiatives and programs to manage and protect the state’s coastal zones, estuaries and marine ecosystems (Department for Environment and Heritage 2004).

#### Planning

State and territory government climate change strategies often highlight the importance of taking into account the predicted impacts of climate change when making planning decisions. These decisions can relate to land‑use planning, refurbishment of key infrastructure, and may call for changes to reflect climate change risks.

Most planning systems have a number of elements, including planning Acts and regulations, and state‑ or territory‑wide planning policies that cover specific matters (such as coastal management). However, there is no uniform approach across Australia’s states and territories regarding the use of planning systems to adapt to climate change. In many cases, planning frameworks explicitly require or recommend that climate change be taken into account in planning decisions (although to date this has primarily related to sea‑level rise in coastal areas). In other jurisdictions, planning frameworks provide inherent flexibility that enables decision makers to consider a range of factors in planning decisions, including climate change, but without imposing any explicit requirement to do so (Maddocks 2011) (chapter 9).

Some states and territories have implemented strategic urban‑planning initiatives that take into account potential climate change impacts. In general, these initiatives recommend that new urban and infrastructure development take into account   
long‑term climate change objectives. For example, the Metropolitan Plan for Sydney 2036 identifies several options for adaptation policy, including the incorporation of adaptation options into building standards, increasing green cover in urban areas, and putting in place guidelines for development in urban centres that address risks posed by climate change (NSW Government 2010b). A further example is the 30‑Year Plan for Greater Adelaide which identifies a number of measures to deal with the long‑term impacts of climate change, through energy‑efficient building design, the protection of coastal communities and reduced vulnerability of critical infrastructure (Government of South Australia, sub. DR88).

#### Coastal planning

In light of the expected rise in sea levels, coastal planning frameworks in most states and territories have been updated to explicitly address rising sea levels and other potential impacts of climate change (chapter 9). In particular, many states have adopted ‘sea‑level rise benchmarks’ that allow planning and development assessment decisions to be based on projections of future sea‑level rise. These benchmarks are generally set as the projected rise in the average sea level in 2100 above the level in 1990, with the exception of Western Australia where the base year is 2010. The 2100 benchmarks range from 80 cm in Queensland (Queensland DERM 2012) to 100 cm in South Australia (Coast Protection Board 2004). (Tasmania and the Northern Territory do not currently have formal sea‑level rise benchmarks.)

Almost all states have coastal strategies in place that implement these sea‑level rise benchmarks. For example, these benchmarks are applied in Western Australia (in the State Coastal Planning Policy) when specifying the minimum distance from the coastline for new buildings and infrastructure, and in Queensland (in the Queensland Coastal Plan) when identifying coastal hazard areas — places that may be affected by climate change by 2100, including from sea‑level rise and cyclones. In South Australia, new developments can only be approved if they are deemed to be safe against a 30 cm rise in sea levels, and if they can be protected by practical measures against a further 70 cm rise in sea levels by 2100 (Coast Protection Board 2004).

Some states also have separate initiatives that provide information to the government and the community about the vulnerability of the coast to sea‑level rise and develop guidelines for local authorities and communities to manage coastal hazards. Examples of such initiatives are Tasmania’s Coastal Works Manual and Victoria’s Future Coasts Program (annex).

#### Water

To address the potential impacts of climate change on water availability, a number of states and territories have incorporated climate change risks in their water planning initiatives and identified the water sector as a priority area for adaptation action. Initiatives include:

* Water for Good guides water supply and use in South Australia to 2050. The plan takes into account the likely effects of climate change such as more pronounced dry weather conditions and a significant reduction in flows into the Murray River (SA Government 2010b)
* the NSW Government’s 2010 Metropolitan Water Plan outlines a range of measures that aim to increase water security for the greater Sydney region. It focuses on dams, recycling, desalination and water efficiency. Some key initiatives of the Plan are to support climate change research, focusing on climate modelling with extended drought periods, and take into account climate predictions when considering water supply augmentation options (NSW Government 2010a)
* Sydney Water’s Climate Change Adaptation Program examines how climate change will affect Sydney Water’s infrastructure, operations, and customers. The program has three key themes: understanding the vulnerability of Sydney Water to the impacts of climate change; assessing existing resilience to natural hazards and system failures and identifying potential adaptation responses; and embedding climate change adaptation into existing business practices and processes (Sydney Water 2010).

#### Emergency management

A number of state and territory governments have incorporated emergency management considerations into their general climate change adaptation strategies. Government actions outlined in these strategies generally relate to providing planning and emergency advice to communities, incorporating climate change risks in local disaster response plans, putting in place community programs to increase preparedness and awareness, and promoting a cooperative approach to managing disaster risks and improving the adaptive capacity of communities.

Following recent extreme weather events such as the 2009 Victorian bushfires and the 2010–11 floods in Victoria and Queensland, state governments have commissioned a number of reviews. These reviews investigated the causes of these events as well as the adequacy of emergency management arrangements in preparing for and responding to these events. The reviews all concluded that providers of emergency services did not operate as well as they could have and made a broad range of recommendations to improve emergency management (chapter 13). In response to these reviews, state and territory governments have initiated a number of reforms to their emergency management structures. Broadly speaking, these reforms aim to improve the community’s adaptive capacity by:

* clarifying roles, responsibilities and coordination arrangements in emergency management
* ensuring that providers of emergency services have the ability and the resources to operate effectively during an emergency
* improving the disaster preparedness of communities
* engaging the community to help them recognise, understand and manage their own hazard risks.

## B.4 Local governments

### Overarching approach

Local governments around Australia are taking a number of actions in response to climate change. These generally focus on:

* reducing greenhouse gas emissions
* undertaking climate change vulnerability and risk assessments
* developing and implementing adaptation strategies to respond to the current and expected impacts of climate change.

Progress in developing adaptation strategies varies significantly across councils. While some councils have implemented a range of measures to manage and respond to climate change risks, others have done very little in this area. Constraints on resources and expertise, especially in many small, rural and remote councils, may be limiting councils’ abilities to respond to climate change (chapter 8). In the case of active councils, the focus of activities has been on including climate change considerations in council operations and providing relevant information to the community to help them manage their climate change risks and adapt to climate change.

Differences in approaches across local governments often reflect differing priority areas for adaptation action — as a result of factors such as demographic composition or geographic location. For example, most coastal councils are exposed to natural hazards such as coastal inundation and sea‑level rise, making coastal planning a common key area of their climate change strategies. On the other hand, inland councils may be more exposed to bushfire and/or inland flooding risk which dictates their approach to climate change adaptation.

### General frameworks

There is no overarching framework guiding local government in Australia when it comes to assessing and responding to the impacts of climate change. In each state and territory, the local government Act is the main statute governing councils in each jurisdiction. These Acts do not generally contain any specific climate change clauses directing councils on how to assess their climate change impacts and their adaptation responses.

Increasingly, councils are using a risk management approach in their activities. In 2006, the Australian Greenhouse Office (now the Department of Climate Change and Energy Efficiency) released a guide to help businesses and organisations identify risks associated with climate change impacts, focus on risks that require further attention and set up a process for ensuring that higher priority risks are managed effectively (AGO 2006). The Guide’s risk management framework is consistent with the Australian and New Zealand Standard for Risk Management, AS/NZS 4360: 2004 (box B.4). A revised version of the Standard (AS/NZS ISO 31000: 2009) was released in 2009, but the overall risk management process remained unchanged. This revised standard was used to develop a new Draft Standard (DR AS 5334) by Standards Australia to identify and manage risks that settlements and infrastructure face from climate change.

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| Box B.4 Standard for risk management |
| The framework for assessing climate change risks is based on the Australian and New Zealand Standard AS/NZS 4360 and has the following steps.   1. Context — identify responsibilities of local authorities, their structure, goals and services they provide, and take into account how climate change will affect them. 2. Identify risk — consider different hazard event scenarios (including the risks associated with each scenario) for each region and/or activity while taking into account the specific characteristics of each community. 3. Analyse risks — identify sources of risks, their impacts, and the probability of these impacts occurring at some point during the lifetime of the development, asset or infrastructure. 4. Evaluate risks — assign a risk rating to each climate change impact. The risk rating ranges from almost certain to rare and depends on the consequence and likelihood of an event. 5. Treat risks — identify objectives, targets and relevant risk management and/or adaptation options.   Communication, consultation, monitoring and evaluation are required at each step of the risk assessment process — a communication plan should address climate change issues, the associated risks and how to manage them. Continuous review is also important to ensure that climate change plans remain relevant. |
| *Sources*: AGO (2006); DCCEE (2010b); NZ Ministry for the Environment (2008a). |
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State and territory governments and local government associations also provide guidance to councils in the form of guidelines and manuals. This material primarily relates to undertaking climate change risk assessments, managing natural hazards in land‑use planning systems, and planning for the health effects of heatwaves (annex).

### Roles and responsibilities

The SCCC considers that local governments will play an important role in adapting to the local impacts of climate change because they administer a range of government legislation and, similarly to state and territory governments, they are responsible for a wide range of services and assets (COAG Select Council on Climate Change 2012b). Several of these services and assets are exposed to the impacts of climate change.

Broadly speaking, the roles of local government include:

* managing public assets (including environmental assets) such as public roads and community recreation facilities
* providing public services such as environmental conservation
* supporting local emergency management
* implementing planning and building regulations in line with state and territory legislation (including management of the coastal zone)
* approving new developments
* providing information and guidance to communities and businesses (Australian Local Government Association, sub. 25).

In its climate change position paper and discussion document (adopted in 2010) the Australian Local Government Association also highlights the roles of local government in addressing climate change. These are consistent with the roles of local government identified by the SCCC’s discussion paper (COAG Select Council on Climate Change 2012b). The Australian Local Government Association (2010) acknowledges that:

* addressing current and expected future impacts of climate change is a shared responsibility which requires the involvement of all levels of government, individuals, businesses, and the community
* local governments must prepare for climate change and, at a minimum, be able to protect their own assets and adapt to regional climate change impacts
* local governments have an important role in providing guidance and education to individuals and businesses to help them understand and acknowledge their responsibilities in responding to climate change
* delivery of local services must be improved in partnership with governments and the private sector.

### Current policies

Local governments have put in place a number of measures to support climate change adaptation. These are often developed by groups of councils formed to take action on climate change, or local government associations. In some cases, councils’ measures may not be explicitly identified as climate change initiatives because they have interdependencies with other local or state government strategies. These relate to various areas such as sustainability, environmental conservation, asset management, land‑use planning and emergency management.

#### State and territory local government associations

All state and territory local government associations have developed climate change strategies (such as the Local Government Association of South Australia’s Climate Change Strategy 2008–12) or undertaken a range of activities to help councils adapt to climate change. These activities aim to support councils to understand and plan for the impacts of climate change. Activities include:

* developing guidelines for councils to consider climate change risks in their activities and to plan appropriate responses (annex)
* organising seminars and forums on climate change issues for local governments
* publishing case studies of adaptation approaches taken by councils.

These associations often work in partnership with state and territory governments to facilitate climate change adaptation in the community. For example:

* the Municipal Association of Victoria works in partnership with the Victorian Government to implement its Future Coasts Program to inform councils and other land managers about the impacts of sea‑level rise (Municipal Association of Victoria, sub. 79)
* the Local Government Association of Queensland initiated the Queensland Disaster Management Alliance in partnership with the Queensland Department of Emergency Services to support disaster management planning. It is also working in partnership with Townsville City Council and the Queensland Government on the Townsville Coastal Hazard Adaptation Strategy. The aim of this Strategy is to inform coastal communities of the risks that they face (Townsville City Council 2012)
* the Local Government and Shires Associations of New South Wales developed a Climate Change Action Pack in conjunction with the NSW Government in 2006. The Action Pack provides information to councils on the expected impacts of climate change and on how to improve their adaptive capacity though changes in land‑use planning and infrastructure management (LGSA 2012).

#### Alliances and partnerships

Several councils have formed regional alliances to provide information on climate change impacts and facilitate adaptation (chapter 8). Adopting a regional approach can be an efficient way for local governments to respond to climate change because it allows them to share resources and knowledge (DCCEE 2010b). Some examples are:

* greenhouse alliances — there are six greenhouse alliances in Victoria. They bring together local governments and a range of local organisations to develop and implement regional programs relating to climate change mitigation and adaptation. Some of them also undertake climate change risk assessments for their region (South East Councils Climate Change Alliance, sub. 12)
* the Sydney Coastal Councils Group — was established in 1989 and consists of 15 coastal councils in the vicinity of Sydney. Its main goal is to help member councils adopt a sustainable approach to managing the urban coastal and estuarine environment. A number of its projects relate to managing the coastal impacts of climate change (SCCG 2011)
* the National Sea Change Taskforce — was established in 2004 as a national body to represent the interests of more than 68 coastal councils. As part of the Taskforce’s broader work on climate change, it released a report in 2008 highlighting the impacts of climate change for coastal communities and the extent to which councils have recognised climate change in their activities. The report also included recommendations to assist councils to plan for climate change (Gurran, Hamin and Norman 2008).

#### Local governments

Local governments around Australia have implemented a range of initiatives to address the challenges of climate change. These initiatives include the provision of information to communities on climate change impacts and adaptation, risk and vulnerability assessments from coastal or inland flooding, environmental protection and emergency management. Some examples of these initiatives are provided below.

##### Information provision

A large number of local governments have implemented regional climate change actions plans or strategy documents which focus primarily on providing information to businesses and communities about local climate change impacts and adaptation strategies. These action plans generally involve:

* conducting climate change vulnerability assessments
* highlighting actions to reduce greenhouse gas emissions
* providing direction for addressing climate change risks
* identifying priority areas for adaptation action.

A number of capital cities have released such action plans. For example, Darwin City Council’s Climate Change Action Plan 2011–2020 provides direction to the Council over the next ten years to implement a range of actions to reduce greenhouse gas emissions and address climate change impacts. The Plan lists a series of actions for the private sector and the community in a number of areas including water, land, biodiversity and energy (Darwin City Council 2011). Similar action plans have been released by the City of Melbourne and the Gold Coast City Council.

##### Infrastructure and property services

A number of local governments have undertaken studies and vulnerability assessments to identify the risks that climate change poses to infrastructure and property in their area, and how to address those risks. For example, Port Adelaide Enfield Council (SA) has undertaken a flood risk study to identify current and predicted climate change risks to the environment and the community. The Council plans to use the study to better manage flood risks to infrastructure and property. A further example is the development of sustainable design guidelines by the City of Melville (WA) showing how the adaptive capacity of infrastructure and property can be improved through planning functions (DCCEE 2010b).

##### Coastal planning

Coastal councils generally have a significant role to play in coastal management since they are responsible for most of the statutory local land‑use planning and also maintain infrastructure exposed to coastal hazards. As part of their general climate change strategy or in compliance with state and territory legislation, coastal councils perform a range of activities to manage the coastal zone. This includes applying sea‑level rise benchmarks, undertaking vulnerability assessments, providing information to the community on potential coastal hazards and implementing measures to prevent beach and soil erosion. For example, Clarence City Council (Tasmania) published the report *Climate Change Impacts on Clarence Coastal Areas* in 2008 to address beach erosion and tidal flooding in coastal areas. The report identified a range of potential adaptive responses that can be pursued in the short, medium and long term. These include amendments to planning schemes, dune and beach rehabilitation works, and raising awareness of climate change adaptation in the community (Clarence City Council, sub. 10).

In addition to state‑ or territory‑wide planning legislation and regulations, some coastal councils have adopted specific policies or actions to address the potential risks of climate change impacts. In Victoria, for example, member councils of the South East Councils Climate Change Alliance require that a Coastal Vulnerability Assessment be included with planning applications (South East Councils Climate Change Alliance, sub. 12).

Other councils have used planning and building regulations to require modifications that may reduce the risks from future coastal hazards. For example, Wellington Shire Council (2011) (Victoria) made an amendment to its planning scheme requiring that new dwellings or extensions to existing buildings in Port Albert have raised floors that are a certain height above the 1‑in‑100 year flood level. A further example is the policy of ‘planned retreat’ adopted by Byron Shire Council (NSW) (chapter 11).

##### Water planning

Councils have implemented a number of water‑planning initiatives to manage water demand and supply more effectively in a changing climate. Such initiatives include water management programs for public facilities, stormwater and wastewater recycling projects, the installation of water‑saving equipment, changes to existing watering regimes and studies on water security. For example, in 2004, Ku‑ring‑gai Council (NSW) established a seven year stormwater re‑use and water‑recycling program in response to the introduction of water restrictions as well as changes in rainfall distribution and frequency. The program was designed to reduce the Council’s reliance on potable water for its recreational facilities (DCCEE 2010b). In a further example, Central NSW Councils (2009) (an alliance of 17 councils in Central New South Wales) undertook a Water Security Study to develop water demand and supply projections for the next 50 years — factoring in potential climate change impacts — and identify options to ensure adequate water availability.

##### Emergency management

Local governments have a wide range of responsibilities in emergency management, such as ensuring local emergency planning and preparedness measures are undertaken, coordinating local volunteer resources, and promoting community education and awareness (Australian Government 2009). Councils generally receive guidance for emergency management from legislation, overarching climate change policies at the state or territory level, or through Australian Government strategies such as the National Strategy for Disaster Resilience. However, some uncertainty about their roles and responsibilities in emergency management remains (chapter 13).

Legislation provides a framework for the management of emergencies, including the role of local governments. For example, in Victoria, the *Emergency Management Act 1986* (Vic) requires that each municipal council prepares and maintains a Municipal Emergency Management plan. These plans have special requirements for councils subject to bushfire risk.

Local governments have also implemented a range of measures relating to emergency management as part of other policies relating to climate change, environmental protection, or health. These include updating existing emergency management plans, upgrading drainage systems to cope with increased rainfall intensity and implementing mosquito‑management programs in areas at risk of regular flooding (DCCEE 2010b). For example, adaptation and mitigation actions in Redland City Council’s (Queensland) Climate Change and Energy Action Plan 2010‑11 include reviewing and updating bushfire management plans and bushfire risk mapping every five years (Redland City Council 2010).

Recent inquiries into extreme weather events made a number of recommendations to improve coordination across councils, as well as their capacity to meet their emergency management obligations. For example, the Victorian Bushfires Royal Commission (2010) made several recommendations for councils to increase their preparedness for extreme events. These include the development of local plans for communities at risk of bushfires and compiling a list of vulnerable residents and their requirements (South East Councils Climate Change Alliance, sub. 12).

## Annex

Table B.2 Examples of guidance material available for local governments

|  |  |  |  |
| --- | --- | --- | --- |
| Government | General | Planning | Other |
| Australia | Climate Change Impacts and Risk Management — A Guide for Business and Government (2006)  The Local Government Climate Change Adaptation Toolkit (2008)  Climate Change Adaptation Actions for Local Government (2009) | Floodplain Management in Australia Best Practice Principles and Guidelines (2000)  Planning Safer Communities Land Use Planning for Natural Hazards: Manual 7 (Emergency Management Australia) | Emergency Management Australia’s Manual Series, including:   * Emergency Risk Management Applications Guide: Manual 5 (2004) * Managing the Floodplain (Manual 19), Flood Preparedness (Manual 20), Flood Warning (Manual 21) and Flood Response (Manual 22)   National Emergency Risk Assessment Guidelines (2010) |
| New South Wales | Guide to Climate Change Risk Assessment for NSW Local Government (2011)  Local Government Newsletters (ongoing — provided annually or twice per year from the Office of Environment and Heritage) | Coastal Design Guidelines for NSW (2003)  Coastal Planning Guidelines: Adapting to Sea Level Rise (2010)  Settlement Planning Guidelines (2007)  Coastline Management Manual (1990)  Estuarine Management Manual (1992)  Floodplain Development Manual (2005)  Floodplain Risk Management Guideline: Practical Consideration of Climate Change (2007) | Coastal Dune Management: Manual of Coastal Dune Management and Rehabilitation Techniques (2001)  Local Council Guide to Water Efficiency Plans (2010)  Local Council Guide for Energy Management Plans (2010)  Estuary Health Assessment Tool (2009)  Economic Appraisal Guidelines — Guidance on Climate Change for Asset and Infrastructure Assessments (2010) |

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Table B.2 (continued)

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| --- | --- | --- | --- |
| Government | General | Planning | Other |
| Victoria | .. | .. | Victorian Coastal Hazard Guide (2012)  Managing Coastal Hazards and the Coastal Impacts of Climate Change (General Practice Note, 2008)  Heatwave Planning Guide (2009)  Emergency Relief Handbook  (2011–2012) |
| Queensland | .. | Guidelines for State Planning Policy 2/11 (Planning for Stronger, More Resilient Floodplains)  Guidelines for State Planning Policy 1/03 (Mitigating the Adverse Impacts of Flood, Bushfire and Landslide 1.0) | Guideline Series: *Coastal Protection and Management Act 1995* (various guidelines for coastal development assessable under the Sustainable Planning Regulation 2009)  Policy Options for Incorporating Climate Change Into the Flood Risk Management Framework in Gayndah (North Burnett Regional Council) (2010)  Queensland Coastal Plan – Guidelines for Preparing Coastal Hazard Adaptation Strategies (2012)  A Guide to Disaster Risk Management in Queensland Aboriginal and Torres Strait Islander Communities (2004) |
| South Australia | .. | The South Australian Planning Policy Library (Version 6, September 2011) and 13 accompanying technical information sheets | .. |

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Table B.2 (continued)

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| --- | --- | --- | --- |
| Government | General | Planning | Other |
| Western Australia | .. | Planning guidelines and manuals (including Planning for Bushfire Protection (edition 2, 2010) and Coastal Planning and Management Manual (2005)) (Western Australian Planning Commission)  Coastal Vulnerability Assessment Western Australia Projects List | .. |
| Tasmania | A Guide to the Resource Management and Planning System  Coastal Risk Management Plan template and guidelines | .. | Local government area climate profiles (Climate Futures for Tasmania Project)  Tasmanian Coastal Works Manual 2010 |
| Northern Territory | .. | .. | .. |
| Local Government Associations | Climate Change Action Pack (includes best practice examples of climate change mitigation and adaptation projects) (NSW Local Government and Shires Association)  Checklist for Local Government Climate Change Adaptation Planning (Western Australian Local Government Association)  Adapting to Climate Change – A Queensland Local Government Guide (Local Government Association of Queensland) (2007) | .. | Extreme Heat Guide for Local Government in South Australia (Local Government Association of South Australia) (2009)  Incorporating Disaster Management into Local Government Corporate Planning Practices (Local Government Association of Queensland) |

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Table B.2 (continued)

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| --- | --- | --- | --- |
| *Government* | *General* | *Planning* | *Other* |
| Local Government Association | A Guide for Councils Developing Climate Change Action Plans (Local Government Association of South Australia) (2011)  Supporting Victorian Local Government Manage Climate Risks and Plan for Change (Municipal Association of Victoria) (2011)  Liveable and Just Toolkit (Victorian Local Governance Association) |  |  |
| Other | Local Council Risk of Liability in the Face of Climate Change — Resolving Uncertainties (Baker & McKenzie) (2012)  The National Climate Change Adaptation Research Facility Local Government Portal (2012) | .. | .. |

**..** Not applicable.

C International approaches

This appendix highlights the international context within which Australia’s climate change adaptation occurs. It provides an overview of the approaches taken by selected international organisations and countries on adaptation to climate change. The focus is on frameworks and broad‑level policies that have been used to guide government actions and facilitate adaptation more widely. The appendix summarises general approaches that have been used rather than providing a comprehensive list of policies or an evaluation of the effectiveness of each approach.

To date, international approaches have been of varying levels of specificity. They range from those that provide high‑level guidance to governments, businesses and households on adaptation options and managing climate‑related risks, to those that impose specific regulatory requirements.

In some cases, stand‑alone adaptation programs have been implemented. In others, adaptation has been incorporated into existing activities (such as international development assistance or government procurement). Along with the frameworks and broad‑level policies outlined here, some countries have also implemented a range of sector‑specific and region‑specific adaptation policies — for example, covering agriculture, building regulation or land‑use planning. Due to the large number of such policies they are not covered in this appendix.

## C.1 International institutions

Adaptation to climate change has been incorporated into the activities of many international institutions of which Australia is a member. This section briefly discusses several institutions that focus explicitly on adaptation. Other international organisations and agreements more broadly may also relate to, or affect, adaptation to climate change — such as trade agreements under the World Trade Organization, the United Nations Convention on Biological Diversity, and the Reducing Emissions from Deforestation and Forest Degradation scheme.

### Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is a scientific body that was established by the World Meteorological Organization and the United Nations Environment Programme. It draws on contributions from many scientists worldwide to review and assess scientific research on climate change. In 2007, part of its *Fourth Assessment Report* examined climate change impacts, adaptation and vulnerability (IPCC 2007a). This work drew on a range of research and examples to assess adaptation to date and future vulnerability to climate change across a number of countries and regions. It will be updated for the *Fifth Assessment Report*, expected to be released in 2014.

While the IPCC does not make recommendations on government policy — and thus does not put forward a policy framework — it has been widely cited and has had a significant influence on the understanding of climate change, regional climate projections and adaptation in Australia and other countries. It has also identified types of potential financial, informational and social barriers to adaptation (IPCC 2007a).

### United Nations

#### United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) is an international convention, first signed in 1992, under which 195 countries have agreed to develop and implement ‘measures to facilitate adequate adaptation to climate change’ (UN 1992b, p. 5) and to ‘take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions’ (UN 1992b, p. 6). The convention also commits developed countries to provide funding and technologies to developing countries to facilitate adaptation.

These agreements are reflected in the Cancun Adaptation Framework, adopted in 2010, under which member countries made a number of commitments to facilitate adaptation (box C.1). A framework was also established for the least‑developed countries to form and implement National Adaptation Plans and for developed countries to support them with financial, technological and other assistance. These National Adaptation Plans build on earlier processes to report on, and plan for, adaptation needs in developing countries, covering activities such as improved water management, crop diversification and disaster‑warning systems. Activities under the Cancun Adaptation Framework are to be facilitated by the UNFCCC’s Adaptation Committee, which will provide information and advice to countries.

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| Box C.1 The Cancun Adaptation Framework |
| Under the Cancun Adaptation Framework, parties to the United Nations Framework Convention on Climate Change committed to:   * plan, prioritise and implement adaptation measures * conduct impact, vulnerability and adaptation assessments, including the economic, social and environmental evaluation of adaptation options * strengthen institutional capacities for adaptation * improve the resilience of socioeconomic and ecological systems * enhance disaster risk‑reduction strategies, including early‑warning systems, risk management and insurance * enhance understanding and coordination of migration induced by climate change * research, develop and deploy technologies and processes for adaptation * strengthen information systems and public awareness * improve climate research, observation and modelling. |
| *Source*: UNFCCC (2011a). |
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Several institutions facilitate funding for developing countries under UNFCCC agreements. Funding arrangements generally aim to facilitate adaptation in addition to achieving other objectives, such as greenhouse gas mitigation, economic development or improved environmental management. The main sources of financial assistance are the Global Environment Facility (2011), along with the Adaptation Fund that was established to finance adaptation projects in some countries (financed by a share of ‘carbon offset’ revenues through the Clean Development Mechanism) (Adaptation Fund 2010). In Durban in 2011, member countries agreed to establish the Green Climate Fund to provide financial resources and assistance to developing countries for adaptation (UNFCCC 2011b).

Arrangements for sharing research and information have also been established. Principally, the Nairobi Work Programme aims to improve the understanding and assessment of climate change impacts, vulnerability and adaptation in UNFCCC member countries. It is working to disseminate information and resources on adaptation options, projects and technologies (UNFCCC 2011c).

Overall, agreements and activities under the UNFCCC have established a high‑level framework for international collaboration on adaptation. Neither the founding convention nor subsequent formal agreements contain an explicit definition of adaptation or specific guidance on how to facilitate adaptation. This may give member countries flexibility in how they interpret and apply their commitments.

#### United Nations Development Programme

Other United Nations agencies also facilitate adaptation and have incorporated consideration of the impacts of climate change into their activities. The United Nations Development Programme (UNDP) provides financial and other assistance and runs programs in a number of countries to meet development outcomes. These include reducing global poverty, improving health and education, and protecting human rights. In short, it aims to achieve ‘climate‑resilient development’ that supports ‘sustainable economic development and livelihoods’ (UNDP 2007, p. 1). Australia supports some of these activities through its own international development programs and collaboration with the UNDP (appendix B).

The UNDP facilitates adaptation in several ways. It provides guidance and advice for countries to undertake risk assessments, incorporate climate projections into development projects, address climate‑related risks, evaluate adaptation outcomes and facilitate adaptation throughout society (UNDP and GEF 2010; UNDP 2007). This includes assistance for countries to form national adaptation programs and source funds for these (UNDP 2012). The UNDP also assists developing countries to implement ‘green, low‑emission and climate‑resilient development strategies’ that lead to policy frameworks for integrating climate and development polices at national, regional and local scales (UNDP 2011b).

Further, the UNDP facilitates funding for adaptation projects. In 2011, 30 projects in 42 countries received such funding through the Global Environment Facility, with a total of US$87 million in grants (UNDP 2011a). These covered activities relating to water management, agriculture, drought and coastal hazards.

The general approach taken by the UNDP is set out in its Adaptation Policy Framework, which is based on four overarching principles.

* Adaptation to short‑term climate variability and extremes is a starting point for adapting to longer‑term climate change.
* Adaptation policies should be assessed in relation to development objectives.
* Adaptation occurs at different levels throughout society.
* Adaptation strategies and their implementation processes are of equal importance, and should include engagement with stakeholders (UNDP 2004).

In addition, the UNDP uses its adaptation programs to address barriers to adaptation (box C.2). This includes revising policies and frameworks, improving technical capacities and skills, encouraging changes to decision‑making processes, facilitating coordination among stakeholders, demonstrating technologies and adaptation practices, and collecting and disseminating information (UNDP and GEF 2010).

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| Box C.2 Types of barriers identified by the UNDP |
| The UNDP, in collaboration with the Global Environment Facility, has identified potential barriers to adaptation. Examples are listed below.  Systemic barriers   * Institutional — an absence of appropriate institutional arrangements or governance structures, a lack of technical and managerial capacity of staff, or ineffective coordination across institutions and society. * Policy — regulations and policies that affect the management of climate change risks and opportunities in key sectors or regions. * Behavioural — a lack of awareness, understanding or capacity at the individual and community levels. * Financial — insufficient allocation of resources through government budgets to reduce climate risks, inappropriate regulatory and fiscal structures, a lack of access to financial and risk transfer mechanisms, and unsustainable funding sources.   Discrete barriers   * Technological — an absence of climate‑resilient technologies and practices, the failure to use these, or a lack of scientific and technical capacity. * Informational — a lack of access to information necessary to plan and manage climate change uncertainty, including insufficient technical capacity to generate and use climate information and modelling. |
| *Source*: UNDP and GEF (2010). |
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#### United Nations Environment Programme

The United Nations Environment Programme (UNEP) supports developing countries to:

* make adaptation decisions based on the best available information
* strengthen institutional and policy frameworks for adaptation
* integrate adaptation into national development planning and legislative processes
* assess the risks and costs of climate change impacts
* conduct economic analyses of adaptation options (UNEP 2012b).

As part of this, the UNEP has developed a Global Adaptation Network (and a set of regional networks) to help governments and others to access and share information, tools and case studies on adaptation (UNEP 2012a).

In addition, the Climate Change Adaptation and Development Initiative, run jointly by the UNEP and UNDP, provides technical and financial assistance to sub‑Saharan African countries and Small Island Developing States to remove barriers to implementing adaptation policy and to integrate adaptation into decision‑making and development frameworks. This involves activities to enable participation by communities, establish suitable policy frameworks, raise awareness and improve communication of the risks and opportunities of climate change (CC DARE nd). The UNEP has also developed frameworks for assessing climate change vulnerability and impacts, and provides policy guidance on incorporating adaptation into national development planning (Poverty-Environment Initiative 2011).

#### International Strategy for Disaster Reduction

The United Nations International Strategy for Disaster Reduction aims to reduce the damage caused by natural disasters and improve the capacity of governments and communities to respond to these. In particular, it seeks to ensure that disaster risk reduction is incorporated into climate change adaptation programs (UNISDR 2011).

The United Nations International Strategy for Disaster Reduction mainly provides information and guidance to countries to reduce disaster risks and improve resilience to natural hazards. It also facilitates collaboration and information sharing among stakeholders. Specific activities include:

* the Global Platform for Disaster Risk Reduction, a forum for exchanging information between governments and other organisations
* PreventionWeb, a website for distributing information on disaster risk reduction
* the production of Global Assessment Reports that examine natural hazards and risk reduction activities worldwide (UNISDR 2012).

This work is complemented by the Hyogo Framework for Action 2005–2015, an international agreement to reduce losses from natural disasters (which Australia supports through its international aid program). The Framework specifies actions to reduce losses from natural disasters, including:

* ensuring that disaster risk reduction is a national and local priority
* identifying, assessing and monitoring disaster risks
* using knowledge and education to ‘build a culture of safety and resilience’
* reducing risk factors and improving preparedness (UNISDR 2007, p. 6).

Implementation in developing countries is supported by financial assistance from the Global Facility for Disaster Reduction and Recovery (GFDRR 2011).

### Organisation for Economic Co‑operation and Development

The Organisation for Economic Co‑operation and Development (OECD) facilitates adaptation by providing analyses, case studies and policy guidance to member governments and the public more broadly. This work ‘supports governments by providing the analytical foundation required to develop efficient and effective policies that promote adaptation to climate change’ (OECD 2011a). The OECD supports the evaluation of the costs and benefits of adaptation actions, and the consideration of adaptation in policy decisions and government processes. It also supports policies to help households and businesses adjust to changing conditions.

Various aspects of adaptation, including policy implications, have been set out in several OECD publications (box C.3). This work is supported by an agreement of member countries to integrate adaptation into economic development decisions, including through development programs that they use to assist other countries (OECD 2009).

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| Box C.3 Key OECD publications on adaptation to climate change |
| A number of OECD publications have examined adaptation to climate change. Several examples are listed below.  Economic Aspects of Adaptation to Climate Change  This report sets out principles for making adaptation decisions and assesses available estimates of the costs and benefits of adaptation in various sectors and countries. It also examines market‑based and regulatory instruments that can facilitate adaptation, including insurance, environmental markets and public–private partnerships (Agrawala and Fankhauser 2008).  Private Sector Engagement in Adaptation to Climate Change  Drawing on a survey of companies in several developed countries (including Australia), this report found that climate‑related risks are widely considered by private companies and addressed through existing risk management frameworks, even though these may not always be labelled as ‘adaptation’ (Agrawala et al. 2011).  Integrating Climate Change Adaptation into Development Co‑operation  This policy guidance document examines ways to integrate adaptation into development policies and activities, including by assessing climate change impacts, raising awareness of climate change, improving the flexibility of regulations and systematically evaluating the effectiveness of adaptation measures (OECD 2009). |
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### World Bank

As a provider of loans and development aid, the World Bank has incorporated adaptation into its activities in a number of ways. It provides information, funding and technical assistance to facilitate adaptation, and supports government policy reforms that create incentives for adaptation. Examples of reforms include removing inefficient subsidies (such as for water‑intensive crops), facilitating the take‑up of insurance, improving water and ecosystem management, and strengthening institutions (World Bank 2010a). Under the Strategic Framework for Development and Climate Change, the World Bank has committed to support adaptation in development processes; provide research; and facilitate adaptation financing, private‑sector involvement and capacity building (World Bank 2010b).

The World Bank also finances adaptation projects in developing countries, partly in conjunction with the Global Environment Facility. Other funding sources include the Strategic Climate Fund (in collaboration with other international agencies), which funds pilot and demonstration programs that integrate climate risks into development planning.

Further, the World Bank contributes to the Consultative Group on International Agricultural Research, a consortium of governments and other bodies that supports agricultural research to reduce poverty, improve human health and enhance the resilience of ecosystems (CGIAR 2012). This includes research to facilitate adaptation to climate change.

## C.2 National adaptation policy

Governments have implemented a range of policies and measures to facilitate adaptation to climate change. This section examines the broad‑level arrangements in several countries, focusing on overarching policy approaches, schemes that provide information and guidance to facilitate adaptation (for example, by individuals and businesses), and the incorporation of adaptation into government processes (such as infrastructure decisions or the delivery of government services).

### Policy approaches

Broad frameworks have been established to guide adaptation policy or government processes in some countries. These range from explicit and binding legislative arrangements (as in the United Kingdom) to reports on climate change that have been commissioned to inform policy responses (as in the United States and Canada). A number of OECD countries have developed national adaptation strategies and undertaken climate change risk assessments. These countries have generally focused on considering climate change risks in a range of policy areas, with some variation in the policy instruments used and assignment of responsibilities between levels of government (OECD 2012).

However, not all countries have adopted an explicit policy framework for adaptation. For example, the New Zealand Government mainly provides information and guidance to facilitate adaptation by local governments and others (discussed below).

#### United Kingdom

The United Kingdom uses several policy tools to facilitate adaptation to climate change, including an explicit legislative framework. Under the Climate Change Act (UK) 2008, the Government must undertake a Climate Change Risk Assessment for the United Kingdom every five years and implement a National Adaptation Programme to manage the identified risks (DEFRA 2011e).

The first such assessment was released in January 2012 and examined the potential risks and opportunities of climate change to the United Kingdom until 2099 (absent future adaptation). This included assessing current exposure to climate‑related risks. It focused on five areas: agriculture and forestry, business, health and wellbeing, buildings and infrastructure, and the natural environment (DEFRA 2012c).

The UK Government has stated that it will release a National Adaptation Programme in 2013 to respond to the risks identified in the Assessment. This will cover a number of sectors; include adaptation policies and actions by government; and set out the roles and responsibilities of government agencies, the private sector and others (DEFRA 2012b; HM Government 2012). The overall principles for the UK Government will be:

… to act mainly where the market is unlikely to act, to help others make good decisions on climate risks and opportunities … and to promote risk‑based decision approaches … (HM Government 2012, pp. 7–8)

In addition, an Adaptation Economic Analysis is being developed to assess the costs and benefits of adaptation options and identify priority areas for government (DEFRA 2011a).

The Climate Change Act also established the Committee on Climate Change to provide independent advice and analysis to the UK Government (DEFRA 2011e). Part of this is the Adaptation Sub‑Committee, which advises the development of the five‑yearly Climate Change Risk Assessments, assesses how prepared the United Kingdom is for climate change, and promotes action to adapt to climate change (Adaptation Sub-Committee 2009). It will also evaluate the implementation of the National Adaptation Programme.

The Sub‑Committee has identified several barriers to adaptation in its progress reports. These include:

* insufficient capacity of local governments to address climate‑related risks
* inadequate transparency and accountability of local authority decisions when approving development on floodplains
* underinvestment in flood‑protection works by governments
* split incentives, where property owners or developers underinvest in property‑level flood protection that would benefit occupiers
* weak price signals to reflect the relative scarcity of water and a lack of water metering for many households
* inappropriate investment processes in the water sector
* insufficient information on options for households to manage exposure to risks
* a perception by some households that managing flood risk is not their responsibility
* the unaffordability of some flood protection measures for low‑income households (Adaptation Sub-Committee 2011, 2012).

The Sub‑Committee has recommended that the UK Government set out steps to remove barriers to adaptation as part of its National Adaptation Programme (Adaptation Sub-Committee 2012).

Other policies in the United Kingdom, discussed later in this appendix, include requirements for large utilities (including those owned privately) and their regulators to report on how they are addressing climate change risks, guidelines for considering climate change in government investment decisions, and the dissemination of information and guidance to facilitate adaptation.

#### United States

Adaptation policies in the United States have been formed at federal, state and local levels of government. Policies at the federal level include the provision of climate research and information, along with the identification and management of some climate‑related risks by government agencies (discussed later in this appendix).

In addition, some states and local governments (such as cities and municipalities) have adopted adaptation strategies, plans and/or policy frameworks. For example, as of August 2012, 14 states had an adaptation plan in place (CCES 2012).

The approaches used differ across states. For example, the Adaptation Strategy for California is based on giving priority to adaptation policies that:

* enhance existing efforts to improve economic, social and environmental outcomes
* modify existing policies without requiring new funding or staffing
* are flexible and can be effective in circumstances that are not fully predictable (California Natural Resources Agency 2009).

More broadly, the adaptation frameworks in several states — including California, Florida, New York and Alaska — are based on common themes, including improving information provision, incorporating climate change in public infrastructure decisions, using planning instruments to reduce the exposure of property and infrastructure to climate risks, and improving the management of water resources and ecosystems (Alaska Department of Environmental Conservation 2010; California Natural Resources Agency 2009; GATECC 2008).

#### European Union

The European Commission has released a white paper that sets out a framework for EU‑wide policy on adaptation. According to this paper, ‘autonomous adaptation’ (responses by individuals and businesses to market signals or environmental changes) may not occur to the optimal extent because of uncertainty, imperfect information or financial constraints (EC 2009). As such, it set out a role for the European Union to facilitate adaptation in sectors that are covered by EU‑wide policies (such as agriculture, water, fisheries and energy networks) and where the impacts of climate change occur across the borders of member states. It recommended that priority be given to adaptation measures that have benefits regardless of uncertainty about future climate change, along with those that also reduce greenhouse gas emissions (EC 2009).

The white paper identified several options for the European Union and its member states to review existing policies — for example, by factoring climate change into rural‑development, river‑basin and flood‑management plans. It also recommended that member states consider requirements that climate change impacts be assessed for public and private infrastructure and incorporated into construction standards (EC 2009).

The white paper also set out a broader EU Adaptation Framework to inform an EU adaptation strategy that is to be implemented by 2013 (EC 2009). This framework is designed to improve understanding of climate change impacts, integrate adaptation into EU policies and support international cooperation to facilitate adaptation. It is based on the principle of subsidiarity, where higher levels of government (such as the European Commission) only make decisions that cannot be effectively handled by lower levels of government (such as member states or sub‑national governments).

More broadly, the European Commission has indicated that it can support adaptation by promoting coordination and information sharing among member states and ensuring that climate change risks are considered in relevant EU policies (EC 2010a). This suggests that it considers adaptation within a range of policy measures, rather than as a stand‑alone policy area.

#### Canada

The Canadian Government facilitates adaptation to climate change mainly by providing information and guidance on adaptation options and ways to factor climate change into risk management. It has also committed to develop an adaptation policy framework to consider climate change risks in the decisions and activities of Federal Government agencies (Commissioner of the Environment and Sustainable Development 2010).

Natural Resources Canada funds research on climate change impacts and adaptation, and provides resources for considering adaptation in decision making. This includes guidelines for local governments to create adaptation plans and incorporate adaptation into their risk management processes, and for designers and owners of infrastructure to assess climate risks and incorporate adaptation into infrastructure decisions (Natural Resources Canada 2011b). Natural Resources Canada (2011a) also facilitates collaboration between each level of government, the private sector and community organisations on adaptation.

In addition, reports have identified barriers to adaptation in Canada, including insufficient access to information, a lack of guidance for land‑use planners, societal expectations, financial and technological constraints, governance arrangements, and some planning and environmental regulations (Lemmen et al. 2008; NRTEE 2009).

### Providing information and guidelines

Information provision plays a central part in adaptation policy across countries. Many governments have funded research on the impacts of climate change and have established arrangements to disseminate information. Governments also provide guidelines for households, businesses and other organisations to manage climate change risks and impacts. In a number of OECD countries, governments primarily facilitate adaptation by providing information on climate risks, typically through web‑based information portals. This is often accompanied by resources and guidance for identifying, evaluating and mitigating these risks (OECD 2012).

In most cases, research on the impacts of climate change is undertaken by a central government agency. For example, detailed research on climate change impacts, projections of climate‑related variables and detailed mapping of these has been coordinated and funded in the United Kingdom by the Department of Environment, Food and Rural Affairs (DEFRA 2011f), and in Canada by Environment Canada and Natural Resources Canada (CCCSN 2011; Lemmen et al. 2008).

In the United States, a number of government research organisations focus on climate change. At the federal level, both the National Oceanic and Atmospheric Administration and the National Aeronautics and Space Administration conduct climate observation, data analysis and climate projections, as well as research climate change impacts (NASA 2011; NOAA 2011). Additional climate change information is provided by the Global Change Research Program, which undertakes and coordinates research on climate science and impacts across a number of Federal Government agencies. Every four years this program conducts assessments of the impact of climate change on natural and human systems. The next assessment, due in 2013, will also report on adaptation progress (USGCRP 2011).

State governments also provide climate information and mapping in the United States. For example, the Government of California disseminates information and maps on natural hazards, including projections of climate change impacts at local scales (California Energy Commission 2011).

Along with research, governments provide resources and guidelines to support adaptation. These often include advice on identifying climate change impacts, guidelines for risk management and strategic planning, case studies and adaptation options. For example, the European Climate Adaptation Platform website (maintained by the European Commission) compiles information on expected climate change impacts and the vulnerability of specific regions, along with adaptation strategies and planning tools (EC 2012). The New Zealand Government provides an online Climate Change Adaptation Toolbox for identifying and responding to climate‑related risks (NZ Ministry of Agriculture and Forestry 2010).

In the United Kingdom, a number of resources are made available through the Climate Impacts Programme (box C.4), which are to be supplemented in future by further resources provided by the UK Environment Agency (2012). More broadly, environmental research and adaptation resources are provided in the United Kingdom through the Living With Environmental Change Partnership, a collaboration between several public‑sector organisations (including government agencies, local governments and research councils) (LWEC 2011).

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| Box C.4 Tools provided by the UK Climate Impacts Programme |
| The UK Climate Impacts Programme provides resources and tools to assist local governments, businesses and others to adapt to climate change. These include:   * *Adaptation Wizard* — a tool that can be used to assess exposure to weather events and climate change, the risks of key climate change impacts, and various options to address these. Such options include bearing losses, spreading risks through insurance, reducing exposure to hazards and exploiting new opportunities * *AdOpt* — guidelines for identifying and selecting adaptation options. These favour a flexible approach for dealing with uncertainty by identifying options to delay some decisions until better information is available. Types of options are also set out, including ‘no regrets’ strategies (that have benefits regardless of climate change) and flexible or incremental measures * *Costing the Impacts of Climate Change* — a methodology to estimate the costs of climate change impacts and adaptation measures. This includes guidance for valuing social and environmental impacts and assessing the value of options that allow decisions to be delayed, as well as detailed case studies covering crops, road maintenance, and the overheating and flooding of dwellings. |
| *Source*: UKCIP (2011). |
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### Incorporating adaptation in government processes

Several governments have introduced processes to consider climate change in their operations. In some cases, this has been through planning processes at the departmental or agency level and/or the use of explicit adaptation guidelines.

Government departments and agencies must develop adaptation plans in both the United Kingdom and United States (at the federal level). These involve identifying the risks that climate change may have for the operations of each agency — including the provision of infrastructure and services — and implementing strategies to manage those risks, such as considering climate change in procurement decisions or undertaking further risk assessments (DEFRA 2011d; ICCATF 2011).

In the United States, this process is supported by the Interagency Climate Change Adaptation Task Force, which recommends changes to government policies and programs to facilitate adaptation (ICCATF 2011). The Task Force has compiled a set of ‘guiding principles’ for adaptation (box C.5).

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| Box C.5 US Interagency Task Force ‘guiding principles’ |
| The US Interagency Climate Change Adaptation Task Force has developed a set of principles to guide activities by Federal Government agencies to facilitate adaptation.   * Adopt integrated approaches — integrate adaptation into core policies and programs where possible. * Prioritise the most vulnerable — give priority to people, places and infrastructure that are most vulnerable to the impacts of climate change. * Use the best‑available science — use the best‑available scientific understanding of climate change risks and impacts. * Build strong partnerships — coordinate across sectors and scales, and build on the existing efforts and knowledge of public and private stakeholders. * Apply risk‑management methods and tools — incorporate risk management methods and tools into adaptation planning. * Apply ecosystem‑based approaches — take into account strategies to increase ecosystem resilience and protect ecosystem services. * Maximise mutual benefits — use strategies that complement or support other climate and environmental initiatives (such as those to improve disaster preparedness or promote sustainable resource management). * Continuously evaluate performance — use measurable goals and performance metrics to continually assess whether desired outcomes are being achieved. |
| *Source*: ICCATF (2011). |
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More broadly, under the Adaptation Reporting Power in the United Kingdom, some government‑owned companies and statutory authorities — as well as some private companies — must report on the current and predicted impacts of climate change on their functions, and their approach for adapting to these impacts (DEFRA 2011b). This requirement covers most large utilities and their regulators, including water providers, electricity generators and distributors, gas distributors, and transport infrastructure operators (airports, ports, road and rail). According to the UK Government, reports submitted to date show that these organisations are assessing the risks of climate change and many are taking steps to manage those risks. The reporting process also helped to identify several informational, technical, financial and regulatory barriers to adaptation (DEFRA 2012a).

Further, the United Kingdom has produced specific guidelines for the consideration of climate change impacts in government policy and project decisions (box C.6) (as part of broader guidelines that generally must be considered in all government expenditure and policy decisions). These guidelines outline ways to deal with uncertainty and increase the flexibility of policies and projects. An additional guide has been produced to assist government agencies to incorporate climate‑related risks into procurement decisions and minimise these risks over the lifetime of long‑lived assets (OGC and DEFRA 2010).

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| Box C.6 ‘Green Book’ guidance in the United Kingdom |
| In the United Kingdom, government policies and projects must undergo economic assessment according to the Green Book. This includes guidelines for addressing the risks of climate change for long‑lived projects that may be affected by weather and climate. The guidelines set out three broad strategies to deal with uncertainty about future climate change.   * Incorporating flexibility in an activity, such as by allowing for future adjustments. * Designing an activity to tolerate a wider range of climatic conditions. * Using measures that have relatively low costs but large benefits (‘low regrets’) or that reduce climate risks as well as having wider benefits (‘win win’).   The guidelines identify ways that adaptation measures can be flexible, including by:   * addressing market failures and providing incentives for effective adaptation (through changes to regulatory instruments and the use of market‑based instruments) * providing information to inform decisions by individuals and organisations * bearing losses and managing impacts where the costs of preventing a risk exceed the benefits * spreading risks, such as through diversification, insurance and ensuring that contracts accurately reflect risks * preventing losses or reducing their consequences — for example, using engineering methods, the choice of location, or regulatory instruments (such as standards) * exploiting opportunities that arise from positive effects of climate change.   The guidelines also recommend the use of ‘real options’ or flexible management approaches by designing activities with the flexibility to be adjusted in the future when more information about climate change becomes available. |
| *Source*: HM Treasury (2009). |
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Approaches in other countries vary. For example, in Canada, the provincial governments of Alberta, Manitoba and Saskatchewan have formed the Prairies Regional Adaptation Collaborative to incorporate climate change considerations into their water, drought and ecosystem policies (PARC nd). In Europe, government agencies and other organisations have collaborated to research the impacts of climate change and options for managing these impacts (EC 2010b). In New Zealand, the central government provides guidelines for local governments on ways to assess and manage climate change impacts. These guidelines cover the provision of services and planning activities, and the management of coastal hazards and flood risks (NZ Ministry for the Environment 2008a, 2008b, 2010). In addition, climate change risks must be taken into account in coastal planning and freshwater management in New Zealand.

D Economic modelling and adaptation to climate change

Economic modelling has been used to examine climate change impacts and how adaptation (and mitigation) to climate change may affect the economy as a whole. Integrated assessment models (IAMs), computable general equilibrium (CGE) models and partial equilibrium (PE) models have been used for these purposes (box D.1).

Modelling approaches could be used to assess adaptation reform options if they can assist in answering one or more of the following questions.

* What are the costs and benefits of adaptation options?
* What types of adaptation should be pursued, and in which sectors?
* What is the optimal timing of adaptation?

However, modelling results need to be treated with appropriate caution. The uncertainties and long timeframes associated with climate change may limit the conclusions that can be drawn from modelling results. The use of sensitivity analysis and ranges can highlight the implications of uncertainty for the modelling results.

Section D.1 describes models that have been used to estimate the impact of climate change, and section D.2 looks at models that have been used to estimate the costs and benefits of adaptation. Section D.3 outlines the strengths and shortcomings of the modelling approaches in assessing climate change adaptation options.

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| Box D.1 Types of models |
| Economic models used to assess the impacts of climate change, and adaptation responses, use mathematical equations to represent economic and physical processes. These equations are used to simulate how various sectors and activities might respond to changes to the environment, economy or policy settings.  Partial equilibrium models  Partial equilibrium models focus on how changes affect a particular firm or sector. These models are used to estimate the direct impacts of a change to the economy on that sector, and offer a more detailed representation of a sector than general equilibrium models. However, they are not designed to capture the flow‑on effects on other sectors of the economy. An example of a partial equilibrium model is the model of the urban water sector developed by Barker, Murray and Salerian (2010).  Computable general equilibrium (CGE) models  CGE models are used to analyse how changes or impacts on one sector of the economy flow through to the rest of the economy. Examples of CGE models include the Monash Multi‑Regional Forecasting model and the Global Trade Analysis Project model.  Within CGE models, the economy is represented by a system of equations representing production, consumption and investment. A number of sectors or regions can be represented, and factors of production are free to move to sectors where returns are highest.  These models are calibrated using real‑world data, and a ‘baseline’ scenario is estimated. Variables are then altered — referred to as a ‘shock’ — and the model is re‑run to examine the impact of the ‘shock’ on the economy. For example, the impact of climate change on agriculture may be represented as a reduction in agricultural productivity. The model provides estimates of the effects of the shock on other sectors. In some cases, model results could be broken down by region.  CGE models can be either ‘dynamic’ or ‘comparative static’ (as can other types of models). Comparative static models compare the model before and after the shock to examine its impact. Dynamic models explicitly include the time dimension into the model, to examine how the impacts of the shock play out over time.  Integrated assessment models  Integrated Assessment Models ‘simulate the key human and natural processes believed to be driving climate change and estimate the socioeconomic impacts’ (Baker et al. 2008, p. 29). Integrated assessment models contain both a model of the economy, and a model of the climate. Economic activity produces greenhouse gas emissions, which lead to climate impacts. These climate impacts influence the economy (for example, by reducing output) through a climate damage function. |
| *Sources*: Baker et al. (2008); Barker, Murray and Salerian (2010). |
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## D.1 Modelling the impacts of climate change

### Australian studies

#### Garnaut Review (2008)

The largest exercise to estimate the impacts of climate change on the Australian economy was undertaken in 2008, as part of the Garnaut Review (Garnaut 2008b). The Garnaut modelling attempted to estimate the economic impacts of climate change on areas including:

* primary production — cropping and livestock
* human health
* critical infrastructure — water supply, electricity transmission and distribution, coastal buildings and ports
* residential buildings (due to increased cyclone intensity)
* international trade.

‘Shocks’ were estimated based on detailed reports of the physical impacts of climate change on each of these sectors, which were provided to the Garnaut Review by expert groups. These ‘shocks’ were incorporated into the Monash Multi‑Regional Forecasting (MMRF) model — a dynamic multi‑sector CGE model of the Australian economy. For example, in the case of coastal buildings, the costs associated with upgrading or relocating homes and businesses were modelled as an increase in capital costs for dwellings and commercial buildings.

The review modelled impacts for a range of climate scenarios. These included a ‘no mitigation’ scenario and two scenarios with mitigation stabilising atmospheric carbon dioxide equivalent concentrations at 550 parts per million and 450 parts per million. These were compared to a reference case of no human‑induced climate change. The temperature rises estimated ranged from 1.5–4.5°C by 2100.

Some limited adaptation responses were included in the analysis. In particular, the MMRF model allows for adaptive responses such as producers switching to another industry if there is a loss of productivity in the industry they were originally in (which is a general feature of CGE models). Other, more specific, adaptation responses were also incorporated into the analysis. For example, the infrastructure analysis considered the effects of planning and building standards that increase the resilience of buildings. These responses were assumed to reduce the magnitude of the shocks that were incorporated into the model.

#### Other Australian studies

Other studies that have attempted to estimate the impacts of climate change on the Australian economy include those by Gunasekera et al. (2007, 2008). Gunasekera et al. (2008) used an IAM — the Global Integrated Assessment Model (GIAM) developed by ABARE and the CSIRO — to develop indicative estimates of the impacts of climate change to 2100. The GIAM model combines ABARE’s Global Trade and Environment (GTEM) CGE model with a climate model used to estimate the average change in regional temperatures.

Gunasekera et al. (2007) used the GTEM and Ausregion CGE models to examine the impacts of climate change on agricultural productivity. They assumed that climate change would reduce agricultural productivity. By incorporating this shock into the model, Gunasekera et al. estimated the impact on agricultural production and trade flows globally.

#### Key results

The Garnaut Review estimated that in 2100, unmitigated climate change would reduce GDP by 5.9 per cent, relative to what it would have been without climate change. Other Australian studies have reported similar figures — though in the case of Gunasekera et al. (2007), this is despite their model only considering impacts on the agriculture sector (table D.1).

Table D.1 Economic impacts of climate change on Australia

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| --- | --- | --- | --- | --- | --- |
| Study | Model | Sector | Year | Temperature rise | Impact on GDP |
|  |  |  |  | °C | % |
| Garnaut (2008b) | MMRF | National | 2100 | 4.5 | ‑5.9 |
| Gunasekera et al. (2008) | GIAM | National | 2100 | 3.5 | ‑5.0 |
| Gunasekera et al. (2007) | GTEM/Ausregion | Agriculture | 2050 | 0.8–2.8 | ‑5.0 |

*Sources*: Garnaut (2008b); Gunasekera et al. (2007, 2008).

The Garnaut Review provided further detail on the economic impacts of climate change, broken down by sector. The impacts on infrastructure were estimated to have the most significant effect: an estimated 2.4 per cent reduction in GDP in 2100. Impacts on agriculture (‑2.1 per cent) were also estimated to be significant. As a result of reduced demand for Australia’s exports (such as coal and other mining products), a decline in the terms of trade resulting from climate change was also estimated to have a significant impact (‑1.4 per cent).

The Review also considered the impacts of climate change on each state and territory. Queensland and the Northern Territory were estimated to experience more than a 10 per cent fall in gross state product due to climate change by 2100 relative to what it would have been without climate change. Western Australia (around 9 per cent) and South Australia (around 7 per cent) were also expected to be significantly impacted. Both Tasmania and Victoria were projected to experience a 4 per cent reduction in gross state product, New South Wales a 2 per cent decrease, and the ACT estimated to experience minimal economic impact.

Finally, the modelling for the Review produced projections for 58 industries. Output was projected to fall in the majority of industries. The two most adversely affected were agriculture (over a 20 per cent decrease in output by 2100 relative to the no climate change scenario) and mining (a 13 per cent decrease in output by 2100).

### International studies

A series of studies was undertaken by the [Fondazione Eni Enrico Mattei](http://www.feem.it/), modelling the impacts of climate change on tourism (Berrittella et al. 2006), human health (Bosello, Roson and Tol 2006) and coastal property (Bosello, Roson and Tol 2007). The studies used the Global Trade Analysis Project (GTAP) model of the global economy. First, datasets for the future world economy were compiled — including labour, capital, land, natural resources and productivity. Shocks were then incorporated into the model to simulate the effect of climate change in each of the sectors.

* In the case of tourism, data were obtained from a previous study which considered the changes in tourism flows resulting from climate change. Based on these data, two sets of variables were shocked — first, consumer spending on hotels, restaurants and recreation activities (assuming that foreign tourists increase expenditure on these). Second, changes in international income transfers associated with foreign tourists were modelled.
* In the case of coastal property, two scenarios were run. In the first case, no coastal protection was built — modelled as a reduction in the amount of land. In the second scenario, the land was fully protected by levees — modelled as a shock in the value of investment.
* Finally, the impacts on human health were modelled as shocks to labour productivity and expenditure on health services.

Eboli, Parrado and Roson (2010) extended this work using the Inter‑temporal Computable Equilibrium System (ICES) model — a dynamic CGE model derived from the GTAP model. In addition to the shocks described above, Eboli, Parrado and Roson included impacts on agriculture and energy demand. Agricultural impacts were modelled as a shock to the productivity of land, while energy demand impacts were modelled as increases or reductions in the demand for natural gas, oil and electricity. The modelling assumed an increased temperature of 1.5°C by 2050.

The economic impacts of climate change have also been modelled using a CGE approach in other sectors, including forestry (Rive, Aaheim and Hauge (2005) using the GRACE model) and agriculture (Bosello and Zhang (2005) using the GTAP model).

A range of international studies have also used IAMs to estimate the economic impacts of climate change. Examples include PAGE (Stern 2007), RICE (Nordhaus 1998) and WIAGEM (Kemfert 2002).

#### Key results

The international models report a wide range of estimates for the impacts of climate change on GDP (table D.2). The estimates for 2100 range from a fall of 0.9 per cent of GDP (Stern 2007) to a fall of 11.4 per cent of GDP (Gunasekera et al. 2008). These variations may be due to a range of factors in the models, including their treatment of adaptation (for example, the PAGE2002 model assumes a proportion of the damages can be mitigated by low‑cost adaptation options), catastrophic impacts and non‑market impacts; the temperature rise considered; and the general uncertainty surrounding the impacts of climate change.

Table D.2 Economic impacts of climate change globally

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Study | Model | Sector | Year | Temperature rise | Impact on GDP |
|  |  |  |  | °C | % |
| Stern (2007) | PAGE2002 | All | 2100 | 3.9 (mean) | ‑0.9 |
| Stern (2007) | PAGE2002 | All | 2100 | 4.3 (mean) | ‑1.2 |
| Gunasekera et al. (2008) | GIAM | All | 2100 | 3.4 | ‑11.4 |
| Kemfert (2002) | WIAGEM | All | 2050 | 0.25 | ‑1.8– ‑0.9 |
| Nordhaus (1998) | RICE | All | 2115 | 2.5 | ‑0.5 |
| Bosello, Roson and Tol (2006) | GTAP | Health | 2050 | Unclear | ‑0.1–0.08a |
| Bosello et al. (2007) | GTAP | Sea‑level riseb | 2050 | Unclear | ‑0.03–0c |

a ‑0.1 refers to the region ‘rest of world’; 0.08 refers to the region ‘rest of Asia’. b For the ‘no protection’ scenario, assuming that coastal land is not protected. c ‑0.03 refers to the region China and India; 0 refers to the region ‘Rest of Annex 1 countries’.

*Sources*: Bosello et al. (2007); Bosello, Roson and Tol (2006); Gunasekera et al. (2008); Kemfert (2002); Nordhaus (1998); Stern (2007).

Some modelling exercises have broken down the impacts according to:

* sector — for example, estimates by Bosello et al. (2007) suggested that the impacts of sea‑level rise may have significant effects on the rice sector in the region ‘rest of Asia’ (losing up to 0.6 per cent of output). Sea‑level rise was estimated to have negligible impact on some other sectors, such as electricity
* region — though these are often relatively aggregated. For example, the GTAP model used by Bosello, Roson and Tol (2006) contains 8 regions — Energy Exporting Countries, the United States, China and India, Rest of Annex 1 Countries (which includes Australia), Japan, Eastern European and former Soviet Union countries, European Union, and Rest of World. It was found that the estimated impacts on health have the most pronounced effect on GDP in the Rest of World region (‑0.1 per cent impact on GDP), with other regions such as the Rest of Annex 1 Countries and the European Union receiving a net GDP increase as result of the health impacts of climate change.

## D.2 Modelling the costs and benefits of adaptation

Modelling exercises may be of use in examining the costs and benefits of adaptation — whether for an economy as a whole, for sectors or regions, or for individual adaptation options. In addition, such models may be able to provide some insights into the optimal timing and types of adaptation.

However, to date, few studies have examined the costs and benefits of adaptation together, within a modelling framework. Of these studies, the majority have used integrated assessment modelling, which can provide an overview of the costs and benefits of adaptation responses. A small number of studies have considered more specific adaptation options within a cost–benefit framework. The use of CGE or PE modelling has been limited.

### What models have been used?

#### Cost–benefit studies

Some studies have used a cost–benefit framework to consider adaptation responses. These studies typically identify the potential risks using climate models and risk analysis, identify a range of adaptation options, and then use a range of approaches to analyse the costs and benefits of these options.

A suite of studies by AECOM used a cost–benefit framework to assess flooding in the Narrabeen Lagoon in New South Wales (AECOM 2009), adapting Victoria’s rail network (AECOM 2011) and adapting water supplies in Victoria’s Central Highlands (AECOM 2010). These studies used Monte‑Carlo analysis (an approach that involves running multiple simulations with random values picked from a probability distribution) and a range of climate scenarios to assess the impacts of climate change. Monte‑Carlo analysis was also used to assess the potential for adaptation responses to reduce these impacts.

In general, the AECOM studies found that a portfolio of adaptation options is the most appropriate response.

* In the Narrabeen Lagoon study, options that passed the cost–benefit test included opening the lagoon entrance, building a levee, installing flood-warning systems and using land-use planning regulation. Two other levees did not pass the   
  cost–benefit test.
* In the Victorian rail study, implementing regenerative braking and replacing cabling in overhead lines were estimated to have net benefits. Other options, such as replacing the current wooden sleepers with concrete sleepers did not pass the cost–benefit test.
* The Central Highlands water study estimated that accepting a lower reliability of water supply would reduce the costs of supplying water, and that implementing scarcity pricing would also reduce costs. However, restricting household connections to the water network was estimated to be a high‑cost approach.

The Economics of Climate Adaptation Working Group (2009) undertook a range of cost–benefit studies examining possible climate change adaptation responses. One scenario considered the risk of flooding (both coastal and riverine) and wind damage in the UK city of Hull. The study considered a range of responses to the risks, including flood-protection measures, flood-awareness campaigns, flood proofing existing buildings, insurance, and improved drainage systems. The costs of the measures included capital and operating expenditures, and were extrapolated from current costs. The study considered benefits including a reduction in the severity of the expected hazard, a reduction in assets at risk, and a reduction in the vulnerability of assets (the expected damage to assets as a result of a given event).

The most cost‑effective options were found to be flood awareness campaigns   
(cost–benefit ratio of 0.01[[2]](#footnote-2)), sea and river defences (0.03–0.13), training staff for emergency management (0.28), and flood proofing floors of new buildings (0.49). Costly options included flood proofing the floors in existing buildings (3.30), sandbagging buildings (2.15) and reducing insurance premiums for small businesses (1.67).

A study by BRANZ (2007) considered the costs and benefits of retrofitting housing in New Zealand to deal with the impacts of climate change. The study considered adaptation options, including increasing the number of nails in roofs, increasing insulation, using stronger steel, installing water tanks, and moving housing inland. For each option, the cost of the option per house was calculated, and multiplied by the number of houses assumed to be at risk of extreme weather events, to estimate the total cost of the measure. Benefits were estimated by making assumptions about the damage reductions resulting from the adaptation measure.

The study estimated that the total cost of adaptation measures would be NZ$2 billion, while the total benefits would be NZ$4 billion. Most of the benefits (NZ$3.6 billion) resulted from increasing the use of insulation, while other measures that were found to have benefits exceeding the costs included additional nails in roofs, and moving houses inland. Using higher quality steel was found to have costs exceeding the benefits.

Finally, some environmental impact assessments have included an analysis of adaptation options (Agrawala et al. 2010b). These assessments generally include an assessment of climate change risks and potential options to manage these risks. For example, the environmental impact assessment for the installation of an electrical substation in the ACT considered climate change risks to the investment. However, the assessment suggested that there were minimal climate change risks associated with the investment in the short term, and thus minimal benefits from proceeding with adaptation measures in the short term (Purdon Associates and AECOM 2010).

#### Integrated assessment models

Few IAMs incorporate adaptation as an explicit variable. However, there are some studies that use IAMs to consider the costs and benefits of adaptation.

Hope, Anderson and Wenman (1993) were the first to consider adaptation as an explicit variable in an IAM framework. They used the PAGE model, in which adaptation was considered to:

* increase the temperature rise that can be considered ‘tolerable’
* reduce damages for temperature rises above the ‘tolerable’ level.

Two scenarios were assessed — one with no adaptation, and one with an assumed package of adaptation responses such as seawalls and land‑use planning — to estimate the costs and benefits of adaptation. The adaptation package was assumed to make a 2°C temperature rise tolerable, and reduce the damage from temperature rises above this level by 90 per cent.

Hope (2009) also used the PAGE model to consider adaptation. Hope modelled two scenarios — one with adaptation, and one without — to estimate the costs and benefits of adaptation. The scenario with adaptation incorporated assumptions used in the Stern review (Stern 2007) — that in developed countries, 100 per cent of the economic impacts of the first 2°C of temperature rise, and 90 per cent of the economic impacts of temperature rises beyond this level, could be managed by low‑cost adaptation options.

The costs and benefits of adapting to sea‑level rise were considered by Tol (2007) using the FUND model. Several scenarios were modelled, including scenarios with and without coastal protection, to determine the cost–benefit ratio of coastal protection adaptation responses.

Recent studies by Agrawala et al. (2010a), Carroro, Bosello and de Cian (2009) and de Bruin, Dellink and Agrawala (2009) have attempted to incorporate adaptation as an explicit variable within the RICE, DICE and WITCH IAMs (box D.2). In these models, adaptation was considered as a continuous dynamic variable, and the amount of adaptation within the model was optimised over time. A range of data sources was used to calibrate these models. For example, in calibrating the WITCH model, Agrawala et al. (2010a) used previously published climate change damage functions and studies on the costs of adaptation, including those published by the UNFCCC (2007).

Brown et al. (2011) used the DIVA model (a global model of coastal systems) to consider the costs and benefits of adapting to sea‑level rise in the European Union. The study examined the risks associated with a 0.18–0.46 metre sea level rise by 2080. The adaptation responses considered included sea and river dikes, and beach nourishment.

##### Key results

Modelling approaches have typically concluded that adaptation offers large net benefits. The studies using the PAGE model have estimated benefit–cost ratios in excess of 30, with the other studies generally estimating a ratio in the region of 2 (table D.3). (The large difference between the PAGE model and the other models is due to the differences in assumptions between the models — the PAGE model assumes that low‑cost adaptation options can reduce much of the damages associated with climate change.) The optimal amount of adaption in the models varies significantly, depending on the assumptions regarding the climate, the benefits of adaptation, and the model used.

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| --- |
| Box D.2 Incorporating adaptation into integrated assessment models |
| In many IAMs, including DICE, RICE and WITCH, the climate change damage (reductions in global output) functions are purely a function of temperature increases. Adaptation is not included as a variable in these models. However, some recent studies have attempted to incorporate climate change adaptation responses into an IAM framework.  de Bruin, Dellink and Agrawala (2009) incorporated adaptation as a variable into the DICE and RICE models. Adaptation was included in the damage function and was assumed to reduce the economic damages associated with climate change, with adaptation costs increasing as more effective adaptation options are used up. The optimal level of adaptation is chosen every 10 years, and is modelled as a flow variable — adaptation in one period has no impact in the following periods (which is unlikely to be a realistic representation of investment in assets such as levees).  Agrawala et al. (2010a) built on the work of de Bruin, Dellink and Agrawala (2009), by expanding the RICE and DICE models to consider adaptation as both a stock and flow variable — allowing investment in adaptation in one period to have an impact on climate damages in future periods.  Carroro, Bosello and de Cian (2009) incorporated adaptation responses into the WITCH model. Adaptation was modelled as a sequence of constant elasticity of substitution functions, and was considered to be either anticipatory, information‑based (modelled as stock variables), or reactive (modelled as a flow variable). A range of adaptation approaches were considered, including coastal protection, early-warning systems, and agriculture and health responses. |
|  |
|  |

Some of the models also offer insights into the optimal timing of adaptation. Both models used by Agrawala et al. (2010a) (in particular the WITCH model) suggested limited adaptation will take place until 2025, due to limited temperature changes up to that point. Carroro, Bosello and de Cian (2009) produced similar results, with relatively little adaptation taking place until 2050 in their model.

The models also led to some conclusions about which types of adaptation may be optimal. Much of the adaptation modelled by Agrawala et al. (2010a) is anticipatory (such as coastal protection) or aimed at enhancing adaptive capacity, with limited implementation of reactive adaptation until the latter half of the century. On the other hand, reactive adaptation plays a bigger role in Carroro, Bosello and de Cian’s (2009) model, and very little research and development expenditure on adaptation occurs.

Table D.3 Key results — integrated assessment models

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Study | Model | Sector | Period | Adaptation costs | Adaptation benefits |
| Hope, Anderson and Wenman (1993) | PAGE | Global | 1995–2100 | 0.5tr (ECU)a | 17.5tr (ECU)a |
| Hope (2009) | PAGE | Global | 2000–2200 | 6tr (USD) | 350tr (USD) |
| Agrawala et al. (2010a) | DICE | Global | 2005–2100 | 0.28% GDP | 0.51% GDP |
| Agrawala et al. (2010a) | WITCH | Global | 2005–2100 | 0.19% GDP | 0.38% GDP |
| Carroro, Bosello and de Cian (2009)b | WITCH | Global | 2010–2105 | 270tr (USD) | 695tr (USD) |
| Carroro, Bosello and de Cian (2009)c | WITCH | Global | 2010–2105 | 10tr (USD) | 16tr (USD) |
| de Bruin, Dellink and Agrawala (2009) | RICE | Global | 2025–2055 | 151tr (USD) | 792tr (USD) |
| Brown et al. (2011) | DIVA | Sea-level rise (EU) | 1995–2080 | €0.3–€1.6bn (annual) | €5bn–€21bn (annual) |

a European Currency Unit, the precursor to the Euro. b High climate change damage with low discount rate scenario. c Low climate change damage with high discount rate scenario.

*Sources*: Agrawala et al. (2010a); Brown et al. (2011); Carroro, Bosello and de Cian (2009); de Bruin, Dellink and Agrawala (2009); Hope (2009); Hope, Anderson and Wenman (1993).

#### CGE and PE models

CGE and PE models have not been widely used to assess the costs and benefits of climate change adaptation. (However, these models can also be useful for highlighting the flow of resources through the economy in responses to climate change — a form of autonomous adaptation.)

Some studies have examined the benefits (though not the costs) of adaptation within the agricultural sector in developing countries. Calzadilla et al. (2009) used the IMPACT PE model and the GTAP model to assess the impacts of adaptation responses in sub‑Saharan Africa. First, climate change was modelled as a reduction in agricultural productivity. Then, two adaptation scenarios were run.

* The first considered an increase in irrigated land. This scenario resulted in a small increase in GDP, with limited impacts on agricultural production aside from wheat.
* The second considered an increase in agricultural productivity. This scenario led to a substantial increase in GDP (1.5 per cent), with large increases in agricultural production in sub‑Saharan Africa.

Further, a study by Nelson et al. (2009) used the IMPACT model linked to a crop model to estimate the agricultural productivity improvements that would be required to reduce estimated child-malnutrition levels in Africa in 2050 to pre‑climate change levels. This study suggested that the cost of increasing productivity would be between US$7.1 billion and US$7.3 billion annually.

## D.3 The strengths and limitations of modelling climate change adaptation

To be relevant for this inquiry, modelling exercises need to provide insights into the costs, benefits and optimal timing of adaptation options. However, the usefulness of the models considered in this appendix is qualified by their considerable limitations. These can include adaptation‑specific limitations, such as the handling of climate change within the models, or general limitations, such as the need for appropriate assumptions and good data.

### Where are these approaches most useful?

At a broad level, IAM and CGE modelling can provide some insights into the impacts of climate change. In particular, such models indicate which sectors and regions may be most severely affected by climate change, providing some focus for policy makers.

IAMs can provide useful insights into the optimal timing of adaptation responses. Studies using these types of models have typically found that it is optimal for the majority of adaptation to occur after 2025, with minimal investment required in the early part of the century.

However, the costs and benefits of adaptation estimated by IAM exercises are less useful for this inquiry. These results tend to be highly aggregated at both the country and sector level, and thus provide limited focus for policy makers as to appropriate adaptation policies.

While CGE and PE approaches have not been widely used for assessing specific adaptation options, they are useful for highlighting market‑driven responses to climate change. Such models can estimate how the allocation of resources within the economy may change in response to ‘shocks’ associated with climate change (for example, a reduction in agricultural productivity).

Cost–benefit studies have generally analysed sets of adaptation investments in specific regions. These studies are important for analysing specific adaptation options, but offer only limited insights for broader adaptation policy.

### What are the limitations of these approaches?

The modelling approaches outlined in this appendix have a number of shortcomings, which limited their potential usefulness for the inquiry. These shortcomings include:

* dealing with the uncertainty associated with climate change
* the quality of assumptions and data
* difficulties valuing non‑market outputs such as ecosystems
* uncertainty when modelling over long time periods
* incorporating climate change impacts.

#### Modelling is data and assumption driven

Modelling in general is data and assumption driven. The accuracy of the results of modelling exercises depends on the accuracy of the data used, and the extent to which the modelling assumptions approximate the real world.

To model the costs and benefits of adaptation, assumptions need to be made as to the cost of adaptation options, how effective they are at mitigating climate change impacts and what level of climate change impacts there will be in the future. The assumptions used can have a significant impact on the modelling results.

For example, the modelling exercises considered in this appendix assumed that adaptation is effective at reducing climate change impacts, and that the money used for adaptation is well spent. If this is not the case in reality, the models would overestimate the benefits of adaptation.

The effect that assumptions can have on the results is highlighted with the contrasting approaches taken in the PAGE and WITCH models. The PAGE model used by Hope (2009) estimated a benefit–cost ratio for adaptation of around 60. On the other hand, the WITCH model used by Agrawala et al. (2010a) estimated a much smaller benefit–cost ratio of around 2.

This may be due to a range of assumptions included in the modelling exercises, such as assumptions regarding the nature of adaptation, the timing of climate change and the damages of climate change. For example, the PAGE model assumes that a large proportion of the damages associated with climate change can be avoided by low‑cost adaptation options (Hope 2009). On the other hand, the WITCH model used by Agrawala et al. (2010a) drew on adaptation cost data from a range of sources, such as the UNFCCC (2007).

#### Uncertainty when modelling over long time periods

Due to the long time periods associated with climate change, modelling of adaptation is conducted generally at least to 2050 and often to 2100 and beyond. However, most models assume behavioural responses determined by:

… parameters and data that have been derived from recent history. These responses will not necessarily still hold far into the future, or for step changes that are outside of recent experience. (Garnaut 2008a, p. 14)

Past experience suggests that people will adapt, and behavioural assumptions in the model probably do not accurately describe the way people will deal with climate change into the future.

#### Uncertainty of climate change

The severity and timing of climate change is uncertain. There is uncertainty about the level of future greenhouse gas emissions, the sensitivity of the climate to greenhouse gas emissions, and how climate change will affect particular regions and activities (chapter 2). As a result, the ability to predict future climate change impacts over the next 100 years and beyond is limited.

To estimate the costs and benefits of adaptation, it is necessary to make a set of assumptions about the physical impacts of climate change, and how these will affect the economy. According to Weitzman (2009), most IAMs are based on a central forecast of damages, which is assumed to be certain, and limited sensitivity analysis is undertaken.

Some researchers have attempted to take a more sophisticated approach that incorporates uncertainty. For example, key climate variables used in the PAGE model (Hope 2009) are expressed as probability distributions. Similarly, as noted earlier, AECOM (2009) used Monte‑Carlo analysis for uncertain variables.

However, there are limitations to these approaches to dealing with uncertainty. These approaches do not take account of risk aversion. In addition, such modelling does not deal well with the risk of catastrophic climate change. According to Jotzo (2010), the low probability of catastrophic climate change could be the main driving factor relevant to economic decision making regarding mitigation. Similar arguments apply to adaptation — the risk of catastrophic climate change could drive very different adaptation responses than those considered in existing models.

Ultimately, where there is uncertainty, modelling results need to be reported in ranges. While the ranges can highlight the implications of the uncertainty, the presence of uncertainty limits the conclusions that can be drawn from these results (both the ranges and the point estimates).

#### Valuing non‑market outputs

Not all of the impacts of climate change can be easily captured in economic terms. These non‑market outputs include environmental goods such as biodiversity and ecosystem ‘services’, and human health.

Non‑market impacts are of particular importance in the context of climate change adaptation. Many adaptation options are likely to have both market and non‑market impacts — for example, the installation of an air conditioner has a market cost (the price of the air conditioner) but non‑market benefits (increased comfort). In addition, in Australia, the impacts of climate change on ecosystems, such as the Great Barrier Reef, are of great significance.

However, standard economic modelling often excludes non‑market outputs. This includes most IAM models.

… RICE, as well as AD‑WITCH and many other [integrated assessment] models, only partially captures non‑market impacts, which are confined to the recreational value of leisure. Important climate related impacts on biodiversity and ecosystem losses or on cultural heritage are not part of the damage assessment. (Carroro, Bosello and de Cian 2009, p. 21)

Some studies attempt to incorporate ecosystem impacts into IAMs, but these approaches are often limited. For example, the FUND model bases the value of ecosystems on the ‘warm glow’ effect, whereby the value people place on ecosystems is largely dependent on their income, and is largely independent of any real change on ecosystems.

These issues are also relevant to cost–benefit studies. For example, the Narrabeen Lagoon study (AECOM 2009) was unable to take account of a range of costs and benefits, including the impacts on the recreational use of the lagoon, ecological impacts and the visual amenity impacts of levees.

#### Treatment of climate change impacts

Most IAMs adopt a simplistic approach to estimating the costs associated with climate change. In these models, an increase in temperature affects output in each sector through a damage function. Such an approach may fail to fully capture the complex impacts of climate change — indeed, parts of some sectors may be positively affected by climate change.

Through the use of ‘shocks’, CGE models may be better suited to considering more detailed climate change impacts. However, where these are used, they tend to consider only a subset of climate change impacts. For example, the Garnaut Review (Garnaut 2008b) modelled climate change impacts on five sectors. However, impacts such as an increase in defence and aid expenditure, and damage to residential buildings due to extreme events, were not modelled.

1. This Program was previously known as the Australian Centre for Climate Change Adaptation. [↑](#footnote-ref-1)
2. A cost–benefit ratio of less than 1 indicates that the benefits of the option exceed the costs. [↑](#footnote-ref-2)