Climate Change

Impacts for Australia

Introduction

Over the past 200 years, human activities have significantly altered the world's atmosphere. Increases in greenhouse gas concentrations have led to a warming of the Earth's surface and, because greenhouse gas concentrations are continuing to increase, this warming will continue. Other changes in climate, particularly rainfall, are likely to be associated with this warming.

CSIRO projects an annual average warming of 0.4 to 2°C over most of Australia by 2030 (relative to 1990), with slightly less warming in some coastal areas and Tasmania, and the potential for slightly more warming in north-western Australia. By 2070, the warming is likely to be 1 to 6°C over most of Australia with spatial variations similar to those for 2030. Greatest warming occurs in spring and least in winter. In the north-west, most warming occurs in summer.

Annual average rainfall could increase or decrease. Changes vary from –10% to +10% by 2030 and –35% to +35% by 2070, relative to 1990. The main exception is the bias towards decreases in the south-west (–20% to +5% in 2030 and –60% to +10% in 2070), and in parts of the south-east and Queensland (–10% to +5% by 2030 and –35% to +10% by 2070). Decreases are most pronounced in winter and spring. Some inland and eastern coastal areas may become wetter in summer, and some inland areas may become wetter in autumn.

Contributing to these climate changes is an increase in carbon dioxide concentration from about 350 parts per million (ppm) in 1990 to 430–455 ppm by 2030, and 525–705 ppm by 2070.

Confidence is high for projections relating to carbon dioxide and warming, and moderate for the direction of rainfall changes.

What would these changes mean for Australia's agriculture and natural resources and its urban and rural communities?

Climate change will have social, economic and ecological impacts. There will be both winners and losers. All our natural ecosystems are vulnerable to climate change. Those particularly at risk are coral reefs, alpine ecosystems, mangroves and wetlands, tropical forests, savannas, deserts and remnant native grasslands.

Agriculture, fisheries, forests and water resources are also likely to be sensitive to climate change as are cities and towns, the energy sector and industry, although the net effects are much harder to predict.

Adaptation can potentially offset some adverse climate change impacts, but this will come at a cost. Some systems will adapt automatically to some degree as changes occur, but a better understanding of impacts can contribute to adaptation strategies designed to minimise adverse impacts and optimise benefits.

This brochure summarises research on climate change impacts and adaptation undertaken by CSIRO and collaborators. For more information, see the chapter on Australia and New Zealand in the Third Assessment Report on impacts, adaptation and vulnerability published by the Intergovernmental Panel on Climate Change (IPCC, 2001).

Agriculture

Increases in carbon dioxide concentrations and temperature and projected changes in rainfall could have a significant impact on Australia's agriculture. However, predicting the likely impacts of these changes is complicated because increased carbon dioxide boosts plant growth and changes water use efficiency, while projected changes in climate can offset or enhance these benefits.

In dryland farming and grazing lands, where low rainfall often limits plant growth, higher carbon dioxide concentrations may increase plant productivity. However, if warmer conditions are accompanied by rainfall decreases in key agricultural regions, particularly in winter and spring, the benefits of higher carbon dioxide levels will be limited. Indeed, productivity for some plants may be reduced.

Because projected changes in rainfall and temperature vary across Australia, it is important to assess regional impacts. The opportunities to adapt to climate change via new crops, industries, and management practices will vary from region to region.

Wheat

Future wheat yields will depend on both the positive effect of increased carbon dioxide levels and the generally negative impacts of projected climate change. The influence of higher carbon dioxide levels on growth will be particularly pronounced in Australia because our wheat is often grown under conditions of limited water. Wheat in Australia is planted in autumn and winter and grows through to spring, so any projected reductions in winter and spring rainfall over southern Australia would increase moisture stress.

Figure 1 shows the sensitivity of wheat yield to a doubling of carbon dioxide concentration, increases in temperature of 0–4°C and rainfall changes of –20

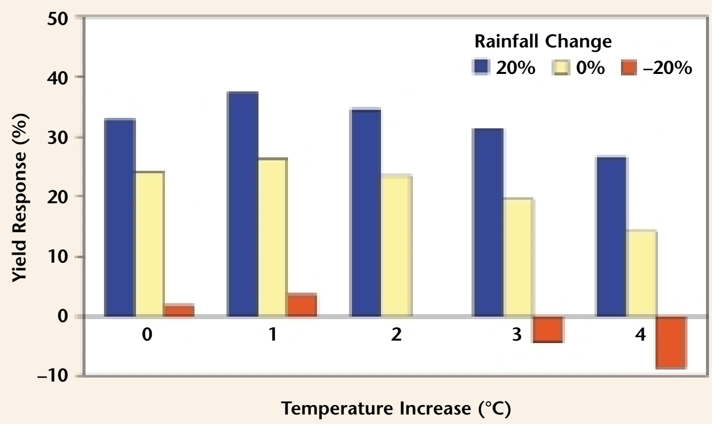


Figure 1: Effect of doubling carbon dioxide (to 700 ppm) and a range of temperature scenarios and three rainfall scenarios (no change, 20% more, 20% less) on average Australian wheat yield (% change from 1986–1996 baseline), using the best variety of wheat under each scenario. The analysis assumes that the regional distribution of cropping is unaffected by global change.

to +20%. These combinations are possible by 2070, except a 0°C warming and / or a 20% increase in rainfall are unlikely. For warmings of 1–4°C with no change in rainfall, yield would increase. However, if rainfall declines by 20%, yield would increase for a 1°C warming but decline for greater warmings. This is because higher temperatures increase the speed of crop development, reducing the time for grain-filling.

The positive response of wheat to higher carbon dioxide levels may come at the price of lower grain protein contents (9 to 15% reduction for a carbon dioxide level of 700 ppm). Low protein wheat is not suitable for uses such as pasta and bread-making. To maintain protein content at present levels, farmers may need to add fertiliser or alternate with nitrogen-fixing plants.

Fruit

Many fruits are sensitive to frost late in the growing season. A projected decrease in frost frequency and severity will reduce frost damage. However, temperate fruits need winter chilling to ensure normal bud-burst and fruit set. Warmer winters will reduce the accumulated chilling, leading to lower yields and reduced fruit quality. Stone-fruit and apples in southern Australia are particularly vulnerable. Adaptation through increased use of chemical treatments is possible, as is selection of varieties that have a lower chilling requirement.

High-rainfall pastures

Temperate pastures in high-rainfall regions are largely found in NSW and Victoria. They are based on exotic grass and grass-legume pastures (e.g. phalaris, ryegrass, clover) and require fertilisation, but provide excellent animal feed and give high levels of animal production.

The positive impact of elevated carbon dioxide levels and negative impact of warming are likely to cancel each other out in this pasture zone.

However, likely decreases in winter and spring rainfall in southern Australia would greatly reduce plant production, significantly constraining animal production.

Rising temperatures are likely to lower milk yield from cows. For example, dairy cows in the Hunter Valley that are kept in the open produce up to 3 per cent less milk than those kept under shelter. This loss represents about 230 litres of milk per cow each year for a high-yielding herd. By 2030, annual milk losses are likely to be between 250 and 310 litres per cow, depending on the rate of warming. Adaptation using shade sheds and sprinklers would limit annual milk losses to about 60 to 90 litres per cow.

Rangelands

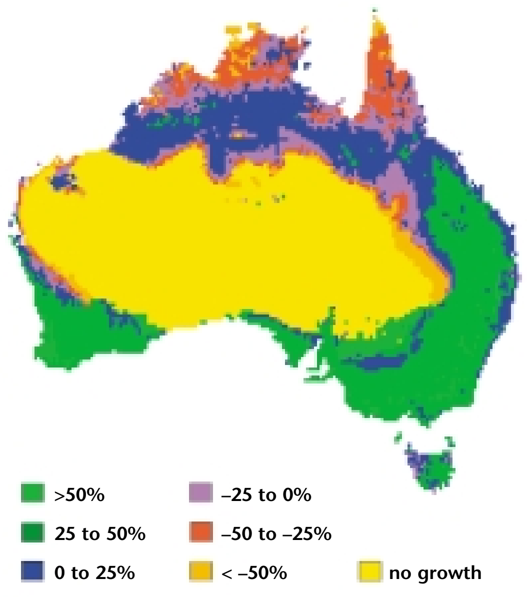
Nearly three-quarters of Australia is rangeland — arid and semi-arid land where the rainfall is too low or too variable to support cropping. Cattle and sheep grazing are the main land uses. Rangelands are ecologically important because of their high species diversity and unique ecosystems.

If rainfall decreases in southern Australia by more than 10% in winter and spring — the main growing seasons for herbage in this area — then forage and animal production will be reduced, despite the benefits of increased carbon dioxide. On the other hand, since summer rainfall in northern Australia may change very little or increase, higher carbon dioxide levels should have a positive impact on plant production in these areas. Decreases in forage quality may reduce some of the potential animal production benefits.

The rangelands incorporate a great diversity of plant and animal species. Climate change and rising carbon dioxide levels have the potential to significantly alter the interactions between plant species in these environments, particularly where there is a delicate balance between the woody and grassy layers.

In cropping and improved pasture areas, there is some scope for adaptation in response to climate change. For example, new plant varieties could be developed that better cope with rising temperature and a drier climate, the zone of tropical and sub-tropical crops could extend southwards, and increases in nitrogen fertiliser may overcome declines in protein content of grains. However, there are few adaptation options in rangelands that rely on natural vegetation to underpin their production systems.

Figure 2. Predicted growth response of forests to doubling of carbon dioxide concentration to 700 ppm and a 3°C increase in temperature.



Forestry

Future forest productivity will depend in part on the balance between the benefits of increased carbon dioxide and the patterns of change in rainfall and temperature.

A doubling of carbon dioxide with a warming of 3°C and no rainfall change, possible by 2070, would encourage tree growth across much of southern Australia, particularly in the wheat belt and semi-arid regions (Figure 2). The increases are likely to be more marked (25–50%) in southern Australia near the more marginal wheat growing areas and the fringes of the pastoral zone. However, a reduction in rainfall in winter and spring in southern Australia, and increased fire frequency, would offset some of these benefits. The benefits will also be affected by changes in pests and in the longer term by limited nutrient supply.

Modest increases (0–25%) in tree growth are likely to occur in parts of the semi-arid tropics. However, in the monsoon tropics of far north Queensland and the Top End, the adverse effect of warming on tree growth will more than offset the gains from a doubling of carbon dioxide, leading to declines of 25–50% in tree growth.

Anticipating the changes up to several decades ahead will assist Australia's forest planners and managers to establish plantations in areas where the climate conditions will be suitable for the life of the trees.

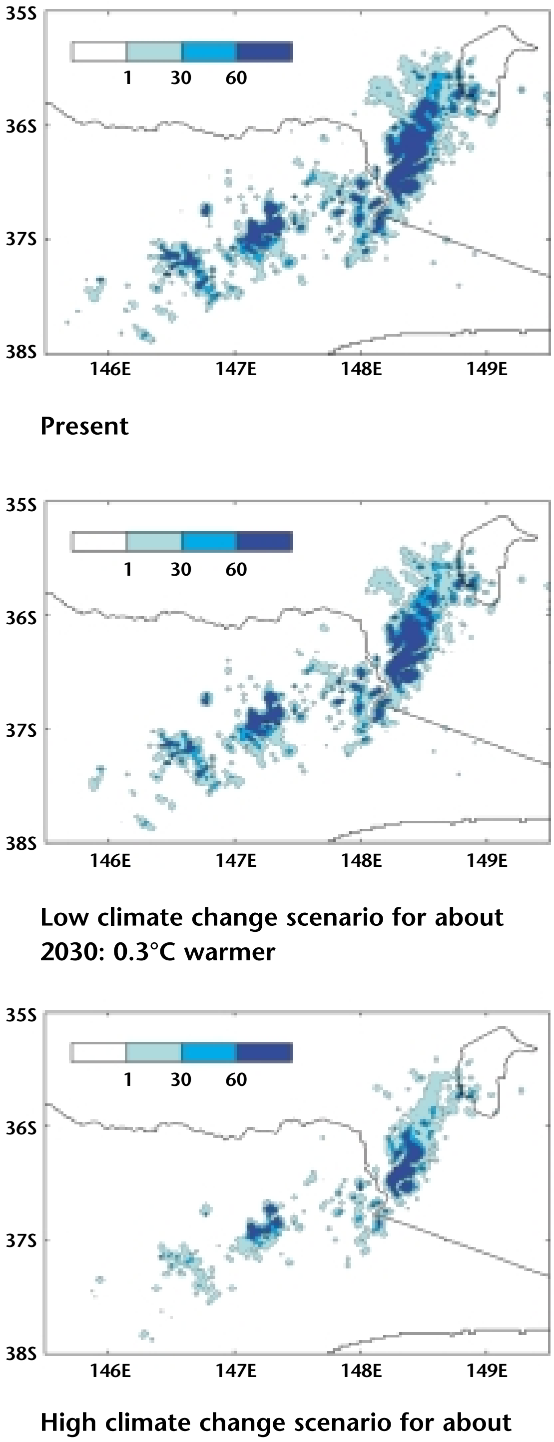
Natural systems

Many natural systems will have difficulty adapting to climate change.

In native forests and woodlands, warmer and drier conditions could threaten many eucalypt species. Eucalypts in alpine systems are particularly vulnerable to warming because they have little scope for retreat. In woodland ecosystems in south-western Australia, the habitats for all frog and mammal species, 28% of *Dryandra* species (a banksia-like native shrub) and one *Acacia* (wattle) species would be significantly reduced for a 0.5°C warming. For a 2°C warming, habitats for 66% of the *Dryandra* species and all *Acacia* species would be eliminated.

The wetlands of Australia are already under threat from dams, irrigation, coastal urban development, and pollution of waterways. Climate change and sea-level rise would add to the vulnerability. If sea-levels rise significantly, the vast freshwater floodplains of

Figure 3: Area covered with at least 30 days snow for present conditions and around the year 2030. A low-climate-change scenario for 2030 leads to 18% less snow cover and a high-climate-change scenario leads to 66% less cover.



Present

Low climate change scenario for about 2030: 0.3°C warmer

High climate change scenario for about 2030: 1.3°C warmer, 8% less precipitation

northern Australia will be subject to significant saltwater inundation. Those wetlands in the Murray-Darling Basin already affected by dams and irrigation would be placed under even more stress by a decline in rainfall.

Riverine environments would be severely affected by reductions in rainfall. While there are possible adaptation strategies, decreasing the amount of water available for irrigation or urban use would be costly and unpopular.

All natural systems are vulnerable to invasion by exotic species. Disturbance by more frequent extreme events like fires and floods is likely to increase that vulnerability by increasing the stress on established vegetation. Projected climate change also increases fire danger in the northern and southern Australian fire zones.

Alpine ecosystems are highly vulnerable to climate change. Less snow and a shorter snow season appear likely. For a warming of 0.3°C with no change in precipitation (a low change scenario for 2030 in the alpine region), the area covered in snow contracts by 18%. If a 1.3°C warming is accompanied by 8% less precipitation (a high change scenario for 2030), the snow area declines by 66% (Figure 3). These factors would reduce many alpine habitats, notably that for

the Mountain Pygmy Possum. Industry based on the snow season would need to adapt.

Coral reefs around the world are becoming stressed by a number of factors: bleaching due to warmer oceans, rising sea-levels, occasional reductions in salinity due to river outflows, increased cloudiness of water, chemical pollutants, local fishing practices and damage from tropical cyclones. Projected global warming will contribute additional stress. Coral bleaching events as severe as that in 1998 may become common by 2020. Increases in cyclone intensity would cause more reef damage. The effect of higher carbon dioxide levels on ocean chemistry may lead to reduced coral growth rates. Natural adaptation will probably be too slow to avert a decline in the quality of the world's reefs.

Pests and weeds

Projected warming will increase the ability of pests to survive winters, and accelerate the development of most of the species that are active in summer.

A warmer climate would enable tropical species, such as Queensland fruit fly and the cattle tick, to spread southwards and threaten exclusion zones established to protect interstate and international trade. Fruit fly damage costs $28.5 million per year at present. If the fruit fly expands its range southwards, damage costs will increase (Table 1), but more importantly, the cost of maintaining the exclusion zone is likely to become unprofitable and export markets will be lost. Other temperate pests, such as the light brown apple moth, which causes fruit damage costing $21 million per year, would be displaced from the warmer parts of its current range. Therefore, crops such as oranges and grapes (grown in the warmer areas) will benefit while cooler regions with apples, grapes and pears will face an increased risk of moth damage.

Plant pathogens are likely to become more severe in areas with dry summers if the frequency of summer rainfall events increases. This would affect the viticulture industry in particular, which is vulnerable to botrytis with summer rainfall. Higher carbon dioxide levels may increase the density of crop foliage and increase the production of pathogens.

Some sub-tropical weeds would benefit directly from climate change and indirectly from reduced competition as unfavourable conditions weaken native species.

As the threat from pests and weeds changes with the climate, new control strategies would be needed.

Table 1. Effect of global warming on pest damage costs (A$millions) for horticultural crops

	Queensland Fruit Fly		*Light Brown Apple Moth*	
	+1°C	***+2°C***	***+1°C***	***+2°C***
Oranges	+1.8	+3.5	–1.3	–4.7
Apples	+2.1	+5.6	+0.5	+0.7
Pears	+0.9	+2.8	+0.2	+0.2
Grapes			–0.5	–1.9

Water resources

Increased water stress is likely due to higher temperature and evaporation. Although increases in stream flow are possible in northern Australia if summer rainfall increases, decreases in stream flow seem likely for southern Australia due to reductions in rainfall. Estimated changes in stream flow in the east-central Murray Darling Basin range from 0 to –20% in 2030, and +5 to –45% in 2070. This would result in water shortages, particularly in winter rain-fed systems that are already under stress. This would sharpen competition between different water users, especially where large diversions to river systems are made for industry and irrigation. Low volume flows are the most sensitive to these changes. Adaptation through increased water use efficiency and demand management strategies is possible in some cases.

In south-western Australia, a reduction in rainfall would adversely affect water supplies for both agriculture and urban communities. However, reduced rainfall in the south-west and Murray Darling Basin would reduce recharge to groundwater, slowing the onset of dryland salinity.

More frequent high-intensity rain in some other areas may have some benefits, contributing to groundwater supplies and filling dams, but would also increase the risks of flooding, landslides and erosion, particularly in catchments with urban development.

Water supplies on atolls and low-lying islands in Torres Strait will be increasingly vulnerable to salt-water intrusion into groundwater from rising sea-levels.

Options for adapting to such changes include integrated catchment management, changes to water pricing systems, water efficiency initiatives, building or rebuilding engineering structures, relocation of buildings, urban planning and management, and improved water supply systems in remote areas and low-lying islands.

Urban and coastal communities

Severe weather affects urban communities in many ways. Torrential rainfall over cities and surrounding catchments can produce severe runoff and flooding. Buildings are damaged not only by the depth of floodwaters but also by the force of the water flow. Both can contribute to structural fatigue. Gales and strong winds directly damage buildings and also generate waves and storm surges that can contribute to coastal flooding.

Each year, severe weather events cause significant damage to the built environment. More than 80% of Australia's population resides within 50 km of the coast, with further growth anticipated. This means that the community's exposure to extreme events — notably tropical cyclones, storm surges and flooding of rivers in deltas and other outflow regions — is growing rapidly. Increases in population in risk-prone areas, combined with increases in storm intensities and rising sea-levels, mean that the cost of flood damage to the built environment will increase.

Rising sea-level, stronger tropical cyclones and increased intensity of oceanic storm surges are likely with climate change. A study has shown that tropical cyclone intensity around Cairns in northern Queensland could increase by up to 20% by about 2050. Stronger cyclones would increase the flood level associated with a 1-in-100 year flood in Cairns from the present height of 2.3 metres to 2.6 metres; a rise in sea-level of 0.1 to 0.4 metres would result in the flood level increasing further to 2.7 to 3.0 metres. This would result in flooding occurring over an area about twice that historically affected. Timely, planned adaptation strategies would reduce the damage such events could cause.

Changes in the timing and amounts of peak seasonal energy loads are likely. Warmer conditions mean less energy demand for winter heating and more energy demand for summer cooling.

Human health impacts

Climate variability and climate change can harm human health both directly and indirectly. Direct effects include injury and death from heat waves, tropical cyclones and floods. Indirect effects include infectious diseases such as dengue fever, food poisoning from fish contaminated by toxic algal blooms, water-borne diseases such as giardia, skin cancer and eye-cataracts due to ozone depletion.

With climate change, parts of Australia may become more favourable for mosquitoes. The potential for mosquito-borne disease infection is likely to increase because warmer conditions would extend the range and growth season of mosquitoes, and encourage humans to spend more time outdoors. Higher temperatures would also accelerate the development of viruses and other pathogens in mosquitoes, so increasing the efficiency of disease transmission. Adaptation strategies, such as behavioural changes, more screening and ventilation of houses and use of safer repellents would constrain the effects on human health.

Estimates of the weather-related deaths in Australia between 1803 and 1992 suggest that 40% were due to heatwaves, 20% to tropical cyclones and 20% to floods. An increase in the intensity of these events is anticipated due to climate change. An assessment of climate-related deaths (excluding floods and cyclones) in Australia's five largest cities by the year 2030 indicates that climate change would lead to an increase in climate-related deaths in summer but a decrease in such deaths in winter.

World Wide Web

This brochure
www.marine.csiro.au/iawg/impacts2001.pdf

The greenhouse effect
www.dar.csiro.au/cc/default.htm

CSIRO Climate Change Research Program
www.dar.csiro.au/div/CCRP/default.htm

CSIRO climate change projections for Australia
www.dar.csiro.au/publications/projections2001.pdf

CSIRO Impacts and Adaptation Working Group
www.marine.csiro.au/iawg

References and further reading

CSIRO (2001): *Climate Change Projections for Australia*. Climate Impact Group, CSIRO Atmospheric Research, Melbourne, 8 pp.

IPCC (2001): *Climate Change: Impacts, Adaptation and Vulnerability. Summary for Policymakers.* Intergovernmental Panel on Climate Change. www.unep.ch/ipcc

Contact

Dr Andrew Ash
CSIRO Sustainable Ecosystems
Davies Laboratory, PMB, Aitkenvale
Queensland, 4814, Australia

Ph: +61 7 4753 8540
Fax: +61 7 4753 8600
Email: andrew.ash@cse.csiro.au

Acknowledgements

CSIRO gratefully acknowledges the following organisations for their contributions:

- Queensland Department of Natural Resources and Mines
- Australian Institute for Marine Studies
- Coral Reefs Cooperative Research Centre
- Department of Mathematics and Statistics, Monash University
- National Centre for Epidemiology and Population Health, Australian National University
- Institute for Science and Technology Policy, Murdoch University.

Disclaimer