

ADAPTATION AND MITIGATION MEASURES FOR AUSTRALIA

15

Key points

Every Australian will have to adapt to climate change within a few decades. Households and businesses will take the primary responsibility for the maintenance of their livelihoods and the things that they value.

Information about climate change and its likely impacts is the first requirement of good adaptation and mitigation policies. This requires strengthening of the climate-related research effort in Australia. The Australian Climate Change Science Program should be provided with the financial resources to succeed as a world-class contributor to the global climate science effort from the southern hemisphere.

A new Australian climate change policy research institute should be established to raise the quality of policy-related research.

Flexible markets using the best available information are the second essential component for successful adaptation and mitigation policies. It will be important to strengthen markets for insurance, water and food.

Government regulatory intervention and provision of services will be required in relation to emergency management services and preservation of ecosystems and biodiversity.

Mitigation will come too late to avoid substantial damage from climate change. Uncertainties in the science mean that we do not know with certainty the extent of damage from successful 550 ppm CO₂-e, or even 450 ppm CO₂-e strategies. Weak mitigation will result much worse outcomes and much greater uncertainty about how bad it could get.

It is likely that Australians and Australian institutions will be adapting to climate change within a few decades. Before that time, Australians will be dealing with the price effects of an emissions trading scheme.

The experience of climate change will vary between households, and across communities, businesses, sectors and regions. Geographic location, degree of exposure and the capacity of those affected to reduce their vulnerability will all influence the Australian experience. The appropriate adaptation response will always depend on a range of local circumstances. Therefore, unlike the mitigation effort, adaptation is best seen as a local, bottom-up response. Households, communities and businesses are best placed to make the decisions that will preserve their livelihoods and help to maintain the things they value.

Some may expect that government can, and should, protect the community from climate change by implementing the right strategy, program or initiative to allow Australians to maintain established lifestyles. This is not a realistic expectation for four reasons. First, climate change will require adjustment of innumerable, locally specific customs and practices over time. Second, the range and scale of impacts that is likely across Australia is such that it is not feasible for governments to underwrite maintenance of established patterns of life for all people in all places. Third, the uncertainty surrounding climate change impacts makes it impossible to predict their timing, magnitude or location with precision.

Finally appropriate responses to climate change impacts will be specific to circumstances. In many instances, centralised government will lack the agility to orchestrate a differentiated response with the necessary precision to address local needs. The informational requirements of government would be extreme and costly. It is unlikely that an intrusive or directive approach to adaptation would be as effective as one motivated by local interests.

The Review favours strong reliance on local initiative in determining how Australia as a whole adapts to climate change. Government, in its roles as manager of public land, national water and infrastructure assets, regulator of markets and other activities, and manager of equity issues, can provide support for this approach by creating the necessary conditions for effective and efficient decision making by communities, households and businesses as they begin (and continue) to adapt to climate change.

Chapter 13 laid out an overarching framework that suggested that it was unhelpful to think about climate change policy in terms of the simple dichotomy of adaptation and mitigation. Typically, the policies required to support the community's adaptation effort have much in common with those required to support adjustment to the effects of a carbon price arising from mitigation policy—though the nature of the shocks being addressed are different (see Table 13.1).

Direct intervention by government in developing the national policy response should involve:

- deepening our understanding of climate change, its impacts and the options available to respond
- developing the capacity of the community to use this information and take advantage of available options
- dealing with events that unfold suddenly or require resources that are of a scale beyond a community's capacity to address.

This entails developing a climate change response, coordinated across all levels of government, that is focused on:

- producing and disseminating information and advice that is useful and useable by a wide range of interests
- utilising markets and market-based policies to create options for individuals and businesses to manage the uncertainties associated with climate change
- building capacity for dealing with events that can overwhelm individual communities or the natural environment.

15.1 Information and understanding

Information on the possible impacts of climate change is essential for determining the most appropriate means of adapting to climate change and the timing and scale of the response. But, as noted in section 12.4, hastening progress towards more ambitious global mitigation will also require a better understanding of climate change, its impacts and our progress in dealing with it.

There is, of course, inherent uncertainty in the basic climate science. The climate is an immensely complex system and long-term projections are inherently fallible. The current range of projections is too wide to be usefully applied by households, businesses and governments in preparing for climate change. For example, our current understanding of potential rainfall outcomes for Australia indicates a range that includes both an extreme dry outcome (10th percentile) and a wet outcome (90th percentile). There are similarly significant uncertainties in projections of sea-level rise.

Added to the uncertainty is the lack of certainty about when and how quickly the impacts will arrive.

An enormous domestic and international effort is required if we are to acquire the information needed for dealing with decision-making in the face of this uncertainty—as well as taking the necessary steps to reduce the cause of the uncertainty and the likelihood of extreme events (by hastening global agreement on more ambitious targets). Of course, a greater global mitigation effort alleviates, at least to some extent, the adaptation challenge that lies ahead.

Integrated assessments of economic and social effects will provide bioclimatic, social and economic analysis and information on the possible economy-wide, regional and sectoral impacts of climate change. New institutional arrangements are required to inform policy development as well as decision making by individuals, communities and business. This will involve public and private efforts in undertaking research and analysis.

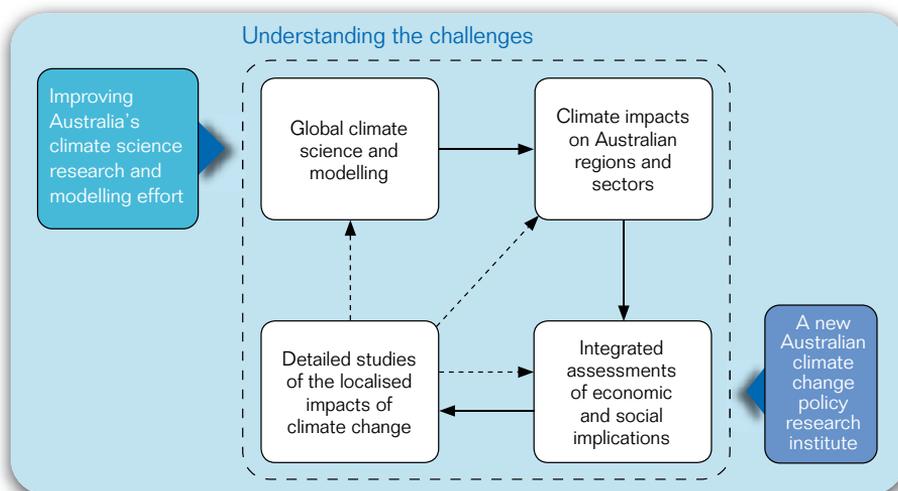
The mix of benefits, and the demonstrated willingness of groups to seek information without government involvement, will require government to be disciplined in ensuring that it only funds activities with public benefits without crowding out private funding or providers.

15.1.1 Institutional arrangements to support the creation and dissemination of information

As well as assisting the development of policy, the creation of scientific knowledge and its dissemination have the characteristics of a public good. A private provider of the information will not be able to capture all the benefits of that information once it is in the public domain. Such information is therefore likely to be underprovided without government involvement.

Confident decisions made with intellectual authority will require a strong base of knowledge across all areas of climate change science—from global science and modelling, to the localised impacts of climate change. Figure 15.1 summarises the various areas of research and demonstrates how they form a system of information creation. Information from earlier stages is built on in later stages, and information from later stages feeds back to inform earlier stages.

Figure 15.1 Areas for further support and investment in the climate change research system



Australia's climate science research and modelling effort

Understanding the earth as a complete system requires an understanding of the various dimensions of that system, including the terrestrial surfaces, oceans, biological systems, atmospheric chemistry, and carbon cycles. The ultimate aim is to model as much as possible of the whole of the earth's climate system, using robust models supported by sufficient computing power, to allow all the components to interact. The predictions of climate change can then take into account the effect of complex feedback between components (IPCC 2001: 48).

Australia has fallen behind in key areas of research such as global and regional climate modelling (DCC 2008). Recent studies have found the evidence and modelling base for climate change in Australia to be sparse (Rosenzweig et al. 2008), and many global climate models have a bias towards the northern hemisphere due to the influential capabilities of the European and North American research institutes.

While pluralism is always valuable in basic research, it is likely that, because of the sheer size and complexity of the task, Australia can only afford one strong coordinated effort in its contribution towards the international climate modelling work. Australia can maintain no more than one dedicated supercomputing capability cost-effectively. The relative size of Australia's population and economy makes the case for a single consolidated approach.

The most recent attempt to improve and consolidate Australia's climate modelling capability has been the establishment of the joint CSIRO – Bureau of Meteorology Centre for Australian Weather and Climate Research (see Box 15.1). This appears to be a step in the right direction.

Addressing the uncertainty and gaps in knowledge at the most fundamental levels of climate science and at the intermediate stages of analysis of climate impacts has large public good dimensions. There is strong justification for Australian governments expanding funding to these research areas on a long-term basis. This suggests that greater effort and funding be allocated as part of the renewal of the Australian Climate Change Science Program (which aims to improve our understanding of the causes, nature, timing and consequences of climate change).

To strengthen this effort, governments should ensure that there is adequate funding for world-class performance in high-priority areas, including through the ACCESS model (see Box 15.1) and investment in substantial supercomputing infrastructure. Such support should be focused on areas where Australia has both a national interest in answering particular research questions and the international comparative advantage in being able to do so. This should be considered as part of the renewal of the Australian Climate Change Science Program.

Some support should be targeted at increasing Australia's participation in international research and modelling efforts (such as the World Climate Research Program and the International Geosphere Biosphere Program) and review and assessment processes (like those undertaken by the Intergovernmental Panel on Climate Change). First, Australia needs to ensure that it is able to play its role as the leading country of science in the southern hemisphere in many of these areas. Second, the ongoing participation of the Australian scientific community in international processes is necessary to enable global progress in climate modelling to be interpreted and absorbed by Australia.

Box 15.1 The Centre for Australian Weather and Climate Research

The Centre for Australian Weather and Climate Research was established in recognition of problems in the historically fragmented approach to climate modelling in Australia, and the need for a unified national effort.

The centre is a new joint venture between CSIRO and the Bureau of Meteorology on climate change research. It will develop a next-generation unified modelling and assimilation capability for Australia known as the Australian Community Climate and Earth System Simulator (ACCESS).

The ACCESS model will incorporate some components of the model used by the UK Met Office Hadley Centre, with a focus on further developing the components that are of national interest to Australia and where Australian researchers have a comparative advantage. The ACCESS model will be developed in collaboration with Australian universities and the Cooperative Research Centre for Earth Sciences, and will supersede all existing Bureau of Meteorology and CSIRO models.

The Review sees it as a matter of importance that the Centre for Australian Weather and Climate Research be given the secure, long-term financial resources and the scientific independence it requires to succeed in its important task and to play its role as the southern hemisphere's anchor for the world's scientific effort on climate change. It is too early to tell whether recent developments will secure the objectives of the centre. An early review should examine progress.

A new Australian climate change policy research institute

Climate change policy is a wide-reaching issue requiring many disciplines and capabilities to come together to understand the full extent of the problem and to analyse and develop potential solutions.

There is no continuing independent centre of research on the range of policy issues the Review has examined. There is a gap in the national research capacity, covering the implications of climate change for various areas of government policy—beginning with targets and trajectories for Australian mitigation policies and extending through to a wide range of adaptation issues.

An Australian climate change policy research institute should be established to inform public discussion and to strengthen the intellectual context for policy development. The roles and responsibilities of the proposed institute should include, but not be limited to, six key areas:

- interacting with climate science and modelling institutions, including the Centre for Australian Weather and Climate Research
- working with the applied science and broader research community
- developing models and analytic frameworks to provide integrated analysis
- linking Australia to international thinking about climate change mitigation and adaptation policy
- enriching the policy debate
- pursuing linkages and joint appointments and training with other academic institutions.

The proposed research institute would need to have disciplinary strengths in the physical (climate) and biological sciences, in applied biological and engineering sciences, and in economics and the relevant social sciences.

It is envisaged that the institute would interact with various elements of the scientific and research communities and in the process expand their sensitivity to issues that are relevant to policy analysis.

As climate change policy will have significant economic, social and environmental consequences with long time frames, it is important that the proposed institute is independent. To maintain independence, the institute should have its own

governance structure. The type of governance and institutional arrangement would need to be explored further. An independent stand-alone institute would ensure that institutional capture is minimised, but a research consortium approach as adopted by the Tyndall Centre in the United Kingdom, would facilitate the inclusion and participation of Australia's geographically dispersed base of policy-oriented researchers.

15.1.2 Limits to the quantity and quality of information

While high-quality and high-resolution information on the projected impacts of climate change are critical inputs to adaptation decisions by households and businesses, there are inherent limits to the availability of such information.

First, there are likely to be elements of irreducible uncertainty in the basic climate science. Nevertheless, efforts must be made to reduce uncertainty, where possible, for adaptation and mitigation decisions. Some level of uncertainty in the climate science, and gaps in the relevant knowledge base, will persist. One of the most significant adaptation challenges for the Australian community is to respond to the immense potential impacts of climate change on the basis of imperfect information.

Second, while it is desirable that the information available on the impacts of climate change be at a high level of detail, cost considerations will mean that the resolution of studies will vary between regions.

Third, scarcity of relevant scientific resources will mean that there is competition for them. Groups faced with the greatest potential exposure and loss will be prepared to invest most in research into impacts. It is important that those who lack the resources—or the capacity to cooperate with others with similar interests to pool funds—are engaged.

Fourth, the creation of information does not guarantee its optimal uptake. Information must be prepared and released in a form that is usable by its intended beneficiary (see Box 15.2).

Box 15.2 Improving the communication of information

Correcting gaps in the public knowledge base rests not just on the research effort, but also on the interpretation and presentation of scientific projections in a meaningful and relevant form that can be factored into local risk management and decision making.

Even when soundly researched information is widely communicated, it may be of limited utility if users have problems comprehending it or using it in making their decisions. The behavioural economics literature acknowledges that people making decisions, whether in households or businesses, deal poorly with probabilistic information.

15.2 The role of markets and market-based policies

The objective of adaptation policy is to facilitate the ability of households, communities and businesses to respond effectively to the impacts of climate change. Markets provide the most immediate and well-established avenue for addressing many of the uncertainties posed by climate change. Fortunately, flexible markets also provide the most efficient mechanism for dissipating the price impacts of an emissions trading scheme.

Australia's prime asset in responding to the adaptation and mitigation challenges that lie ahead is the prosperous, open and flexible market-oriented economy that has emerged from reform over the last quarter century. Government can facilitate adaptation by continuing to promote broad and flexible markets, and seeking to correct remaining barriers to efficient exchange.

Markets are well placed to transfer risk to those best placed to deal with it and disperse concentrated risks across a wide base of industries, communities, regions and countries. This is achieved through insurance and financial markets, and through dispersed but interconnected domestic and international product markets. The smooth flow of goods and services, and factors of production, increases the ability of the Australian economy to respond at least cost to abrupt shocks and anticipated changes over the longer term.

Broad and flexible markets allow scarce resources to move to where their economic value is highest, at a time when new information is continually changing our understanding of value. When resources are 'stuck' in an area of declining productivity, the growth of the economy is hampered by the exacerbation of scarcity. For example, as agricultural yields decline in some regions due to increases in temperature or declining precipitation, capital, labour and remaining water resources will produce better outcomes for their owners, for regional communities and for the national economy if they are able to move to other more productive crops, industries or regions.

The benefits of flexible markets are evident even in the absence of climate change. However, the requirements of adaptation to climate change, and adjustment to mitigation policies, increase the importance of efficient markets.

Some particular domestic and international markets will be especially important to Australia's adaptation response, and potentially to our capacity to smoothly adjust to the effects of a carbon price. These markets may require increased policy attention. Included in this category are markets for insurance, water and food.

15.2.1 Insurance markets

Households and businesses are able to manage many risks effectively through the insurance and financial markets. As the frequency and intensity of severe weather events increase with climate change, demand will rise for related insurance and financial services.

In the context of climate change adaptation, there are two types of benefits of insurance and related financial instruments.

First, the insurance industry, and financial markets more broadly, provide financial instruments that enable the market to moderate exceptionally bad outcomes for particular groups of people. They do this through sharing risk across a broad base of parties facing different degrees of risk from varying sources. They also transfer risk between those who are more risk averse and those more willing and able to accept risks. The financial markets' capacity to reallocate costs and risks globally to those most willing and able to bear them will help reduce the costs of adaptation for the wider society (IMF 2008).

Second, adjustments to insurance premiums for risk-reducing behaviour will provide incentives for households and businesses to adopt risk-reduction measures (IMF 2008). Of course, insurance and other financial products do not remove risk altogether. They are least suitable for reducing large and highly correlated risks, such as large climate change outcomes with global effects.

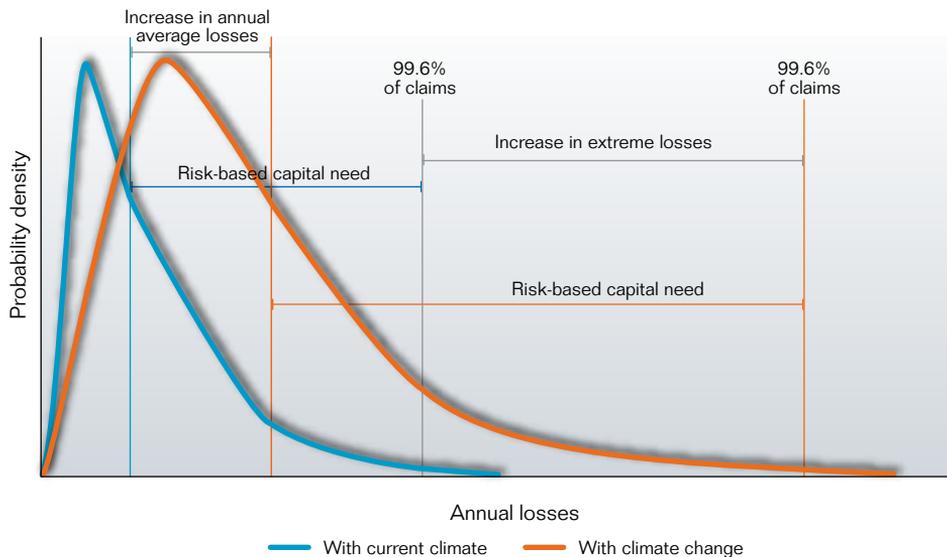
Climate change poses new challenges for insurance markets by widening the probability distribution of possible losses and increasing the severity of damages and payouts.

Primary insurers are able to provide coverage for risks that are not strongly correlated and where the exposure is limited relative to the total size of any one insurer. Traditional indemnity-based insurance has been able to deal with climate variability and weather risks for centuries (OECD 2008). However, the insurance industry will have to deal with an increase in the more 'exceptional' risks. These involve the possibility of extremely large losses, with the risks being highly correlated across many households, businesses or even regions.

If insurance claims greatly increase as a result of severe weather events, there is a possibility that such risks may overwhelm the financial sector's capacity to provide insurance coverage (Association of British Insurers 2005). The challenge for the industry will be to develop new ways to spread risks so that it can offer coverage to more people exposed to a wider range of more costly outcomes. As the probability distribution of impacts widens, more risk capital is needed to bridge the gap between expected and extreme losses (Association of British Insurers 2005). Figure 15.2 depicts the higher capital needs that result from climate change impacts.

The global market for reinsurance has supported primary insurers by providing a range of financial instruments to transfer catastrophic, low-probability, highly correlated risks between parties with different preferences or appetites for risks at a global scale. Over the past decade, the market for global catastrophe reinsurance has grown strongly in volume and in the variety of its financial structures, while its geographic coverage has expanded to a more limited degree (IMF 2008).

Figure 15.2 Impact of climate change on probability loss distribution and implications for risk capital requirements



Source: Association of British Insurers (2005).

The recent innovation and deepening in these markets shows their considerable potential to promote adaptation to climate change (IMF 2008). By its nature, however, conventional insurance is of limited value when an adverse event (for example, damage from increases in sea level) is likely to have similar impacts over wide areas of the world. Nor is conventional property insurance of much help when the uncertainty mainly involves the timing rather than the extent of an impact. An example is sea-level rise if it were to become clear that the melting of the Greenland ice sheet had become irreversible. In this case, there might be scope for developing new property insurance products that share characteristics with traditional life insurance: life insurance covers the risk of timing of death, although the fact of eventual death is itself certain. The development of innovative products along these lines would occur within the commercial insurance sector.

Government can promote a deep and flexible insurance sector by:

- **Improving the provision of basic climate science information**—With improved information, insurance markets can be expected to deepen in response to need.¹ The insurance industry is equipped to analyse and respond to new risks that flow from climate change, including in risk assessment capacity, diversification of risks, and pricing.
- **Promoting insurability through appropriate approaches to policy**—Moderate levels of climate change should not raise any significant challenges for the industry, but there will always be some residual risks that are highly correlated and sometimes uninsurable. In the case of more severe climate change, such risks will increase, as will the expectation that government will play the role of insurer of last resort. Appropriate approaches to regulation, particularly in land-

use planning and zoning decisions, will improve insurability (Insurance Council of Australia 2008), and minimise pressures for the expansion of this role for government.

- **Minimising regulation**—In the light of the required rapid expansion of the industry, government will need to avoid discouraging rapid growth and innovation in the sector while maintaining standards.^{2,3} As the Henry Review has noted, insurance products are subject to a range of insurance transaction taxes and direct contributions to the funding of fire services, which leads to inefficient outcomes. The interaction of these taxes and levies increases the cost of premiums, which may reduce insurance uptake (Australian Treasury 2008; IPART 2008). Such regulations may ultimately inhibit the necessary expansion of the industry and the emergence of new products. The revenue benefits of such taxes need to be evaluated against their inefficiencies and economic costs, particularly given the role of insurance in encouraging firms and households to adapt to climate impacts. The Henry Review is well placed to undertake such analysis.

15.2.2 The role of water markets

The challenges for rural and urban water supply are partly a consequence of emerging climate change, partly of increased demand with population and economic activity, and partly of uneconomic pricing leading to unsustainable consumption patterns. The pressures associated with climate change can be expected to intensify, increasing the importance of removing unnecessary market distortions.

Australia's rural water market is the result of many years of reform, but some barriers to efficient operation remain. While extraction of in-stream flows has been priced, access to groundwater and surface flow is less regulated, which has led to perverse incentives.

While water trading and the use of price signals have been in place in some parts of the rural sector for over 20 years, in others water remains free. Where water trading has been introduced, the initial allocation of property rights in water has locked in, and even exacerbated, the overallocation that prevailed under previous systems of licensing.

Artificial jurisdictional boundaries have resulted in restrictions on trading between rural consumers, and have largely prohibited trading between the rural and urban water sectors. While this has been done to manage the pace of the transition that a region exporting water undergoes, it has resulted in a distorted price signal in some areas, and no price signal in others. This effect has also occurred in the urban sector and been compounded by the absence of a competitive water market.

Climate change provides an added impetus to accelerate and raise ambitions for water market reform. Water markets that are transparent, broad and flexible, and based on clearly defined property rights, are better able to manage shocks.

By 2100 under a best-estimate no-mitigation scenario, the impact of climate change on urban water supply infrastructure is expected to be moderate to

extreme, depending on location. Under the hot, dry extreme scenario, the impact is expected to be extreme in all capital cities. An effective market could minimise ad hoc infrastructure investment decisions, promote optimal timing of large infrastructure investments, and assist in bringing a broader range of supply options to the market.

One major benefit of water reform is securing environmental flows. This involves recognising the need for waterways to have sufficient flows to maintain the ecosystem services they provide, by supporting freshwater flora and fauna, or improving water quality. Traditionally the environment was not considered a 'productive' use of water, but contemporary thinking recognises its significant benefits for the wider community.

The establishment of a well-functioning water market that delivers the best possible outcomes in the context of climate change will require the active involvement of government. Government is required to establish the most effective administrative and regulatory arrangements for the functioning of the market. Once the water market has matured, the role of government moves to one of adequate monitoring and enforcement.

The Review endorses a set of common principles, developed from a set proposed by PricewaterhouseCoopers (2006), that would go a long way to deliver effective management of Australia's water resources and assist in the adjustment to a new climate future if supported in practice, namely:

- Water rights need to be clearly defined, with exclusive ownership, and be separable from other resources, such as land.
- The total quantity of water rights allocated in each catchment and over time needs to be flexible enough to accommodate new scientific information on climate change and sustainable water use.
- Security levels for water rights need to be defined in a way that is consistent with the variability and uncertainty of aggregate supplies.
- Clearly defined rules are needed to set the boundaries of the market and acceptable behaviour by market participants, and reduce transaction costs by providing greater certainty.
- Reliable and timely information is needed to allow buyers and sellers to make informed decisions.
- Clear administrative processes are necessary for effective trade and to support the enforcement of the trade.
- Arrangements must secure low transaction costs compared to the value of the trade, with costs known in advance.
- The market should have few limitations on who can participate.

In addition to these principles, the Review considers that providers of new sources of water should not be prevented or discouraged through regulatory and other barriers (provided they meet health and safety standards). Market

participants should be able to introduce new, including manufactured, sources of water to each market and to transfer water between markets, when they consider it commercially viable to do so.

With a well-designed and comprehensive water market in place, price signals will reflect the scarcity value of water across rural and urban Australia. It can reasonably be expected that households, businesses and other consumers will modify their water use accordingly.

15.2.3 Food markets

The global agricultural sector will be adversely affected by climate change in the absence of effective mitigation. It is likely that the levels and volatility of prices on world markets will increase. The recent global food price crisis provides an indication of how things could develop (ACIAR 2008). In future, it is likely that international food markets will face multiple supply shocks with resulting impacts not unlike those recently witnessed.

If Australia becomes increasingly dependent on food imports, as projected under a best-estimate no-mitigation case, rising global food prices and price volatility could become increasingly important issues for consumers.

Global food markets that are functioning efficiently can absorb shocks. However, existing food markets are characterised by arbitrary and variable interventions by governments of both developing and northern hemisphere developed countries. The responses of governments around the world to recent price shocks have exacerbated price increases and instability.

Traditionally, trade tariffs, subsidies and quarantine restrictions have been the primary obstacles to efficiently functioning food markets. With food prices soaring and in the face of mounting political pressure, recent policy changes by major food-exporting countries have increased barriers to trade. The most notable of these have been increased export restrictions (or similar restrictions) and domestic price controls (von Braun 2008b).

- **Export restrictions**—Worldwide production of cereals has not kept pace with demand. Droughts, bad weather and general rises in the domestic price of food in the key food-exporting regions of Asia have led many countries to restrict exports to protect domestic supplies. This has in turn increased international food prices sharply (von Braun 2008a, 2008b).
- **Domestic price controls**—In many other countries, governments have sought to soften the impact of price rises on domestic markets by resorting to price controls and government subsidies to curb inflation and manage the political backlash. However, holding down prices through regulations or subsidies reduces the incentive for producers to increase supply, thereby exacerbating shortages and pushing global prices even higher. Price controls may yield short-run political benefits, in countries imposing them, but not in the rest of the world. In the longer term, these benefits are likely to be outweighed by the damaging effects on economic efficiency (World Bank 2008).

It is in Australia's long-term interest to pursue the liberalisation of international food markets by removing the distortionary policies of the world's future food importers and suppliers. Australia would benefit from broader and more open and reliable global food markets as an exporter. It would benefit as a neighbour of developing countries that are from time to time reliant on supplies from international markets. And it would benefit in food security if, as it may, climate change makes Australia a large importer of food.

It is also in our long-term interest to ensure that barriers to import such as unnecessarily restrictive quarantine measures do not unnecessarily prevent goods from overseas entering our domestic markets. The banana market in the aftermath of Cyclone Larry in North Queensland in March 2006 illustrates how restrictions on trade can lead to extreme price fluctuations in response to supply checks. Banana prices rose by up to 500 per cent in the wake of the cyclone (Watkins et al. 2006). Australia needs to be sure that the restrictions are justified—especially in circumstances in which supply shocks are likely to be more important.

15.2.4 Beyond markets

Some services that are of high value to Australians do not lend themselves to provision through a market (see the discussion of Type 4 costs of climate change in Chapter 1). The foremost example is the conservation of ecosystems and biodiversity. The irreversibility of ecosystem collapse and species extinction warrants regulatory intervention.

In addition to the priority areas for domestic policy outlined above, government will have a role to play in two other policy areas relevant to both adaptation and mitigation.

- There are second-order market failures common to adaptation and mitigation that will not be corrected through the provision of climate information and the development of broad, open and flexible markets. These market failures—in information; research, development and innovation; and network infrastructure—can be dealt with through specific measures that aim to lower the costs of adaptation. They are discussed in chapters 17, 18 and 19.
- Government also has a broader role to play in the areas of income distribution and related questions of structural adjustment to avoid regressive and inequitable outcomes that may arise from climate change adaptation. These issues are discussed in Chapter 16.

15.3 Scaling the challenges: five examples

Chapter 6 identifies four areas—irrigated agriculture in the Murray-Darling Basin; urban water supply infrastructure; buildings in coastal settlements; and ecosystems and biodiversity—for which the impacts of climate change are anticipated to be large. Reference to these four sectors illustrates the diversity of considerations and issues inherent in the adaptation policy challenge. A fifth area of emergency management is also examined.

15.3.1 Irrigated agriculture in the Murray-Darling Basin

Declining runoff in southern Australia is a significant threat to the continuation of irrigated agriculture in the Murray-Darling Basin. Extensive development of water storage and distribution systems during the 20th century has encouraged excessive extraction of water from the environment. This has resulted in significant adverse impacts on streamflows and groundwater supplies. Existing strategies for managing water supplies were developed in the second half of the 20th century, during a period of higher rainfall, and are not suited to a progressively drying climate (CSIRO 2008).

Historically, and for a variety of reasons, the price of irrigation water does not often reflect its true economic value. Not surprisingly, when viewed independently of these historical considerations, we observe the inefficient allocation of this resource.

The effect of declines in water supplies for irrigated agriculture could be reduced by improving the efficiency of the existing infrastructure for water delivery. Currently, between 10 and 30 per cent of the water diverted from rivers into irrigation systems is lost before it reaches the farm gate, and up to 20 per cent of the delivered water may be lost in on-farm distribution channels (CSIRO 2008). It is unlikely that this situation would be perpetuated if the scarcity of the water was accurately reflected in its price. The combination of current water market reforms and the ongoing drought conditions experienced in much of the Murray-Darling Basin has prompted large-scale infrastructure commitments by state and federal governments.

Agriculture in Australia has developed around its capacity to adapt to natural climate variability. However, the scale and accelerated impacts of human-induced climate change with limited mitigation are likely to breach the capacity of the sector to continue operations at even a tiny proportion of its current scale. By 2100 under a best-estimate no-mitigation case, the economic production of irrigated agriculture in the Murray-Darling Basin is projected to fall by 92 per cent; under the hot, dry extreme case, production falls by 97 per cent. Under such outcomes, the variety and volume of irrigated agricultural crops will diminish. Significant structural change of the sector would be necessary from 2050 when impacts from reduced precipitation are projected to start to become critical (Quiggin et al. 2008). The only viable adaptation response might be to abandon established patterns of agriculture.

Even with effective mitigation aimed at stabilisation of CO₂-e concentrations at 550 ppm, and possibly 450 ppm, major adaptive changes are likely to be required. Commercial-scale and technologically sophisticated farming operations, with the ability to increase water efficiency and compete in water markets, may replace smaller operators that fail to invest in efficiency improvements.

15.3.2 Urban water supply infrastructure

Australia's urban water supply infrastructure is old, inadequate for current population levels, and not designed to cope with changing climate conditions (Marsden Jacob Associates 2006; Productivity Commission 2008).

By 2100 the Garnaut–Treasury reference case points towards an Australian population of 47 million people. Population growth alone is likely to place significant additional stress on urban water supply infrastructure. With projected increased temperature and evaporation and reduced rainfall, under the best-estimate no-mitigation case, climate change adds greatly to the stress on urban water supply infrastructure later in the century.

For Australia's coastal cities, which include the major population centres, an array of water supply and demand management options are available to allow diversification of supply in response to climate change (Marsden Jacob Associates 2006). The expansion and opening of water markets would allow the emergence of the lowest-cost supply options and the optimal balance between reduction of use and expansion of supply.

In addition to improved use of existing water sources, it is likely that new forms of supply that are not climate dependent will be required. New water sources can initially be expected to have higher capital and operating costs. These should fall over time because of 'learning by doing' and economies of scale, although it is likely that the cost of water will be permanently higher than it is today (J. Quiggin 2008, pers. comm.).

For Australia's major inland cities and towns, recycled water and purchase of irrigation entitlements may be among the few alternative water supplies available (Marsden Jacob Associates 2006).

A drying climate would be likely to also result in increased ground movement, which would damage water distribution infrastructure such as mains pipes. In the next two to three decades, operational and maintenance costs for existing water supply infrastructure will probably increase (Maunsell 2008).

By mid-century a degree of adaptation to the new climate will be under way. Technological development and engineering standards will have been modified to reflect the changing climate, and ageing assets replaced. However, as the century continues, the significant increase in severe weather events anticipated under a best-estimate no-mitigation case would lead to further increases in operational expenditure.

15.3.3 Buildings in coastal settlements

As the climate changes in the absence of strong effective global mitigation, Australia's coastal communities and associated infrastructure would be subject to increasingly frequent and severe weather events, as well as impacts from sea-level rise, storm surges and associated coastal flooding. The broad preference of

Australians for living on the coast makes the ability of the coastal built environment to withstand climate change impacts a determining factor in the distribution of future human settlements.

Domestic and public infrastructure tends to be long-lived—for example, residential buildings typically have a design life of about 40 years (Maunsell 2008), although average actual lives are longer. Infrastructure planning for new and existing settlements should consider the potential climate change impacts on the entire life cycle of the proposed infrastructure. This can reduce future maintenance requirements, the need for premature replacement or abandonment, and the need for relocation of entire settlements in the case of increasingly severe weather events.

Steps can be taken to decrease the vulnerability of new buildings to climate change. These generally fall into three categories: changes in design, changes in materials, and changes in location (BRANZ Ltd 2007; CSIRO et al. 2006; Engineers Australia 2008).

For existing settlements, changes in both building design and materials can provide effective options for adaptation at reduced cost if retrofitting aligns with asset renewal. For new settlements, the foremost consideration is to avoid placing infrastructure in highly exposed positions.

By 2100 under a best-estimate no-mitigation case, measures for coastal protection may not be adequate to withstand the damaging impacts of climate change on buildings. The relocation of industries, activities and households away from certain coastal areas may be the only available adaptation response.

15.3.4 Ecosystems and biodiversity

Climate change is a significant and additional stressor on ecosystems and biodiversity in Australia. It will affect ecosystems and biodiversity by shifting, reducing and eliminating natural habitats. In Australia, many species of flora and fauna are at risk from rapid climate change because of their restricted geographic and climatic range. Where ecosystems and species have low tolerance for change, altered climatic conditions can trigger irreversible outcomes such as species extinction.

Climate change impacts will reduce the availability of various ecosystem services.⁴ Opportunities for medical advances from natural sciences research may be lost. Natural resource-based industries such as snow season tourism and tourism in the Great Barrier Reef, wet tropics and Kakadu regions will be adversely affected.

Given that net losses are currently occurring with only the initial effects of climate change, significant resources will be required to minimise future loss (Australian State of the Environment Committee 2001; Beeton et al. 2006).

Natural resource management networks and programs have been established in Australia to conserve our natural environments. With climate change, additional

efforts will be required to build the resilience of the Australian environment. This can be achieved by reducing existing non-climatic stressors such as land-use change, overallocation of water, and pollution (Howden et al. 2003). Similarly, expanding the existing system of land reservation and exploring new methods for engaging private landholders will facilitate species migration, encourage conservation and promote resilience.⁵

It is important to avoid perverse outcomes for ecosystems in the implementation of policy in related areas, such as agriculture, forestry, fisheries and fire management. For example, water markets must ensure that environmental needs are adequately met in water allocations. The incentives for plantation forestry introduced by an emissions trading scheme must sit alongside adequate valuation of native vegetation.

Maintaining viable, connected and genetically diverse populations increases their likelihood of survival (IPCC 2007; WWF–Australia 2008). Conserving Australia’s ecosystems will also assist in greenhouse gas mitigation due to their large cumulative sequestration capacity (see Chapter 22).

Now and in the future, natural resource managers will need to consider geographical shifts in habitats, the resulting new species assemblages, and the effect of these developments on, for example, the location and management of conservation reserves. Future natural resource management practice will need flexibility to allow managers to respond quickly to a dynamic environment and new information.

An enhanced research effort is required to improve knowledge of ecosystem function under differing levels of climate change. Functionally critical species and habitats need to be identified and appropriate actions taken to manage them. Much less is known about marine than terrestrial ecosystems. This information divide will need to be addressed (Beeton et al. 2006). Systematic effort is required to improve statistical information on environmental qualities including water quality, populations, endangered species and land degradation.

The development of environmental markets, through which incentives are provided for private landholders to assist in conserving and restoring ecosystems, has potential to assist in the adaptation and mitigation effort. These mechanisms can be designed to reveal the necessary price incentive for private landholders to change land-use practice. Pilots such as the BushTender project in Victoria (see Box 15.3) have been successful across a variety of ecosystems (DSE 2008); however, the deployment of market-based mechanisms is relatively new and is yet to be applied on a broad scale.

Box 15.3 Victoria's BushTender project

The Victorian Department of Sustainability and Environment has conducted a trial of an auction-based environmental market—the BushTender project—since 2001. Through the project, landholders bid for contracts to conduct conservation activities on their land. The land in each tender is assessed for its conservation value and landholders nominate their costs, which presumably include opportunity costs from reduced productivity. Bids are then assessed based on (1) estimated change in the on- and off-site environmental outcomes; (2) the value of the assets affected by these changes; and (3) the cost (determined by the landholder's bid). Successful bidders enter into contracts with government under which they receive periodic payments for conservation. The project is part of a range of experimental markets which include BushBroker (for native vegetation land clearance credits), CarbonTender (for carbon offsets) and EcoTender (combining multiple environmental objectives).

15.3.5 Emergency management services

Australia's emergency management systems and services have been operating for many years and are relatively robust and well developed (Department of Transport and Regional Services 2004). The provision of these services is largely within the jurisdictional responsibility of state and territory governments but is heavily supplemented by the work of volunteers, most notably those in the rural fire services and state emergency services.

With the mainstream science projecting increases in the intensity and frequency of severe weather events across Australia in the absence of mitigation, and to a lesser extent with mitigation, there will be increased demands on emergency services. Understanding the implications of climate change at a local level will be centrally important in the future planning of these services.

In some instances, at least for the time being, investing in emergency services will be the most cost-effective response for dealing with the uncertainties of climate change. One example is rising sea levels, the effect of which will become manifest gradually over many decades. Storm surges accompanying deep low pressure systems may become more frequent long before it is possible to justify investment in sea walls or the abandonment of low-lying coastal property. They may overwhelm the capacity of affected communities to respond.

Notes

- 1 Before Hurricane Hugo in 1989, the insurance industry in the United States had not experienced any losses from a single disaster of over US\$1 billion, whereas today such disasters are relatively common, predictable and manageable. Most insurance experts now agree that it is the potential US\$100 billion-plus catastrophic event which is now a challenge for the industry (King 2005).
- 2 Increases in average and extreme losses will tend to increase the amount of risk capital needed to satisfy the requirements of the regulator.
- 3 Insurance remains the only industry within the Australian financial services sector operating under both state and federal supervision.
- 4 Ecosystem services transform natural assets (soil, plants and animals, air and water) into benefits that people value for financial, ecological or cultural reasons (Binning et al. 2001). Ecosystem services with direct use values are quantifiable. Other values are difficult to calculate and highly subjective. Attempts to quantify some ecosystem service values include (1) an estimated \$2 billion per annum contribution of the Great Barrier Reef to the Australian economy through tourism (Hoegh-Guldberg & Hoegh-Guldberg 2003), and (2) an estimated \$1.2 billion per annum derived in benefit to the Australian agricultural sector from natural crop pollination (PMSEIC 2002).
- 5 Government regulation or acquisition may be justified where land is of significant conservation value, or where certainty of outcome is required. Currently, around 10 per cent of Australia's land mass is under some form of government conservation through the National Reserve System (DEWHA 2004). This compares with 64 per cent under private ownership (ABS 2008). National statistics are not available, but estimates suggest that the Indigenous estate accounts for approximately 20 per cent of the Australian land mass (Altman et al. 2007). Approximately 10 per cent of the Indigenous estate, or 2 per cent of Australia's land mass, is within the boundaries of the National Reserve System (DEWHA 2004).

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