View complete contents

Climate change impacts

By Kevin Hennessy

Key messages

- The impacts of climate change are already clearly visible in Australia. Further impacts predicted to occur will be experienced across all sectors of the economy and in all ecosystems.
- Southern and eastern Australia's water supply reliability is expected to decline as a result of reduced rainfall and increased evaporation, affecting irrigation, domestic and industrial water use, and environmental flows. This is likely to be accompanied by a growth in water demand due to population growth.
- Development and population growth in Australia's coastal regions will exacerbate the risks from sea-level rise and increase the likely severity and frequency of coastal flooding.
- Significant losses of unique Australian animal and plant species are expected to occur in sites such as the Great Barrier Reef, the Queensland Wet Tropics, the Kakadu wetlands, south-west Australia, eastern alpine areas, and Australia's sub-Antarctic islands, disrupting ecosystem function and causing the loss of ecosystem services.
- The risks to infrastructure include the failure of urban drainage and sewerage systems, more blackouts, transport disruption, and greater building damage. Higher temperatures, altered groundwater and soil conditions, sea-level rise and changed rainfall regimes may also lead to accelerated degradation of materials.
- Heatwaves, storms and floods are likely to have a direct impact on the health of Australians, such as causing an increase in heat-related deaths. Biological processes such as infectious diseases and physical processes such as air pollution may affect health indirectly; for example, by increasing exposure to dengue fever.
- Moderate warming in the absence of rainfall declines can be beneficial to some agricultural crops, and higher levels of carbon dioxide can stimulate plant growth. However, these positive effects can be offset by changes in temperature, rainfall, pests, and the availability of nutrients. Production from cropping and livestock is projected to decline over much of southern Australia, as is the quality of grain, grape, vegetable, fruit, and other crops.

Introduction

Australia is the driest inhabited continent in the world. In addition, the climate is inherently variable as noted in our literary history – 'of droughts and flooding rains'. There is now strong evidence that our climate is also changing, with Australia warming by about 0.8ºC since 1960, and more heatwaves, fewer frosts, more rain in north-west Australia, less rain in southern and eastern Australia, an increase in the intensity of droughts, and a rise in global sea level of 77 mm from 1961–2003 (see Chapter 1). The impact of these changes, which are due to a combination of natural variability and changes in greenhouse gas concentrations from human activities, can now be clearly seen in stresses on our water supplies and farming, changed natural ecosystems, coastal impacts, and reduced seasonal snow cover.[1,2]

It is now likely that the world will see 2ºC global warming on top of changes already experienced within the lifetime of the current generation. Without rapid action to reduce CO_2 emissions, there is a serious risk that global warming could be as much as 4ºC by later this century.[3]

For Australia, heatwaves, fires, floods, and southern Australian droughts are all expected to become more frequent and more intense in the coming decades. Snow and frost are very likely to become rarer or less intense events. Locally and regionally, the greatest impacts will be felt through changes in water availability and sea level, and extreme weather events.

Australia is highly vulnerable to these projected changes in climate and this highlights the need for adaptation to the unfolding and unavoidable changes that lie ahead (see Chapter 5). Adaptation needs to be informed by a good understanding of the impacts of climate change. Global and national assessments show that a changing climate affects food production, disturbs coastal margins, displaces species, and changes economies. New extremes in temperature and sea level will exceed the habitable limit for some species.[4] Shifting population patterns of plants, animals, and people will bring more changes.

Although the impacts of climate change are on the whole negative for the environment and the economy, not all climate changes will be deleterious, especially in the next few decades. Moderate warming in the absence of rainfall declines can actually be beneficial for some agricultural crops. Therefore it is important to understand how the likely impacts of climate change will be distributed.

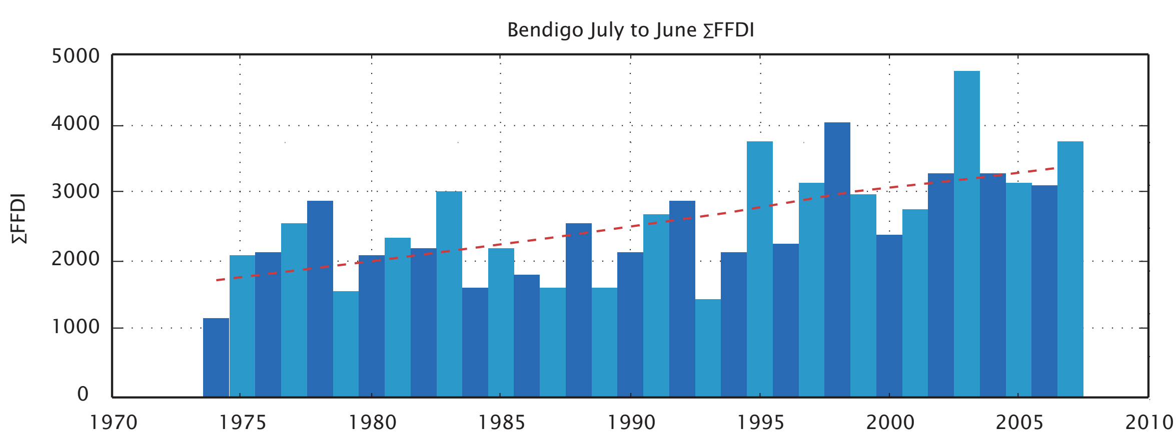
▸ ***Figure 4.1****: Change in annual total Forest Fire Danger Index (FFDI) from 1974 to 2007 at Bendigo.[5] The dotted trend line shows an increase of 51 FFDI units per year.*

Climate extremes – a window into understanding the impacts of climate change

Climate change impacts will increasingly be experienced first through extreme events rather than gradual changes in mean temperature or rainfall. Consideration of current vulnerability to extreme events helps to establish the context for assessing changes in vulnerability due to future changes in extremes. Extreme weather and climatic events that we experience today are most likely a combination of climate variability combined with an underlying change in climate associated with anthropogenic greenhouse gas emissions (see Chapter 1). The evidence for a human contribution through increases in greenhouse gases varies regionally and for different climate variables, and it is very difficult to attribute specific causes to individual extreme weather events. However, there are statistical methods for assessing whether an extreme event may have been made more likely because of increases in greenhouse gases.[6] Regardless of the cause, it is important to understand the impacts of existing extreme weather and climate events and use these as a window into future climate change in an enhanced greenhouse world.

A good case study of how we can look at the impacts of current extreme events and assess their importance in the future is the Victorian bushfires event in early February 2009, which killed 173 people and more than 1 million animals, destroyed more than 2000 homes, burnt about 430 000 hectares, and cost about $4.4 billion.[7] Conditions leading into that fire were extreme, with high temperatures, low humidity, high winds, and very dry fuel as a result of years of drought, all of which combined to produce an extreme forest fire danger index (FFDI). When the daily FFDI is greater than 50, the risk rating is 'Extreme' and a 'Total Fire Ban' is usually declared. The bushfires of February 2009 had a FFDI that greatly exceeded 100 in many locations and, as a consequence, an additional fire rating 'Catastrophic' has since been added to the rating system.

An analysis of the annual total FFDI (i.e. the sum of daily FFDI indices) for the last 30 years shows that in southern Australia the index has been trending upwards, primarily in response to increasing temperatures and a worsening drought since the mid-1990s (Figure 4.1).[5]



In terms of future fire-weather risk, a modelling study conducted by the Bushfire CRC, the Bureau of Meteorology, and CSIRO[5] found that the simulated annual-average number of days with 'Extreme' fire danger increases by 5–25% by 2020 relative to 1990, for a 0.4ºC global warming. For a 1ºC global warming, the number of 'Extreme' days increases by 15–65% by 2020. By 2050, the number of 'Extreme' days increases by 10–50% for 0.7ºC global warming and by 100–300% for 2.9ºC global warming.

This example illustrates how examining today's extreme weather events can be important for understanding impacts in the future. Chapter 6 further illustrates how understanding extreme events such as coastal flooding and heatwaves can inform adaptation.

Climate change impacts across Australia's economy and environment

Climate change impacts will be experienced across all sectors of the economy and in all ecosystems. There are six areas in particular where the impacts will be significant: (1) water security, (2) coastal development, (3) natural ecosystems, (4) infrastructure, (5) agriculture and forestry, and (6) health.

Water security

Water security, or reliability of water supply, in southern and eastern Australia is expected to decline in future as a result of reduced rainfall and higher rates of evaporation.[2] There is likely to be less water available for irrigation, domestic use, and industry, and lower environmental flows. For example, median stream flow in the Melbourne catchments is estimated to decline by 10% by 2030[8] and median stream flow in south-western Australia is estimated to decline by 25% by 2030.[9]

The decline in water supply is likely to be accompanied by a growth in water demand as our population expands. It is the combination of growing demand and reduced supply that makes water potentially one of Australia's most critical national issues. A CSIRO report on water availability in the Murray–Darling Basin (MDB) found that water resource development in conjunction with drought has caused major changes in the flood regimes that are important for floodplain wetland systems.[10] The report found that run-off in the southern MDB between 1997 and 2006 was the lowest ever recorded. Such conditions are likely to be increasingly common by 2030 and beyond. Surface water availability across the entire MDB is more likely to decline than to increase, especially in the south, where the reduction could be substantial. The median decline expected for the MDB is 9% in the north of the basin and 13% in the south. This could further reduce flow at the Murray River mouth by around a quarter under present water-sharing arrangements. In the driest years, water availability in the Condamine–Balonne basin could fall by over 20%, around 40–50% in the NSW water regions (except the Lachlan basin), over 70% in the Murray region, and 80–90% in the main Victorian regions.[10]

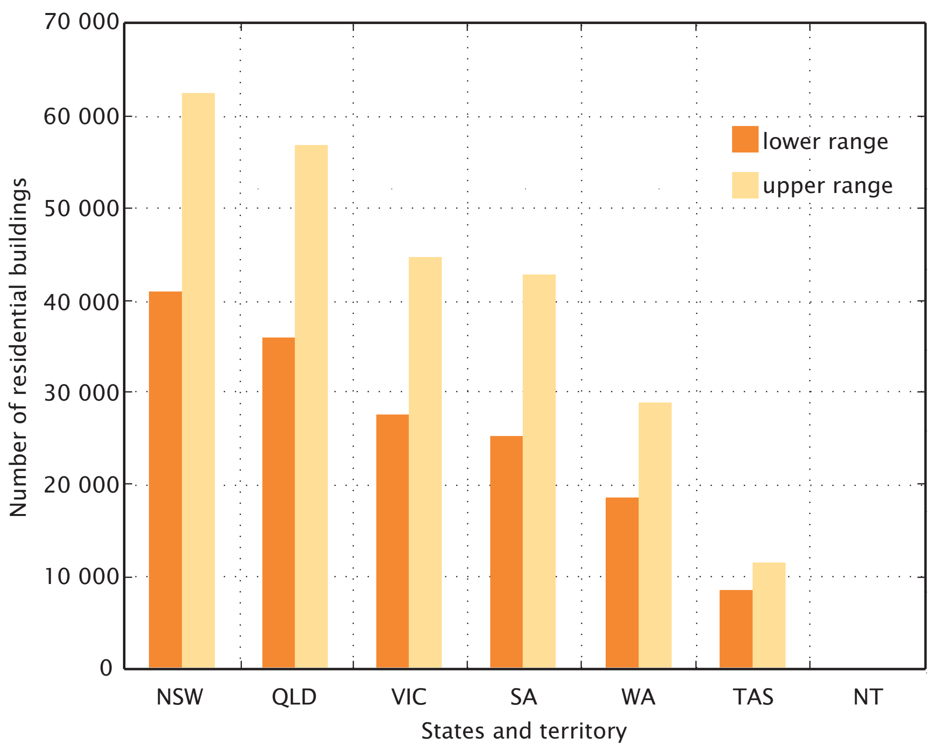
Greg Rinder/CSIRO

These impacts point to a growing need for adaptive strategies (see Chapters 5 and 6), many of which are in hand already. They include, for example, the Murray–Darling Basin Water Agreement, the conversion of open irrigation channels to pipelines, desalination plants, the introduction of state water conservation plans, and the adoption of the 'water-proofing' of Adelaide as a model for other cities.

Coastal development

Continued development and population growth in Australia's coastal regions – where around 85% of the population now resides – will exacerbate risks from sea-level rise and increase the likely severity and frequency of coastal flooding caused by climate change.[2] There is likely to be an increased risk of coastal flooding, especially in low-lying areas exposed to cyclones and storm surges (see Figure 4.2). For example, the area of Cairns at risk of flooding by a 1-in-100-year storm surge is likely to more than double by 2050.[2]

A 2009 report titled *Climate change risks to Australia's coasts* stated that, 'many coastal environments such as beaches, estuaries, coral reefs, wetlands and low-lying islands are closely linked to sea level. There is a lack of detailed knowledge as to how these environments will respond to sea-level rise, but the risk of beach loss, salinisation of wetlands and inundation of low-lying areas and reefs beyond their capacity to keep pace must be recognised. With a "mid-range" sea-level rise of 0.5 m in the 21st century, events that now happen every 10 years would happen about every 10 days in 2100. The current 1-in-100-year event could occur several times a year' (see Chapters 1 and 6).



▲ ***Figure 4.2***: *Estimated number of residential buildings at risk of inundation from a 1.1 m sea-level rise (including 1-in-100-year storm tide for NSW, Victoria, and Tasmania and high tide event for others).*[1]

Furthermore, sea-level rise is expected to begin eroding many of Australia's sand beaches faster than they can form if current rates of rise continue through the 21st century. Some beaches could recede by hundreds of metres over the course of this century.[2] Remote Indigenous communities in the north of Australia and communities living on the low-lying Torres Strait Islands are particularly vulnerable to sea-level rise. Together, these impacts will raise the pressure for wiser and safer forms of coastal development (see Chapter 6).

Natural ecosystems

Among the most significant impacts of climate change may be the loss of unique Australian animal and plant species and the gradual changing of quintessentially Australian landscapes.

Significant losses of biodiversity are projected to occur in iconic sites such as the Great Barrier Reef, the Queensland Wet Tropics, the Kakadu wetlands, south-west Australia, our sub-Antarctic islands, and eastern alpine areas.[2]

A recent study concluded that this loss of diversity is likely to disrupt ecosystem function and cause the loss of ecosystem services.[11] These changes have major implications for Australia's 9000 protected areas, including national parks, nature reserves, private conservation reserves, Indigenous Protected Areas, and other reserve types that cover 88 million hectares (11.5% of the continent). The four main threats are the arrival of new (native and exotic) species in a region, altered fire regimes, land-use changes, and altered hydrology. In response, one of the key tasks will be to protect native habitat at the landscape scale, ensuring habitat connectivity so that native species can readily relocate as climatic conditions change (see Chapter 5).

Changes to marine ecosystems will be among the most serious impacts. For example, a 0.5°C warming of the tropical oceans may cause bleaching of 30% of the Great Barrier Reef and a 1°C warming may bleach 65%.[12] Such changes could directly affect a tourism industry worth $5 billion a year and supporting around 70 000 employees.[2]

A CSIRO assessment[13] outlines a range of other projected marine climate impacts including:

- the expansion of mangroves into newly flooded coastal lands
- declines in seagrass meadows and seaweed beds due to storms and warmer water
- the southward migration of tropical pelagic fish and other marine species
- a loss of diversity in coral fish and other coral-dependent organisms
- a risk to marine food chains from ocean acidification, potentially affecting fisheries.

Changes in coastal ecosystems are already taking place, with the southward migration of some species, particularly along the south-east coast of Australia. A major question for several coastal ecosystems is whether only a modest climate change may induce a threshold beyond which some ecosystems might 'flip' into a different state. The initial responses to climate change by a range of ecosystems will be to migrate either inland or polewards, raising the issue of 'coastal squeeze' in southern Australia where populated areas stand in the way of this natural adaptive response and the expanse of the Southern Ocean sets a boundary to southward migration of shallow water organisms. The coastal systems most at risk are estuaries and associated wetlands, coral reefs, tidal flat communities and salt marshes, and beaches where there is a lack of sand for replenishment.

Infrastructure

Infrastructure is particularly sensitive to changes in extreme weather in addition to more gradual changes in rainfall or sea-level rise. Today's design criteria for extreme events are likely to be exceeded more frequently in future.[2] Typical risks include the failure of floodplain protection and urban drainage and sewerage systems, more heatwaves causing blackouts or buildings failing under excessive wind loads. Examples include the January–February 2011 floods in eastern Australia, the January 2009 heatwave in south-eastern Australia,[14] the February 2009 fires in Victoria, and Cyclone Larry in March 2006. In addition to these acute impacts, there are a whole range of chronic impacts such as accelerated degradation of materials and infrastructure (such as water pipes, road surfaces, transmission lines, foundations, and building materials) associated with higher temperatures, altered groundwater and soil conditions, sea-level rise, and changed rainfall regimes. There are also indirect effects such as the increasing urban heat island effect (that is, an increase in temperature caused by heat-retaining materials in the urban environment) putting more demand on energy for air-conditioning.

The Victorian Government, with significant input from CSIRO, conducted a risk assessment of its infrastructure in the context of climate change. Table 4.1 shows a summary of the exposure and sensitivity of Victoria's infrastructure to climate change.[15] Victoria's water, electricity, and buildings are particularly sensitive. Buildings have the greatest exposure and sensitivity to climate change by 2030, especially in relation to foundations, storm and flood damage, and bushfire risk.

View complete contents

Table 4.1: Climate change exposure and infrastructure sensitivity matrix for Victoria by the year 2030[15]

	Climate change impacts											
Infrastructure type	Increased solar radiation	Decrease in available moisture	Increased variation in wet/dry spells	Increased temperature and heatwaves	Decrease in rainfall	Increase in extreme daily rainfall	Increase in frequency and intensity of storms	Increase in intensity of extreme wind	Increased electrical storm activity	Increase in bushfires	Sea-level rise	Humidity
Water	Negligible	Definite	Definite	Definite	Definite	Definite	Definite	Negligible	Negligible	Definite	Negligible	Negligible
Sewer	Negligible	Definite	Definite	Negligible	Definite	Definite	Definite	Negligible	Negligible	Negligible	Definite	Negligible
Stormwater	Negligible	Definite	Definite	Definite	Negligible	Definite	Definite	Negligible	Negligible	Negligible	Definite	Negligible
Electricity	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Negligible	Negligible
Gas and oil	Negligible	Definite	Definite	Negligible	Negligible	Definite	Definite	Negligible	Negligible	Definite	Definite	Negligible
Fixed line telecom network	Definite	Negligible	Negligible	Definite	Negligible	Definite	Definite	Definite	Definite	Definite	Definite	Negligible
Mobile network	Negligible	Definite	Negligible	Negligible	Negligible	Negligible	Negligible	Definite	Negligible	Negligible	Negligible	Negligible
Roads	Definite	Definite	Definite	Definite	Negligible	Definite	Definite	Negligible	Negligible	Negligible	Negligible	Negligible
Rail	Negligible	Negligible	Negligible	Definite	Negligible	Definite	Definite	Negligible	Definite	Negligible	Negligible	Negligible
Bridges	Definite	Negligible	Negligible	Definite	Negligible	Definite	Definite	Definite	Negligible	Negligible	Negligible	Negligible
Tunnels	Negligible	Negligible	Negligible	Negligible	Definite	Definite	Definite	Negligible	Negligible	Negligible	Definite	Negligible
Airports	Definite	Definite	Definite	Definite	Negligible	Definite	Definite	Definite	Negligible	Definite	Negligible	Negligible
Ports	Negligible	Negligible	Negligible	Negligible	Negligible	Definite	Definite	Definite	Negligible	Negligible	Definite	Negligible
Buildings and structures	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite	Definite
Urban facilities	Definite	Definite	Definite	Definite	Negligible	Definite	Definite	Definite	Definite	Definite	Definite	Negligible

Table key	
Negligible risk – Presents 'negligible' risk within the probability of natural variation	Negligible
Definite risk – Presents 'definite' risk within the probability of natural variation	Definite

Agriculture and forestry

Unlike most other sectors, where there are few positive impacts of climate change, agriculture and forestry is different because plants can respond positively to higher concentrations of CO_2 in the atmosphere.[16] Higher levels of CO_2 increase the rate of photosynthesis and improve the efficiency of water use in plants, hence stimulating plant growth (known as CO_2 fertilisation). Experiments where CO_2 concentrations have been increased by around 50% (to approximately 550 ppm) have produced growth increases of around 15%[17] in crops and 10–50% in tropical savanna grasses.[18] In studies where CO_2 has been increased up to 700 ppm, wheat yields have risen by 10–50%, cotton biomass by 35%, whole boll yields by 40%, and lint yields by 60%.[19] Data supporting these conclusions have been collected in major field experiment studies in Australia (Wheat FACE experiment at Horsham in Victoria and OZFace experiment in Townsville, Queensland – see Figure 4.3).

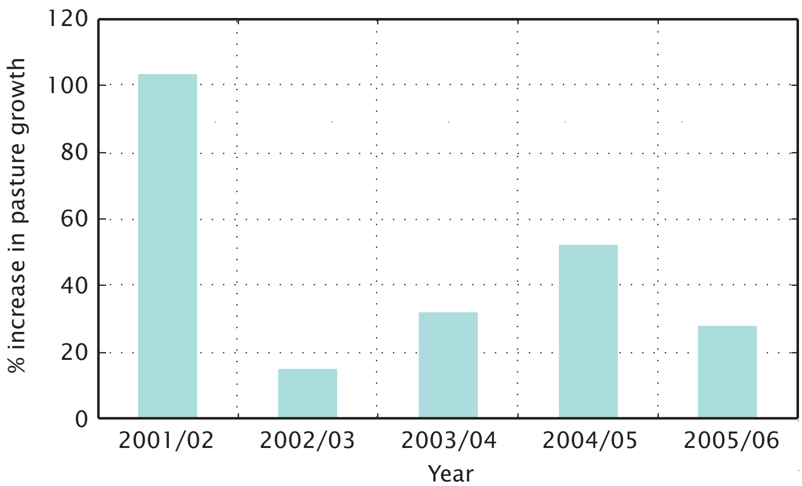


***Figure 4.3**: Relative growth response of tropical native pasture when exposed to 550 ppm CO_2 concentration compared with current concentrations (380 ppm).*[18]

However, the positive effects of CO_2 can be more than offset by accompanying changes in temperature, precipitation, pests, and the availability of nutrients. As a consequence, production from cropping and livestock is projected to decline by 2030 over much of southern Australia due to increased drought[2] and the fact that the availability of nutrients will limit productivity in most Australian landscapes. Heat and drought are likely to reduce the quality of grain, grape, vegetable, fruit, and other crops. A 20% reduction in rainfall could reduce pasture productivity by 15%, and livestock weight gain by 12%, which would substantially reduce farm income. There is likely to be a southward movement of pests and diseases as the southern regions warm. The forestry and plantation industries are likely to face greater risk of fire.[2]

John Coppi/CSIRO

There are likely to be some additional positive effects beyond that of CO_2 fertilisation, such as a likely reduction in frost, and the prospect of longer growing seasons for some crops. See Chapter 7 and the CSIRO report *Adapting Agriculture to Climate Change*[20] for a discussion of the adaptation options for agriculture, and Chapter 5 for a general discussion of the issue of adaptation.

Health

Climate change has an impact on health both directly and indirectly (Figure 4.4). Direct impacts are via heatwaves, fires, storms, and floods. For Australia, heatwaves are likely to have a major impact on human health. Heat-related deaths for people aged over 65 in six of Australia's largest cities are likely to increase from around 1100 per year at present to around 2300–2500 by 2020 and 4300–6300 by 2050 (allowing for demographic change). During a 2-week heatwave in early 2009, 374 heat-related deaths were recorded in Victoria (see Chapter 6). While most attention is focussed on extreme heat events, there is also the chronic effect of increased heat loads, which is exacerbated in urban environments by the urban heat island effect.

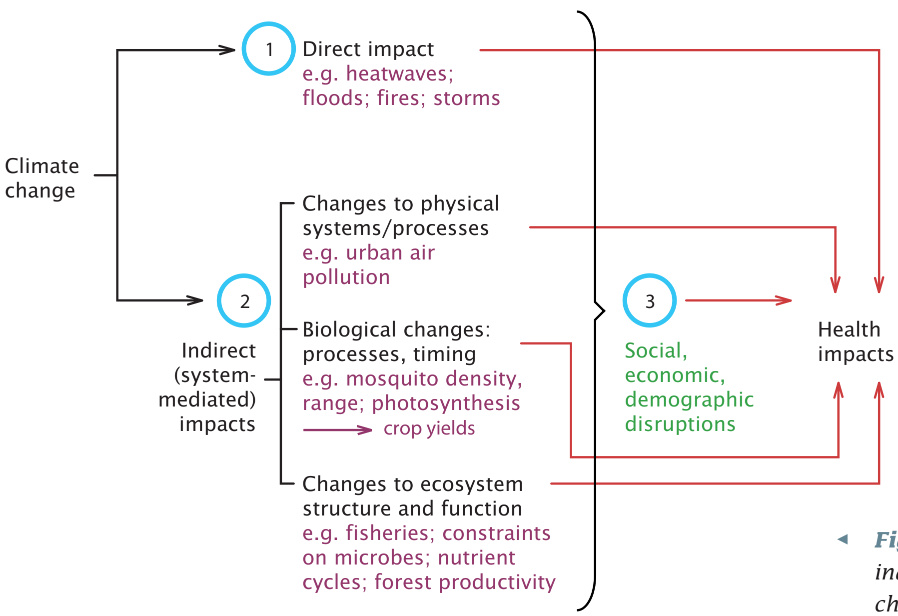


***Figure 4.4**: Direct and indirect impacts of climate change on human health.*[21]

Health is also affected by climate change indirectly, principally through biological processes such as vector-borne and other infectious diseases and physical processes such as air pollution. For example, Australia can expect an increase in disease due to the spread of insect vectors, with 0.6 to 1.4 million more people exposed to dengue fever by 2050, as well as a rise in water-borne and food-borne diseases.[2] Higher temperatures are likely to cause an increase in the concentrations of volatile organic compounds and ozone in the atmosphere. An analysis of future climate found that under an SRES A2 (relatively high emission) scenario, increased ozone pollution is projected to cause a 40% increase in the projected number of hospital admissions by the period 2020–2030, relative to 1996–2005, and a 200% increase by the period 2050–2060.[22]

Conclusion

The impacts of climate change on Australia's economy, society, and environment over the coming decades will be significant. Some impacts will be unavoidable in the short term because of climate changes already locked in due to past and current greenhouse emissions. Adaptation on a scale far more extensive than is currently occurring will be essential in all walks of life in order to limit these impacts, but significant environmental, economic, social, and institutional barriers to adaptation remain (see Chapters 5 and 6). Adaptation alone cannot absorb all the projected impacts of climate change, especially over the long term. Some of these impacts can be further avoided, reduced, or delayed by reducing global net greenhouse gas emissions, so it is clear that Australia's approach to climate change needs to embody both adaptation and emission reduction strategies.[23]

Further reading

CSIRO (2008) *Water availability in the Murray-Darling Basin. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project.* CSIRO, Australia. http://www.csiro.au/partnerships/MDBSY.html.

Department of Climate Change (2009) *Climate change risks to Australia's coasts*. Department of Climate Change. http://www.climatechange.gov.au/publications/coastline/climate-change-risks-to-australias-coasts.aspx.

Hennessy KJ, Fitzharris B, Bates BC, Harvey N, Howden SM *et al*. (2007) Australia and New Zealand. In Parry ML, Canziani OF, Palutikof JP, Van den Linden PJ and Hanson CE (eds). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK. pp. 507–540. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch11.html.

Lucas C, Hennessy KJ and Bathols JM (2007) *Bushfire Weather in Southeast Australia: Recent Trends and Projected Climate Change Impacts*. Bushfire CRC, Melbourne.

Poloczanska ES Hobday AJ and Richardson AJ (eds) (2009) *Report Card of Marine Climate Change for Australia (2009)*. National Climate Change Adaptation Research Facility (NCCARF) Publication 05/09. NCCARF, Gold Coast. http://www.oceanclimatechange.org.au/content/index.php/site/welcome.