Barriers to Effective Climate Change Adaptation

A Submission to the Productivity Commission by the Department of Sustainability, Environment, Water, Population and Communities.

Contents

Introduction

The Department of Sustainability, Environment, Water, Population and Communities (the Department) is responsible for implementing the Australian Government's policies to protect our environment, water and heritage, and to promote a sustainable way of life.[1] Climate change poses a growing challenge for governments as we work to conserve and safeguard Australia's biodiversity and support the wellbeing of our communities.

The Department welcomes the Productivity Commission's inquiry into barriers to effective climate change adaptation. It is an opportunity to raise understanding of the likely impacts of climate change and to consider the implications for our environmental assets, our industries and economy, our cultural identity, health and wellbeing. The inquiry also provides for consideration of the effectiveness of available mechanisms for supporting the resilience and adaptive capacity of the natural environment, and our society's ability to respond to changes in environmental resources and ecosystem services.

Climate change impacts on Australia's environment

In 2001, the loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases was recognised as key threatening processes under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. More recently, the Australian Government's 2010 position paper *Adapting to Climate Change in Australia* has identified "natural systems of national significance" as one of six priorities for adaptation action[2]. The 2011 *State of the Environment* report[3] notes that, despite efforts to manage threats and pressures to biodiversity in Australia, our natural ecosystems are still in decline, and identifies climate change as a key driver. Australia has suffered the largest documented decline in biodiversity of any continent over the past 200 years. Biodiversity decline includes the loss and simplification of ecosystems, decline in the number and range of species in a particular region and loss of genetic diversity within populations of plants, animals and other organisms.

Biodiversity decline is caused by a range of threatening processes. Major historical and current threats to the biodiversity of our land and inland waters are habitat loss (largely a result of land clearing for agricultural use and urban settlement) and weeds and feral animals. These threats are intensified by added stressors, which may include changed fire regimes, unsustainable resource use, pollution and nutrient run-off. Threats and stressors can act synergistically, compounding effects and causing faster rates of decline than if they acted alone.

Climate change will affect biodiversity directly (such as through changing temperatures, sea level rise, variations in rainfall and changes in the frequency and intensity of extreme weather events) and indirectly (such as through changing fire regimes and an expansion of the range of favourable habitats for introduced species). Compared with natural climate variation over geological time scales, human-induced climate change presents a potent risk to the environment. There is less potential for natural systems to successfully adapt because climate change is taking place rapidly (for example, the linear warming trend of the past 50 years was nearly double that of the past 100 years)[4] and the health and resilience of natural systems may already be compromised due to existing human-induced stressors.

The Intergovernmental Panel on Climate Change (IPCC) has identified natural ecosystems as the sector most vulnerable to climate change in our region.[5] The IPCC predicts that climate change will result in a significant loss of biodiversity within the next decade in some ecologically rich sites – including the Great Barrier Reef and Wet Tropics of Queensland. Other sites at risk include the Kakadu wetlands, south-western Australia, the sub-Antarctic islands and alpine areas. Impacts of climate change on Antarctic and Southern Ocean ecosystems include changes to marine food chains through a decrease in sea ice extent, reduction in salinity of coastal waters and ocean acidification. Penguin populations in some areas of Antarctica are decreasing rapidly.[6] Increasing acidity in the Southern Ocean threatens animals and plants[7] that use calcium carbonate for shells or other structures, and shell weights of some creatures have already dropped.[8] If the trend towards increasing ocean acidity continues, larval development of krill will be disrupted.[9] Krill are the largest source of animal protein in the Southern Ocean. If krill populations are undermined, this will have implications for the food chain, not only for whales, penguins and seals, but also for humans.

Socio-economic consequences of changes to natural systems

Natural capital and ecosystem services

Our natural environment provides many ecosystem services essential to human existence and our enjoyment of life. The 2005 UN *Millennium Ecosystem Assessment* framework[10] identified ecosystem services in four categories:

- provisioning services, such as food and water;
- regulating services such as pollination and the control of floods and diseases;
- supporting services such as nutrient cycling and climate regulation; and
- cultural services, such as spiritual, recreational, and cultural benefits.

These ecosystem services can be considered part of the overall stock of resources that contribute to the wellbeing of each individual in society.[11] However, the unique characteristics of 'natural capital' assets should be recognised:

> "*Like reproducible capital assets (roads, buildings, and machinery), ecosystems depreciate if they are misused or are overused. But they differ from reproducible capital assets in three ways: (1) depreciation of natural capital is frequently irreversible (or at best the systems take a long time to recover), (2) except in a very limited sense, it isn't possible to replace a depleted or degraded ecosystem by a new one, and (3) ecosystems can collapse abruptly, without much prior warning*".[12]

Any changes to natural environments may diminish their ability to provide ecosystem services that support our well being. Ecosystems can appear to be functioning well but suddenly collapse because the supporting base has eroded without noticeable warning signs.[13] In some cases, the impact of climate change could be the final stressor that results in a collapse of already vulnerable ecosystems.

Environmental degradation and biodiversity decline threaten to diminish Australians' culture and lifestyle. Our unique environment helps define what it means to be Australian. Our biodiversity and superb natural areas inspire us and enrich us culturally, spiritually and artistically. In the face of

increasing urbanisation, we are placing higher store on the value of natural places to relax and recharge the spirit and for recreation and exercise.

Although the full range of impacts is difficult to quantify, the declining quality of our natural systems under climate change will undoubtedly reduce the liveability of our communities.

Urban Communities

In urban areas, climate change impacts include higher temperatures due to heat island effects, greater climatic variability resulting in threats to water supplies and increased vulnerability to extreme flooding events. Prolonged droughts also impact heavily on urban waterways and water-dependent biodiversity, as well as reducing the amenity of urban parklands.

In recent times, many Australian cities have faced challenges of increasing demand for water at a time of reduced supply due to drought and ageing infrastructure. Governments have largely responded with prolonged water restrictions and expensive investments in expansion of water storage and supplies.

Alongside water supply challenges, existing environmental pressures such as peri-urban development in areas of remnant vegetation may also be heightened under the impacts of climate change.

Rural communities

Projected increases to the frequency and intensity of drought and fire will have ramifications for consumptive and environmental uses of rural water, particularly as regrowth following fire events has the potential to impact substantially on catchment water yields.

Biodiversity plays a crucial role in maintaining the productive capacity of our landscape. Biodiversity can act as a buffer against a harsh and variable climate by binding and nourishing soils and filtering streams and wetlands. Declining river and wetland health, reduced water availability and quality, increased erosion and reduced productivity are some of the challenges that may occur as consequences of biodiversity loss under climate change. For example, in the western regions of inland South-eastern Australia, increased temperature and evaporation is likely to lead to drier soil conditions throughout the year and reduced vegetation cover caused by poorer growing conditions is likely to lead to increased soil erosion. Despite the likelihood of drier conditions for much of the year, flood-producing rainfall events are likely to increase in frequency and intensity in these areas, increasing erosion and placing further stress on the systems.[14]

Decreased production in some areas as a result of climate change may ultimately lead to relocation of families and businesses to more productive areas.

Coastal communities

The impact of climate change on coastal communities includes the threat of inundation, erosion and effects on water quality and supply from rising sea levels and extreme weather events. These threats are likely to be exacerbated by continuing degradation of coastal buffer zones such as mangroves and coral reefs, which provide protection from extreme weather events. Such

ecosystems are also important habitats for a range of species of commercial and recreational significance.

The Australian fishing and aquaculture industries contribute around $2 billion to our economy per year. Expected climate-induced changes to coastal habitats, ocean temperature, currents, winds, nutrient supply, rainfall, ocean chemistry and extreme weather conditions from climate change will affect Australia's fisheries.[15] For example, changes in the rainfall pattern in Northern Australia are likely to affect catches of prawns, barramundi and mud crabs as harvesting of these species is dependent on patterns of summer rainfall, while extended periods of extreme temperature in shallow estuarine waters may affect the distribution of prawn nursery habitat such as seagrass.[16] Degradation and migration of estuaries and mangroves, which provide critical nursery habitat for fish and other marine life, may also affect the abundance and distribution of commercially important species. This would impact on industries such as commercial fishing and tourism, resulting in flow-on economic and social impacts on coastal communities.

Changes to ocean current circulation may also lead to changes in the distribution of commercially fished species, and greater impacts of invasive species in marine ecosystems. For example, an increase in water temperature has resulted in the strengthening of the southward flow of the East Australian current: warmer, saltier water is now found 350 km further south than was the case sixty years ago.[17] This trend is linked to the southward migration of a predatory sea urchin to Tasmanian waters. In areas where the sea urchins migrate, kelp forests are destroyed and the biodiversity dramatically reduced, resulting in reduced incidence of abalone and other important fishery species.[18] The migration of sea urchin coupled with an increase in water temperature is also likely to impact the Tasmanian rock lobster industry, worth $72 million per year. The 2009 *Marine Climate Change in Australia Report Card* predicts that this current is likely to strengthen a further 20 per cent by 2100.[19]

Box 1 - The Great Barrier Reef

The Great Barrier Reef is highly vulnerable to the effects of climate change. Effective adaptation is essential to minimise risk of severe and widespread declines in biodiversity and ecosystem services.

Through the *Great Barrier Reef Climate Change Action Plan 2007-2012*, the Great Barrier Reef Marine Park Authority is working with partners and stakeholders to identify and test strategies for adaptation measures that can reduce these risks. Various reef-based industries (such as tourism and commercial fishing) have contributed to this and developed climate change action plans of their own that identify options and potential barriers to effective adaptation.

The Great Barrier Reef Marine Park Authority has also determined priority issues for effective protection of biodiversity in a changing climate. These include continuing implementation of the Reef Protection Plan, a strengthened focus on conservation of inshore biodiversity, and research and development into active interventions and restoration of vulnerable species and habitats.

Indigenous communities

Environment and a sense of country are intrinsic to Indigenous culture, identity and law. Remote Indigenous and Torres Strait Islander communities are particularly reliant on healthy ecosystems for their traditional culture, subsistence and livelihoods. The link between healthy landscapes and Indigenous people's wellbeing is well documented. The impact of climate change on sacred sites and traditional lands may adversely affect communities' mental and physical well-being.[20]

In the Torres Strait, rising sea levels are impacting on more than just fisheries and farming areas. A number of the low lying communities and islands in the region have been impacted by encroaching sea levels with housing and infrastructure being threatened.[21]

Across northern Australia, rising sea levels may adversely affect important sources of food for Indigenous people and a basis for traditional cultural activities and habitat for totemic species.[22] For example, in the low lying wetlands of Kakadu National Park, saltwater intrusion has already been observed, and increases in average temperatures of 2-3°C (compared to 1990) could result in losses of up to 80 per cent of freshwater wetlands in Kakadu.[23] Saltwater intrusion will impact on freshwater dependent wildlife and traditional food resources such as magpie geese, barramundi and turtles.[24] Sea level rise may also affect mangrove ecosystems in Northern Australia, which are very important sources of food for Indigenous people and a basis for traditional cultural activities and habitat for totemic species.[25]

Tourism

"Nature in Australia" was identified as the foremost experience type that could motivate international travellers to visit Australia,[26] so it is not surprising that 64 per cent of international visitors participate in a nature-based experience.[27] Any significant changes to Australia's biodiversity or natural environment can be expected to have a direct impact on the tourism industry. For example, 5.8 million visitor nights (38 per cent of total inbound tourism) are spent in tourism regions regarded as extremely vulnerable to the effects of climate change.[28]

Tourism on the Great Barrier Reef is threatened by the loss of the reef's biodiversity. Rising water temperature, ocean acidification and declining water quality cause physiological stress in corals (e.g. coral bleaching) and may lead to mortality, which in turn reduces the diversity of coral reef systems and their attraction for tourists. In dollar terms, the value of the reef to the Australian economy has been assessed as $51 billion. The cost of total coral mortality could erode $38 billion of that value, approximately 3.5 per cent of gross domestic product.[29]

The freshwater wetlands of Kakadu National Park in the Northern Territory are vulnerable to salt water intrusion caused by rising sea levels. Damage to the wetlands and the flora and fauna it supports would likely affect tourism numbers.[30]

Rising temperatures have the potential to impact rainforest ecosystems that carry significant attraction for tourists. A 1°C rise in temperature compared to 1990 would greatly reduce the area of cloud forest and other highland rainforest across the Wet Tropics of Queensland, whilst a 2°C rise could force all endemic Australian tropical rainforest vertebrates, including ringtail possums and tree kangaroos, and many insects to extinction.[31] On Lord Howe Island, climate change could increase the

altitude of the cloud layer through rising sea surface temperatures. The cloud layer maintains the humidity and rainfall required by about 86 per cent of the island's endemic plant species.[32]

Adaptation

Scope

The Inquiry's Terms of Reference identify climate change adaptation as

> *'action by households, firms, other organisations and governments to respond to the impacts of climate change that cannot be avoided through climate change mitigation efforts'.*

While this provides the inquiry with a useful focus on the efforts and actions of human society (particularly governments) in responding to climate change impacts, an exclusively anthropocentric emphasis may be limiting. Other interpretations include greater emphasis on the ability of natural systems to adapt, rather than human societies. An example is "ecosystem-based adaptation", defined by the Convention on Biological Diversity as:

> "*adaptation that integrates the use of biodiversity and ecosystem services into an overall strategy to help people adapt to the impacts of climate change*"

This approach recognises and seeks to overcome limited understanding of the role of ecosystems, or natural capital, in adaptation to the social and economic impacts of climate change.

While there remains a wide spectrum of views, a broad perspective, such as that chosen by the IPCC that includes the resilience of natural systems and capacity of ecological communities to adapt to a changing climate, could be of benefit in pursuing a holistic approach.

What is effective?

The Productivity Commission has proposed that 'effective adaptation' could be that which maximises the net benefit to the community as a whole, that is

- it is done at least cost;
- resources are allocated to activities that generate the greatest net benefit to the community; and,
- the timing is optimal, based on the relative costs and benefits of taking action at different points in time.

While the emphasis on efficiency and optimality appears logical, it remains to be seen how feasible this can be in all contexts given an inevitably large degree of uncertainty around the impacts of climate change over long time frames, particularly in the context of ecosystem responses. However, uncertainty about the future need not be reason to delay developing strategies for adapting to climate change. While the Department supports the intent of the Productivity Commission's proposed approach, a more dynamic, flexible and creative approach may be appropriate in the environmental context, explicitly recognising the inherent uncertainty around ecological impacts associated with climate change. Policy interventions to support adaptation will need to be

considered continually over time as improved information becomes available, recognising that postponing difficult decisions may incur greater costs.

The 2011 CSIRO report, *Climate change: science and solutions for Australia,*[33] describes successful adaptation as a mixture of *incremental* and *transformational* decisions and technologies. 'Incremental adaptation', the report states, 'is what we tend to do throughout our normal lives as we cope with changed circumstances, gain new knowledge, acquire new technologies, or move to different places and jobs: we adapt constantly, and do not fear it'.

Transformational adaptation, on the other hand, requires 'far more profound change in people and the way they go about their work and lives. Some decisions do need to be taken as soon as possible, but there are others that we need to start planning for now, even though action on the ground may come later, and others still that we can consciously postpone while we monitor and assess what unfolds'.

Box 2 – State of the Environment

The 2011 *State of the Environment Report* notes governments have a key role in both mitigation and adaptation to climate change. These include:

- supporting scientific studies that are unlikely to be undertaken by the private sector (particularly relevant to the Australian Government)
- providing information to the private sector and the community to encourage and assist adaptation (relevant to all tiers of government, but of particular importance to state, territory and local governments)
- adopting policy settings that facilitate adaptation and a regulatory framework that supports, rather than distorts, effective market signals (a critical role for the Australian Government, but one that state and territory governments can significantly reinforce)
- employing policy mechanisms such as land-use planning, building codes and product standards to deal with situations where short-term market responses may act to restrict longer term adaptive action (primarily relevant to state and territory governments, but also to the Australian Government for setting minimum energy performance standards and the Building Code of Australia, and to local governments, which play an important role in on-ground implementation)
- fully factoring climate change into planning, resourcing and managing the provision of public goods and services such as public health and safety, emergency services, flood and coastal protection, water supply, drainage and sewerage services, protection of public lands, parks and reserves, fisheries and other natural resources (relevant to all three tiers of government, but especially to state, territory and local governments).

Adaptation in Australia's Commonwealth parks and reserves

Climate change poses a growing challenge for managers of all Commonwealth parks and reserves. Increasing temperatures, sea level rise and changes in rainfall patterns will lead to changes in habitats and the abundance, distribution and composition of native species. Climate change may also exacerbate existing pressures from weeds and introduced pest animals. Changing landscapes and climatic conditions will also have implications for existing recreational and cultural values.

A number of major recent studies have highlighted adaptation challenges in management of Australia's natural environment, including:

- *The Impacts and Management Implications of Climate Change for the Australian Government's Protected Areas.*[34]
- *Implications of Climate Change for Australia's National Reserve System.*[35]
- *Implications of climate change for Australia's World Heritage properties: a preliminary assessment.*[36]
- *Great Barrier Reef Climate Change Action Plan 2007-2012.*[37]

Australia's National Reserve System

The National Reserve System is Australia's network of protected areas and represents the collective effort of government and non-government organisations, the business sector and Indigenous landholders to formally protect biodiversity in perpetuity. The National Reserve System Program supports the acquisition and covenanting of properties to be managed for nature conservation, targeting under-represented and vulnerable areas. The Indigenous Protected Areas element of Caring for our Country supports Indigenous communities to manage their land for conservation and protection for all Australians. More than 50 Indigenous Protected Areas have been declared to date, covering some 26 million hectares and representing about one quarter of the National Reserve System which now covers nearly 14 per cent of Australia's landmass.

In working towards the establishment of a comprehensive, adequate and representative protected area estate, a key priority for investment through the National Reserve System component of Caring for our Country has been the target of building up to 10 per cent representation of National Reserves in each of the 85 bioregions across the country.

Healthy, functioning and resilient ecosystems are our best defence for the environment against a changing climate. Protected areas build resilience by enhancing the natural systems' abilities to adapt to or overcome habitat threats such as weeds and feral animals, and by helping to protect water resources and regenerating vegetation from these threats. They form a buffer against the impacts of climate change by providing refuges for species to survive and adapt, thereby reducing the extinction risk for some of our most at-risk native species. By creating these havens across the landscape, the National Reserve System is providing the conditions to support Australia's native plants and animals to adapt to climate change.

The vast protected areas in arid Central and Western Australia, home to a wide range of fauna and flora, are resilient, self-sustaining ecosystems in themselves. However, along the agricultural zones of the south-western and eastern seaboards, the country is fragmented by land clearing, extensive pastoralism and intensive agriculture. Here, the reserve system is building resilience by expanding and linking protected areas to extend habitat ranges, to increase connectivity, protect water catchments and vegetation structures to reduce soil erosion and to promote healthy ecosystem function.

Strategic management of adaptation in Australia's Commonwealth parks and reserves

Climate change poses a growing challenge for managers of all parks and reserves, including the seven Commonwealth terrestrial reserves:

- Australian National Botanic Gardens
- Booderee National Park
- Christmas Island National Park
- Kakadu National Park
- Norfolk Island National Park
- Pulu Keeling National Park
- Uluru – Kata Tjuta National Park.

Climate change impacts will vary widely across each of the Commonwealth reserves. Parks Australia has developed a "Climate Change Strategic Overview 2009-2014" to identify the principles and objectives (Box 2) that will guide Parks Australia's response to managing the consequences of climate change in Commonwealth terrestrial reserves. In addition, each Commonwealth terrestrial park and reserve is developing strategies specific to its habitats, landforms and climate. These strategies are published online as they are finalised.

The Director of National Parks has provided a separate submission to the Productivity Commission in his statutory role in the conservation and management of protected areas. It provides further detail on this issue.

Box 3 - Managing the consequences of climate change in Commonwealth terrestrial reserves:

Understanding the implications of climate change

Scientific knowledge of the implications of climate change at the local level is in its infancy. While there is a growing body of research on the impacts of climate change on Commonwealth reserves, there remains a lack of information in a number of key areas (such as the aquifer and associated biodiversity at Uluru-Kata Tjuta National Park). In the absence of robust, definitive and location specific scientific research a risk management approach needs to be taken. Such an approach, embedded at a policy level, would assist reserve managers in understanding which adaptation decisions are most urgent and where to focus available resources.

Implementing adaptation measures to maximise the resilience of our reserves

The resilience of our parks and reserves in the face of climate change is dependent both on the rate of change and the ability of the areas to adapt. A key focus of park management is to reduce the pressure of significant threats such as invasive species and inappropriate fire regimes to build resilience and give species and communities their best chance of adapting and evolving. Undertaking significant adaptation activities beyond current programs will require additional resources.

Working with communities, industries and stakeholders to mitigate and adapt to climate change

Many communities and businesses rely on parks and reserves to attract tourists and provide essential ecosystem services. Parks Australia works with stakeholders and businesses, as well as educating visitors, in the steps being taken to mitigate climate change in the parks, and the role they can play in assisting these efforts.

Communicating the implications of climate change and our management response

Parks Australia has published its completed climate change strategies and key research papers online. This is the first step in sharing knowledge and experience with stakeholders to ensure that everyone is informed about the potential impacts of climate change and management directions. As park management plans are reviewed they also include information and actions relating to climate change and adaptation.

Great Barrier Reef Marine Park

The Great Barrier Reef Outlook Report 2009 identified climate change as one of the greatest threats to the long-term health of the Great Barrier Reef. Impacts include increased frequency of severe weather events, ocean acidification, rising sea and air temperatures and rising sea levels.

Climate change is already affecting the Great Barrier Reef, and greater impacts are predicted over the course of this century. Climate change will affect fundamental environmental processes, alter habitats, and change the behaviour, abundance and distribution of many species.

Many of these changes will have implications for the communities and industries such as tourism and fishing that depend on the Reef. Building their resilience to these changes will be increasingly important if economic and social impacts of climate change are to be minimised.

The Great Barrier Reef Marine Park Authority (GBRMPA) is implementing the Great Barrier Reef Climate Change Action Plan,[38] and working with a range of partners to build the resilience of the Reef so it can better withstand the impacts of climate change.

The GBRMPA engages with industries and communities to:

- Provide relevant information on ecosystem impacts and risks
- Support them as they devise and implement adaptation practices
- Support the incorporation of adaptation practices into business models
- Encourage them to contribute to efforts to build the Reef's resilience to climate change
- Collecting data that can help us to understand social and economic risks and identify strategies to reduce vulnerability to changes in reef condition under a changing climate

Biodiversity Fund

While a large focus of the government's Clean Energy Future plan has been on mitigation efforts, the Land Sector Package announced as part of the Plan contains a number of important initiatives that will contribute to adaptation in the natural environment.

The Biodiversity Fund will integrate with the emerging carbon market, investing $946 million over its first six years to help land managers store carbon, enhance biodiversity and build greater environmental resilience across the Australian landscape.

The Biodiversity Fund will invest in biodiverse plantings, helping land managers expand native habitat on their property through planting mixed vegetation species appropriate to the region, which will help build landscape resilience and connectivity. The Biodiversity Fund will also support land managers to protect, manage and enhance existing native vegetation in high conservation areas for its carbon storage and biodiversity benefits. Threats to biodiversity will be tackled through funding to control invasive pests and weeds in a connected landscape.

Regional Natural Resources Management Planning for Climate Change Fund

Regional Natural Resource Management (NRM) organisations will be supported to update existing regional NRM plans to guide planning for climate change impacts on the land and to maximise the environmental benefits of carbon farming projects.

The NRM Planning for Climate Change fund will invest $44 million over the next five years to help guide where biosequestration projects should be located in the landscape to maximise the benefits for biodiversity, water and agricultural production.

Funding is divided into two streams:

Stream 1: $28.9 million over five years will support the 56 regional NRM organisations revise existing regional NRM plans to help identify where in the landscape adaptation and mitigation activities should be undertaken. This stream will be administered by the Department.

Stream 2: $15 million over five years will support development of regional-level information in the form of scenarios about the impacts of climate change which can be used for medium term regional NRM land use planning. This stream will be administered by the Department of Climate Change and Energy Efficiency.

Box 4 – Adaptation and biodiversity

Current policy frameworks for maintaining biodiversity focus on building **resilience** in the landscape and seascape through:

- maintaining well functioning ecosystems;
- protecting a representative array of ecosystems;
- minimising or removing existing stressors;
- building connectivity; and
- protecting ecological refugia.

A significant difficulty is that policy interventions often require coordinated planning and implementation across jurisdictions and industry sectors.

Policy interventions to facilitate adaptation could be enhanced by improved recognition and inclusion of the value of ecosystem services – including their capacity to ameliorate the socio-economic impacts of climate change – and further understanding of the vulnerability of ecosystem services to climate change. This could provide a basis for:

- Consideration of climate change adaptation objectives in ecosystem regulation, management and programmatic decisions.
- Consideration of expected ecosystem change in business decision-making and industry development and adaptation.
- The purposeful use of ecosystem services to enhance socio-economic adaptation and resilience.

Adaptation in urban areas

A large number of measures have been implemented in recent years in the urban water sector. Adaptation actions include access to a broader range of water supply options, integrated water management, water-sensitive urban design, catchment planning for water supply and adaptive infrastructure planning. Recognising that securing and diversifying water supplies is central to building a sustainable Australia, the Australian Government is investing over $1.5 billion in a wide range of urban water projects under the 'Water for the Future' initiative.

Integrated urban water management requires a holistic approach that aims to optimise the use of all urban water sources , including stormwater, recycled water and water derived from desalination. Water sensitive urban design initiatives have been undertaken in many cities. Typically, stormwater or other re-use water is harvested and used for non-potable purposes such as establishment of urban wetlands and watering of urban parks and gardens. These have the effect of increasing water security by reducing demand on potable water, moderating the urban climate, increasing urban amenity and reducing the volume of pollutants entering waterways and the ocean through stormwater discharges.

Barriers

The Productivity Commission proposes to classify barriers to adaptation into: market failures; regulatory barriers; behavioural and cultural barriers; and organisational barriers. While this could be a useful conceptual classification, many adaptation challenges – particularly in the environmental policy sphere – fall across several of these categories, and are not easily addressed independently.

Information and uncertainty

A common and significant constraint on the efficient operation of markets – and barrier to effective adaptation – is limitations in the availability and precision of information. This includes an incomplete understanding of the vulnerabilities of ecosystems, the likely impacts of climate change on ecosystems, and uncertainty in gauging localised effects across Australia. Improved understanding of climate change impacts, and the underlying climate science, is a requirement for effective adaptation.

In order to continue working towards 'effective' adaptation - in terms of greatest net benefit and optimal timing – it is also important to improve our understanding of the contribution of our natural capital stocks to societal wellbeing, and how these will be affected over time by the impacts of climate change. This includes improving our knowledge of the values of ecosystem services, and the increasing economic impact of anticipated extreme weather events under climate change.

The National Plan for Environmental Information *(http://www.environment.gov.au/npei/index.html)* is aiming to improve the quality and coverage of Australia's environmental information to facilitate sound decisions, individually and collectively, about the major issues affecting our natural assets. It plans to bring together national environmental information from agencies and information sources, building and maintaining this critical information infrastructure for the future.

Box 5 – Information to support adaptation

The Bureau of Meteorology is supporting climate change adaptation through its scientific research and information services. This information assists across a range of government priorities including planning and infrastructure decisions, natural disaster preparation and response, as well as agricultural and environmental policy options. The Bureau's work with CSIRO and universities in better understanding climate change and improving models and supplying climate projections is critical for impacts and adaptation. However, despite the availability of useful climate data and information, key challenges remain for this information to reduce barriers in climate change adaptation.

Services to support robust climate change attribution.
Analysis of recent and future significant climate events (e.g. droughts, floods, and heatwaves) requires a greater level of monitoring and analysis. Perhaps the most important aspect is determining which events are attributable to climate change. This would provide the community and decision-makers with clear and solid signals upon which to base their adaptation decision making and responses.

Monitoring, forecasting and projections of extreme climate events.
Improved monitoring of Australian climate in order to better define 'current climate' and launch a new 'red flag' climate information service to provide greater forewarning of unusual and risky climatic trends. Improving seasonal forecasting has enormous potential to forewarn of extreme climate events and assist adaptation efforts. On-line access to climate change projections data and information would be a great enabler to determine impacts and develop adaptation strategies and lower the costs of research.

National coordination of climate information resources.
There are a range of climate science and climate information sources including the Bureau of Meteorology, CSIRO, Cooperative Research Centres, universities, the National Climate Change Adaptation Research Facility and commercial organisations. It can be confusing for decision-makers to identify the type of information that is useful for a particular purpose and who to approach for that information. A nationally coordinated facility to assist people improve their climate literacy levels and better identify their data and information needs would further reduce barriers to adaptation.

Property rights and public goods

Frequently the ownership of environmental resources cannot be well-defined or enforced. Individuals cannot be excluded from using a natural resource, e.g. clean air or biodiversity on public land. In the marine context, where Australia has the third largest jurisdiction in the world, this is even more pronounced, due to jurisdictional complexities and limited scientific understanding of common resource stocks.

In the water sector, where clarifying property rights has been a significant focus of Australia's water policy, uncertainties remain for stormwater, recycled water or groundwater recharge. Unregulated interception activities can also represent a 'leak' in water entitlements (impacting on the value, reliability and consistency of entitlements).

Behavioural and cultural barriers

In a country characterised as a 'land of drought and flooding rains', there is perhaps more than elsewhere an ingrained scepticism that 'additional' adaptation to climate change impacts is necessary. As such, while there is growing recognition that the severity of events may be increasing, there may remain a level of inertia in individual behaviour and choices. Particularly in times of economic instability and uncertainty, it can be difficult for long term issues such as climate change adaptation to achieve significant attention in public and private consciousness.

While the government is seen as an insurer of last resort in many cases, there may be potential for private incentives for climate change adaptation to be diluted by government provision of services for the public good.

In relation to diversification of drinking water sources, community attitudes to date have precluded the uptake of recycled water for drinking purposes, as was seen in Toowoomba some years ago. Considerable research and public education is needed to address this opportunity. The Australian Water Recycling Centre of Excellence, funded by the Australian Government, is currently investing resources in this area.

Box 6 – Adaptation in rural water management

A substantial challenge in adaptation in the rural water sector is a lack of consistency between different sectors (e.g. rural, urban, and mining) in relations to water entitlements, allocation, planning, pricing, and regulating. Policy duplication between commonwealth, states, territories and local government can lead to inefficiencies, excessive compliance costs, administrative burdens and uncertainty for households and businesses.

To the extent that they remain outside formal water access entitlements, some interception activities (such as plantation forestry, farm dams, peri-urban development, and flood plain and overland harvesting) represent potential "leaks" in the entitlement system that impact on the value and reliability of entitlements, as well as on the broader water resource.

Sub-optimal pricing policies, compounded by less water in the market, may have ramifications for the cost of maintaining and renewing water infrastructure, which in turn has ramifications for viability.

Delayed, inadequate or patchy implementation of various aspects of the National Water Initiative (including consistent water planning; risk assessments; allocation and entitlement frameworks; markets and trade barriers) could compromise the capacity of industry and communities to adjust and adapt through market mechanisms.

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