G20 CLIMATE RISK ATLAS

Impacts, policy, economics

cmcc

AUSTRALIA

With the scientific contribution of Enel Foundation

How to read the Atlas: graphs, colours and scenarios.

The maps used in this Atlas are taken from **The World Bank Official Boundaries** - ***https://datacatalog.worldbank.org/search/dataset/0038272*** (accessed on May 28, 2021). For the section Energy, the maps are based on Panoply Data Viewer ***https://www.giss.nasa.gov/tools/panoply/credits.html***

Each sector of this Atlas contains data and information on various climate scenarios.

When reported in graphs, the **colour black** indicates data and information referring to the current state, the past or the baseline.

When the authors refer to **RCP (Representative Concentration Pathways)**, the 3 colours used across the factsheet refer to 3 scenarios, which are 3 different development options with different levels of greenhouse gas emissions, **respectively low emissions (green), medium emissions (orange), and high emissions (red)**. The same colour code is used when RCPs are associated with Shared Socioeconomic Pathways (SSP).

In some cases, the authors refer to global warming scenarios. In these cases, the 3 colours used refer to a temperature rise of **1.5°C (green), 2°C (dark green), and 4°C (red)**.

When the authors refer exclusively to **Shared Socioeconomic Pathways - SSPs** (Population affected by river floods in the section: "Water"), data related to **SSP3** - that encompasses, among other things, slow economic growth, material-intensive consumption, and persisting or worsening inequalities – **are reported in a lighter shade**; **SSP5** – which refers to social and economic development that is coupled with an energy-intensive lifestyle and the abundant exploitation of fossil fuel resources – is shown using a **middle shade of the colour**, whereas data related to **the present** conditions **are represented in a dark shade**.

Further details on scenarios, methodologies, and the full list of references are available at: **www.g20climaterisks.org**

Concept and graphic design by element6.eu

AUSTRALIA CLIMATE

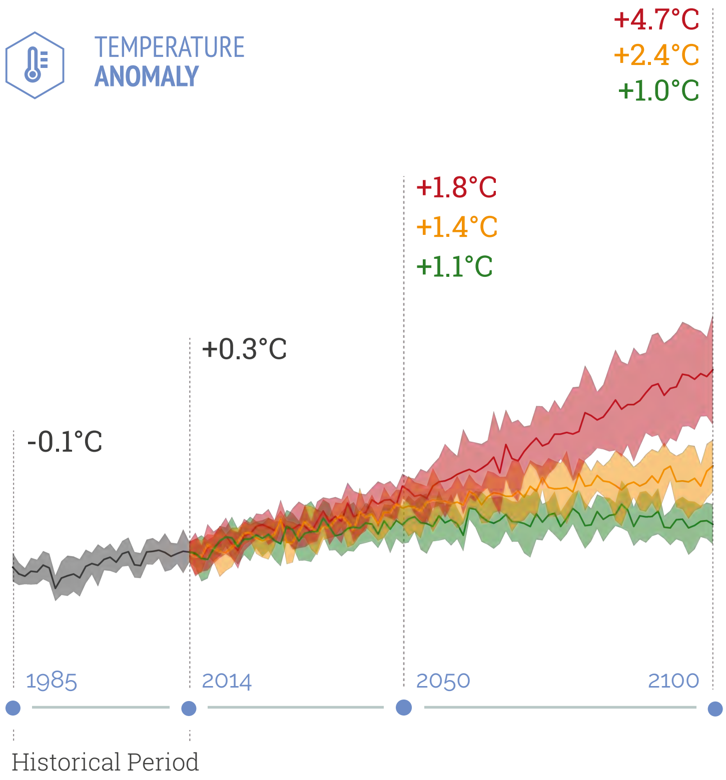
OVERVIEW

Australia is home to tropical, temperate, arid, and alpine climate regimes. Whereas its interior is arid and semiarid, the northern regions are dominated by tropical climate systems with monsoonal rain during the summer and a dry season for the remainder of the year. The southern regions experience winter storm activity originating in the Southern Ocean, and summer high pressure systems pushed southward by the monsoon.

TEMPERATURE PROJECTIONS

Under a low emissions scenario projected temperature variations will remain contained at around +1°C, both by 2050 and 2100.
Under a high emissions scenario, with no reduction in GHG emissions, much greater temperature anomalies are expected by both 2050 and 2100.

TEMPERATURE ANOMALY



TEMPERATURE

Temperature in Australia varies with latitude. Higher values are typical in the north-west, whereas lower values are reached when approaching the polar zone in the south, especially on the island of Tasmania.

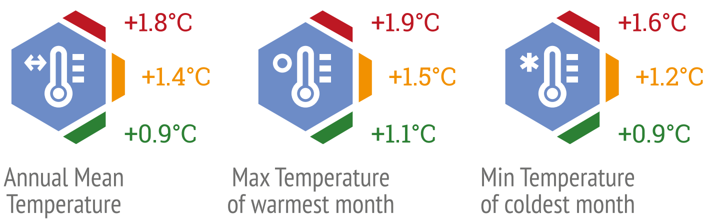
MEAN TEMPERATURE

+7 29

Celsius degrees / Over 1991-2020

EXPECTED VARIATION FOR TEMPERATURE AT 2050

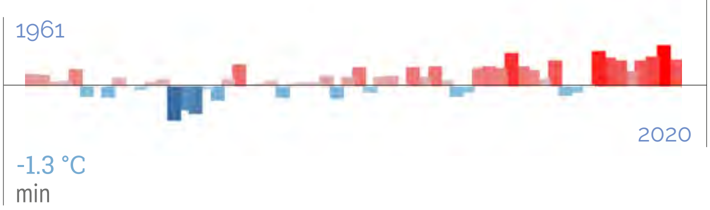
The indicators show variations in selected temperature characteristics for a thirty-year period centred on 2050 (2036-2065) with respect to the reference period 1985-2014.



TEMPERATURE TREND

Temperature anomalies over the last 60 years with respect to the annual mean of 22°C in Australia during the 1961-1990 period

max
1.6 °C



PRECIPITATION

Historically observed trends show rising rainfall in many tropical areas and falling rainfall in many temperate areas. Rainfall from tropical cyclones also cause intermittent widespread flooding. The El Niño-Southern Oscillation climate pattern occurs intermittently every 2–7 years affecting inter-annual rainfall patterns in eastern and southern regions. El Niño events are associated with increased likelihood of extreme events such as drought and above average rainfall. Sea surface temperatures also play a role in rainfall variability, particularly in the south of the continent.

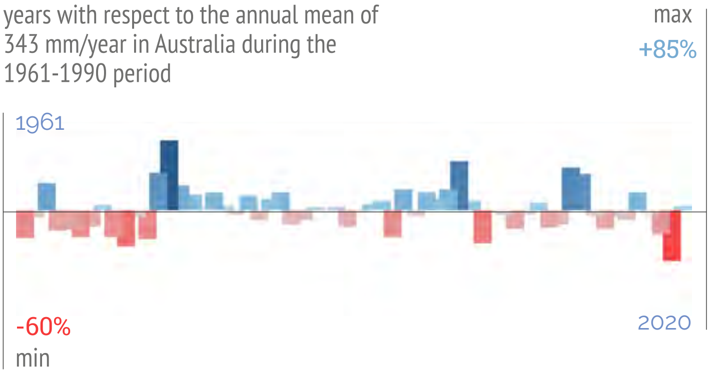
MEAN PRECIPITATION

146 — 2,209

mm/year / Over 1991-2020

PRECIPITATION TREND

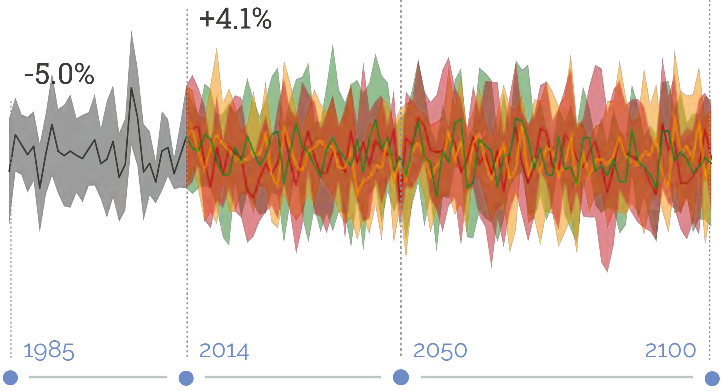
Precipiation anomalies over the last 60 years with respect to the annual mean of 343 mm/year in Australia during the 1961-1990 period



PRECIPITATION PROJECTIONS

Precipitation trends are complex and reveal a large variability following all emissions scenarios, although a slight tendency to reduction is observed under a high emissions scenario. This is due to the complexity of the precipitation regime and dynamics requiring more detailed spatial and temporal analysis.

PRECIPITATION ANOMALY



EXPECTED VARIATION FOR PRECIPITATION AT 2050

The indicators show variations in selected precipitation characteristics for a thirty-year period centred on 2050 (2036-2065) with respect to the reference period 1985-2014.

Annual total precipitation	+0.0%	-2.1%	-0.5%
Precipitation of wettest month	+3.2%	+2.0%	+1.0%
Precipitation of warmest quarter	-3.2%	-3.2%	-0.0%

VARIATION OF SPECIFIC CLIMATE INDICATORS

Climate indicators variation showing impacts of climate change on sectors such as agriculture, health and water. Analysis considers 3 threshold average temperature increase: **+1.5°C**, **+2°C**, **+4°C**.

Agricultural drought proportion of time	% of time	+27%	+15%	+12%
Hydrological drought proportion of time	% of time	+24%	+13%	+10%
Heatwave duration	% of time	+3,980%	+320%	+87%
Runoff increase	% of area	+30%	+9%	+5%
Agricultural drought frequency	% of change	+76%	+36%	+22%
Hydrological drought frequency	% of change	+13%	+10%	+12%
Heatwave frequency	% of change	+63%	+24%	+11%
Runoff decrease	% of area	+7%	+3%	+2%

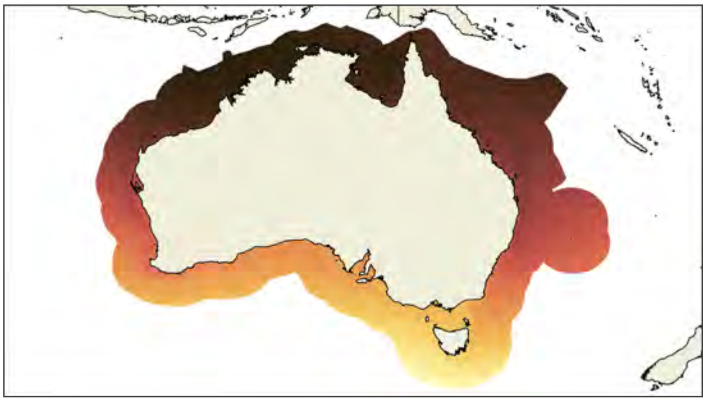
AUSTRALIA OCEAN

OCEAN IN AUSTRALIA

Australia's marine exclusive economic zone comprises a wide range of coastal ecosystems including extensive meadows of seagrasses, tidal salt-marshes, mangroves, and the Great Barrier Reef. In particular, coastal systems can be divided into three main areas: Indian, Pacific and Southern ocean marine regions.

CURRENT CLIMATE CONDITIONS

Mean sea surface temperature reflects the different climate regimes, from the cold waters of Tasmania to the subtropical regime on the northern coasts.

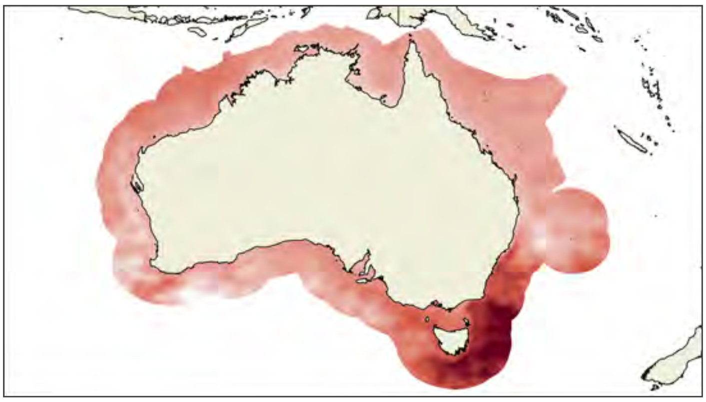


MEAN

SEA SURFACE TEMPERATURE

Celsius degrees / Over 1991-2020

TREND



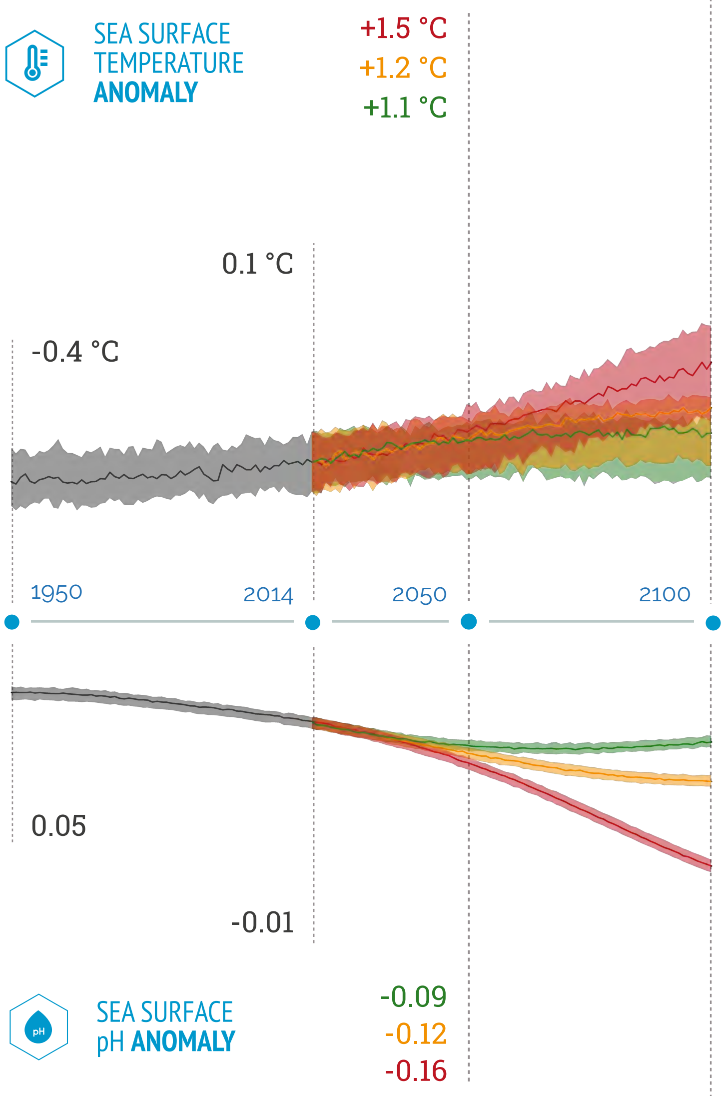
Surface temperature trends indicate a general warming of 0.2°C per decade in all marine areas, with increased gains in the colder regions facing the Southern Ocean.

FUTURE PROJECTIONS

Projected annual changes within the marine EEZ for the two most significant marine indicators of climate change: sea surface water temperatures and pH.

Seawater temperature changes are in line with the definitions of each scenario, with maximum values in 2100 above +3°C under a high emissions scenario in 2100.

+3.4 °C
+2 °C
+1.3 °C



Seawater surface pH becomes more acidic in all scenarios, closely reflecting rising atmospheric CO_2 concentrations, and only a low emissions scenario leads to a stable condition by 2100.

-0.09
-0.19
-0.39

ECOSYSTEM INDICATORS AT 2050

Regional changes in key marine ecosystem indicators under projected future scenarios by mid-century (2036-2065) with respect to present climate conditions (1985-2014).

	Indian	Pacific	Southern Ocean
Temperature regulates the metabolism of marine organisms determining which habitats remain suitable. Excessive warming will likely push ecosystems beyond tolerance thresholds.	25.22°C	22.51°C	15.46°C
	+1.26 °C	+1.74 °C	+1.11 °C
	+1 °C	+1.42 °C	+0.82 °C
	+0.85 °C	+1.43 °C	+0.71 °C
pH represents the acid/base status of marine waters, where a decreasing pH reflects the acidification of the ocean due to increased absorption of atmospheric CO_2.	8.09	8.1	8.1
	-0.16	-0.16	-0.16
	-0.12	-0.12	-0.12
	-0.09	-0.09	-0.09
Oxygen is fundamental to sustain marine life and its reduction can have a large impact on coastal ecosystem services including fisheries and aquaculture.	212.9 mmol/m³	222.6 mmol/m³	254.59 mmol/m³
	-2.02 %	-2.58 %	-1.97 %
	-1.6 %	-2.24 %	-1.33 %
	-1.35 %	-1.89 %	-1.21 %
Chlorophyll is an indicator of the biomass available at the base of the marine food web supporting all ecosystem productivity.	0.16 mg/m³	0.27 mg/m³	0.34 mg/m³
	-4.29 %	-6.72 %	+10.56 %
	-11.66 %	-14.55 %	+2.35 %
	-7.98 %	+2.24 %	+4.11 %

FISH CATCH POTENTIAL

Fish catch potential is an estimate of the maximum fish catch achievable given the marine resources available over a sustained period. It is linked to the concept of maximum sustainable yield, meaning the maximum amount of fish that can be extracted from a system without causing a collapse in fish populations.

It is a characteristic of the natural system, which is substantially different from realized catch, and a direct result of the fishery policy in place.

Fish catch percentage change

2050

-11.4%

-4.7%

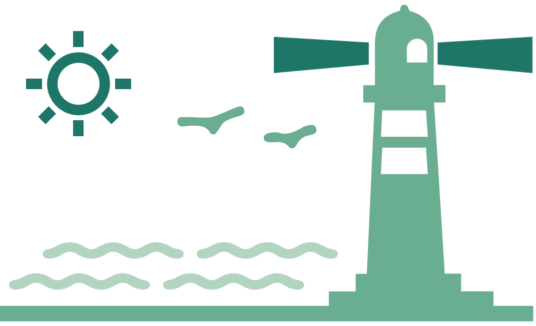
ANALYSIS DETAILS

All datasets were analysed using only data from within the marine EEZ and therefore excluding overseas territories, detached islands and any disputed or joint territories with other nations. In the assessment of current climate conditions, seawater surface tempereature data was obtained using satellite observations distributed in the framework of ESA Climate Change Initiative.

Future projections of marine indicators are represented by the combined analysis of results from 15 different Earth System models participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6). These models include new and better representations of physical and biogeochemical processes, compared to previous IPCC assessment reports.

Fish catch potential data was obtained using the FAO's technical report and refers to the best and worst case climate scenarios from the Fifth IPCC Assessment Report. These mean estimates are subject to substantial uncertainties as discussed in the original work.

AUSTRALIA COASTS



OVERVIEW

Australia's coastline extends for 66,530 kilometres along the Pacific, Indian and Southern oceans, the Timor Sea and the Gulf of Carpentaria. Tidal waters influence rivers, creeks and waterways for several kilometres inland. Australia has a great variety of coastal ecosystems, including rocky cliffs, sandy beaches and dunes, wetlands and the Great Barrier Reef. Most of the 25 million people living in Australia are concentrated in large coastal cities, with settlements and infrastructure often located in low lying areas and coastal floodplains.

Shoreline Length: 66,530 km

Sandy Coast Retreat at 2050: -51.7 m

CLIMATE CHANGE HAZARDS

Coastal hazards such as erosion, storm tide inundation and permanent flooding, can have strong adverse impacts on coastal regions, with loss of sandy shores, damage to settlements, infrastructure and ecosystems. Climate change can exacerbate these impacts due to rising sea levels and increasing impacts of waves and storms. In Australia, tropical cyclones are expected to increase in intensity and possibly impact highly populated coastal areas further south. Changes in rainfall intensity associated with tropical and extratropical storms may exacerbate the impact of storm surges on the coast.

SEA LEVEL RISE

Relative sea level rise has been observed over the past century around the coast of Australia, with a yearly average increase of 1.82 millimetres per year since the 1990s. The latest IPCC projections indicate that, by 2050, global sea levels may rise between 0.18 metres, under a low emissions scenario, and 0.23 metres, under a high emissions scenario.

Observed and projected sea level rise at 2050: 1.82 mm/year; 0.23 m; 0.18 m

EXTREME SEA LEVEL

Extreme sea levels are expected to increase in line with sea level rise, increasing the frequency of damaging high water level conditions. On average, one in 100 year extreme sea level events in Australia are expected to rise from 2.84 metres at present day to 3.03 metres by 2050, under a medium emissions scenario.

Current and projected extreme sea level at 2050: 2.84 m; 3.12 m; 3.03 m

OBSERVED STORMS

The Australian continent features a broad range of wave climate regimes and storm patterns. In general, the northern half of Australia is exposed to large tropical cyclones, whereas other populated areas further south are subject to seasonal ocean storms. With a growing shoreline population, damages to settlements and infrastructure from inundation and erosion have been increasing.

FUTURE STORMS

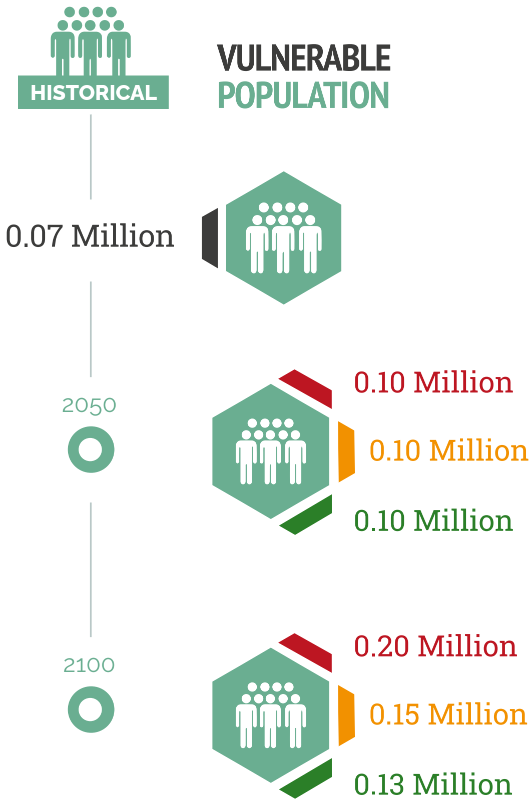
Large storms are expected to increase in intensity as a consequence of the increasing energy stored in ocean waters, exacerbating the impact of the rising waters on buildings, infrastructure, services and ecosystems. Increasing temperatures are likely to affect storm patterns around the Australian continent, with a possible increase in extreme sea levels and a southward migration of tropical storms, affecting areas higher population densities.

VULNERABILITY AND RISK

Population and assets, including buildings and infrastructure, are concentrated on the coast. Coastal areas gradually more at risk of being inundated in the future. Increasing storm energy is likely to exacerbate erosion and inundation issues already present around the Australian coast, which will be compounded by sea level rise.

For example, in the City of Gold Coast, one of the largest coastal cities in Australia, the area vulnerable to climate change is projected to increase by 20% if no action is taken to reduce this impact, including 746 hectares of conservation area. Damage to coastal assets, including buildings and infrastructure are expected from shoreline recession, storm erosion and increasing flood occurrence and intensity.

Key coastal ecosystems can also be impacted by rising seas and increasing storms, with potential damage to mangroves, wetlands, and estuaries. The population exposed to the annual coastal flood level is expected to increase from 70,000 to 100,0000 people under a medium emission scenario by 2050.



INFLUENCE OF SEA LEVEL RISE ON EXTREME SEA LEVEL

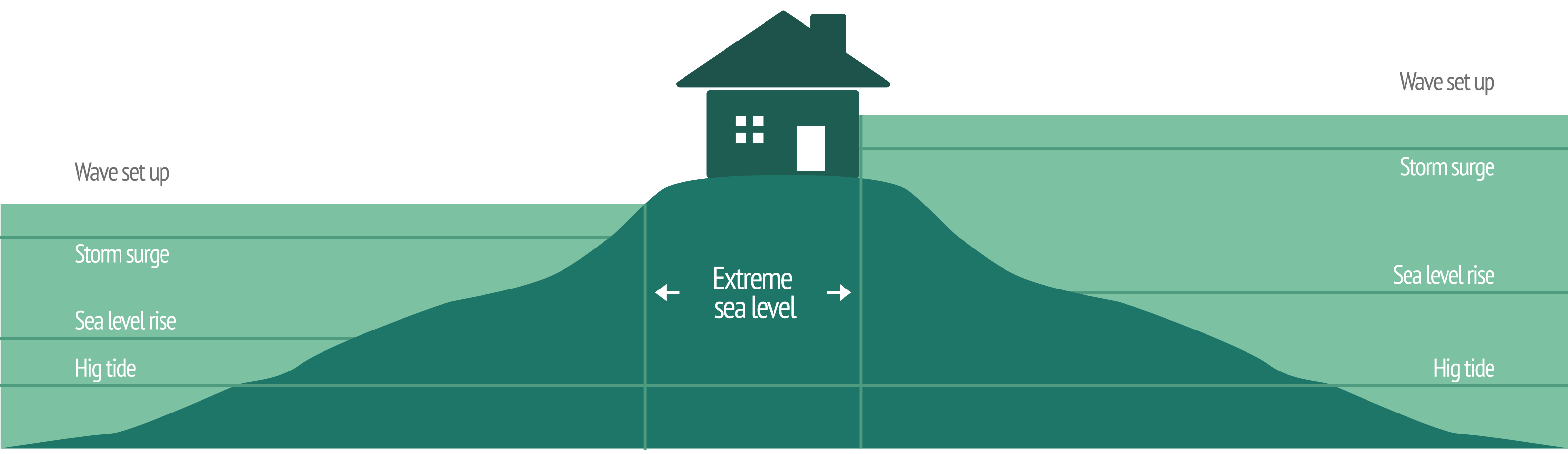
Present and future sea level rise are a consequence of carbon induced global warming causing melting ice and ocean expansion due to heat accumulation.

The extreme sea levels reported here are based on the 100-year storm surge + wave set up + sea level rise + high tide indicators. The first two parameters (storm surge + wave set up) are based on the 100-year value for the event; sea level rise is its projected value at 2050; and high tide is the absolute value of the highest tide calculated for a given locality, which won't be influenced by climate change.

+ Wave set up refers to the accumulation of water near the shore due to the presence of breaking waves.

+ Storm surge is an occasional increase in sea level driven by shoreward wind-driven water circulation and atmospheric pressure.

+ High tide is usually the highest tide reached in a given location based on tide records.



Present sea levels have risen globally by approximately 20 centimetres over the past century.

Future sea level rise is a projection based on different global warming scenarios, at approximately 100 centimetres by the end of 2100, with consequent inundation during extreme sea level events.

AUSTRALIA
WATER

OVERVIEW

Australia has been facing challenges associated with growing urbanization, growing demand for food, and the need for environmental flows, all of which have increased water demand.

The deep vulnerabilities of Australia's water resources have been exposed in recent decades, with extreme floods and droughts also threatening ecosystems. In addition, climate change, mainly in the south, has exposed the region to a further decrease in water availability.

The high variability in precipitation around the country affects runoff, streamflow, groundwater recharge and water availability for human use.

Renewable internal freshwater resources: 492 billion m^3

Renewable internal freshwater resources per capita: 19,998 m^3

40% of Australia sees less than 300 millimetres of rainfall per year. Whereas 72% of water runoff occurs in the north, in coastal Queensland and Tasmania, only 7% is generated in the Murray-Darling Basin, where more than two-thirds of Australia's irrigation water is used. Water harvesting, storage and distribution have therefore become vital to urban and regional development whilst also contributing to the ecological decline of rivers, wetlands and floodplains.

CLIMATE CHANGE HAZARDS

Climate change can affect water resources through increasing temperatures, higher rates of evapotranspiration and altered rainfall patterns. This leads to changes in the water cycle, including decrease of snow and ice coverage, alterations of surface runoff and groundwater storage, as well as drought and flood occurrence. Australia's water security has already been significantly influenced by climate change.

The severity of floods has increased and droughts are becoming more severe due to drier, hotter conditions, leading to declines in soil moisture due to increased water loss from plants and soil. Southeast Australia has experienced a 15% decline in late autumn and early winter rainfall, and a 25% decline in average rainfall in April and May since the mid-1990s.

KEY POINT RUNOFF

Australia is the driest populated continent and, on average, only 9% of precipitation becomes runoff, and approximately 2% percolates through the soil to recharge groundwater: one of the lowest proportions of rainfall conversion in the world.

At a country scale, an average increase in surface runoff by approximately -4% and 4% is expected, respectively, under the low emissions and high emissions scenarios for the 2045-2055 period, compared to 2015-2025.

If temperatures rise by 1.5°C, 2°C or 4°C, 2.0%, 3.3% or 7.0% of the country will likely experience an increase in runoff, whereas 5%, 9.4% or 30% of the surface of the country will likely experience a respective decrease in runoff.

2050

Changes in annual runoff
% of change

+3.6%

-3.8%

2050

Runoff increase
% of area

+7%

+2%

KEY POINT DROUGHTS

Prolonged periods of lower than average rains, mostly driven by the El Niño cycles, can cause droughts and may impact ecosystems, water availability for human uses, including domestic use and agriculture, and create the conditions for catastrophic bushfires. The role of climate change in rainfall reduction over southern Australia and along the Great Dividing Range has been broadly discussed. Many parts of the country - especially in the southeastern regions, but also in the west - have seen sharp declines in cool-season (April to October) rainfall in recent decades.

The likelihood of severe droughts in Australia is expected to increase by 16.8%, 18.1% and 25.6% (2040-2059) under low, medium and high emissions scenarios. Similarly, If temperatures rise by 1.5°C, 2°C or 4°C, there is an expected increase of hydrological drought frequency by 8%, 9.7% and 14%, respectively.

2050

Severe drought likelihood increase

% of change

+25.6%

+16.8%

2050

Hydrological drought frequency

% of change

+13.0%

+9.0%

2050

Groundwater Recharge

% of change

+24.7%

-11.7%

KEY POINT GROUNDWATER

Australia's use of groundwater has increased significantly over recent decades. For example, in the 13 years from 1983 to 1996 the national reliance on groundwater increased by nearly 90%. Current effects of climate change can be seen through the spatial variations of the groundwater availability, also compromised by the more frequent prolonged drought periods.

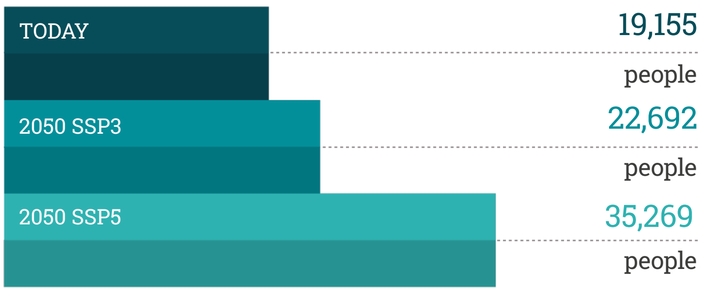
Many studies agree on a strict positive correlation between future rainfall trends and groundwater recharge in Australia. In addition, coastal groundwater may be susceptible to changes in salinity because of saltwater intrusion, associated with sea level rise. At the country level, a -11.7%, +14.9% and +24.7% change of the annual groundwater recharge for the period 2045-2055 compared to the timeframe 2015-2025 is expected respectively under low medium and high emissions scenario.

KEY POINT FLOODS

The flooding of rivers following heavy rainfall is the most common form of flooding in Australia. Flooding of rivers in inland areas of central and western New South Wales (NSW) and Queensland, as well as parts of Western Australia, can spread for thousands of square kilometres and may last for weeks or even months. For example, the March 2021 floods in NSW, driven by a seasonal La Niña climate, caused widespread damage; at some locations approximately 900 millimetres of rain fell in one week.

Changing rain patterns may affect the frequency and intensity of floods. Changes in the population exposed to river floods are expected, with an increase from about 19,000 in the present day to 23,000 under SSP3 and 35,000 under SSP5 by 2050. As such, potential impacts related to river floods might increase.

POPULATION AFFECTED BY RIVER FLOODS

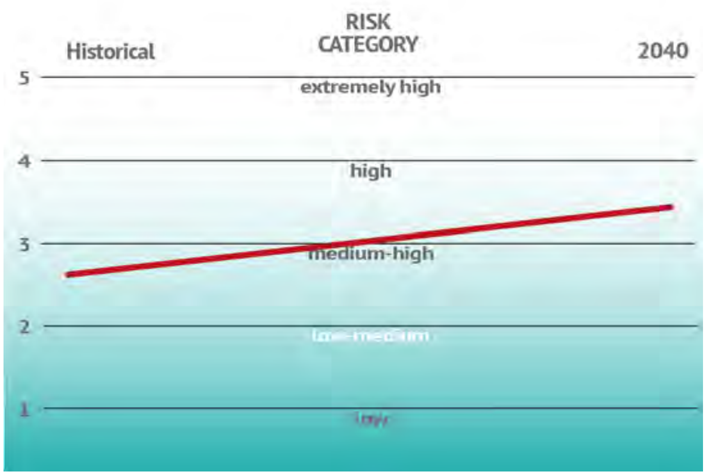


RISK INDICATORS

The water stress index summarises current and future water related vulnerabilities and risks at the global level. Scores are based on the ratio of total water withdrawals, including agriculture, industrial and human consumption, to available renewable surface and groundwater supplies.

WATER STRESS

Australia's water stress level is considered medium-high for the recent past (1960-2014 average), and it is expected to increase in the near future (2030-2050) based on climate change projections.



AUSTRALIA

AGRICULTURE

OVERVIEW

Australia is a major agricultural producer and exporter. In fact, the agricultural sector is still a significant contributor to GDP and employment. Australia is a major agricultural producer and exporter. In fact, the agricultural sector is still a significant contributor to GDP and employment.

Production of cereals, oilseeds and grain legumes, for both human consumption and livestock feed, occurs throughout the more fertile and well-watered areas across New South Wales, Victoria, South Australia, and Western Australia. Sugarcane is also grown throughout tropical areas of Australia such as Queensland, whereas tropical crops and fruits are found right up to the Northern Territory. In the temperate regions of South Australia and New South Wales, there is significant production of fruits (grapes, nuts and citrus) and horticulture. Irrigation in agriculture is extremely important, especially for high value cash crops, adsorbing 64% of total water withdrawal in 2017.

33.5 Mt
Sugarcane

9.3 Mt
Barley

20.9 Mt
Wheat

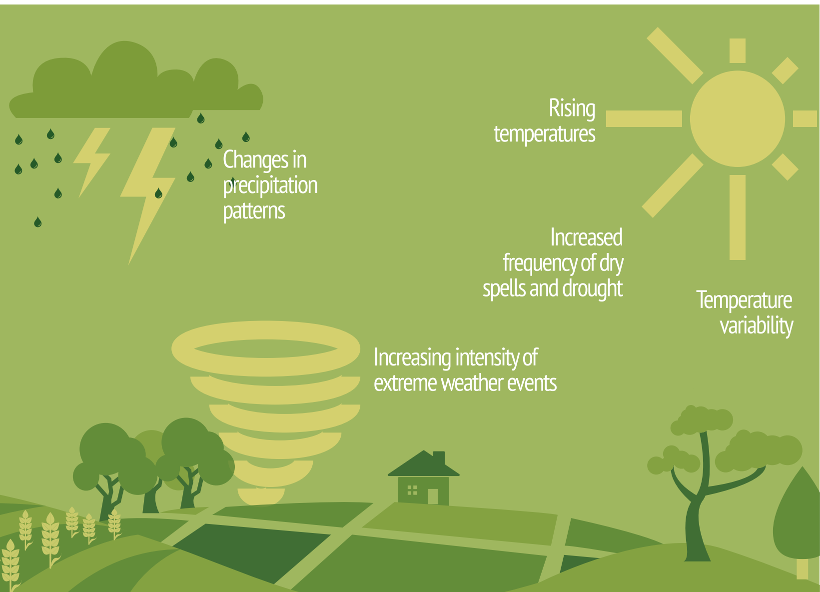
3.9 Mt
Rapeseed

1.7 Mt
Grapes

	Added Value of Agriculture, Forestry and Fishing	Share of Agriculture Value added in Total GDP	Agricultural land	Area Equipped for Irrigation
2000	26,185 USD Million	3.3 %	23,769 Thousand HA	2,384 Thousand HA
2018	30,678 USD Million	2.3 %	31,306 Thousand HA	2,546 Thousand HA

EXPECTED IMPACTS ON AGRICULTURE PRODUCTIVITY

Rising temperatures, reduction in average annual precipitation, and intensification of extreme events such as heat waves and drought, affect production variability with a tendency towards yield reduction for many cultivated species, accompanied by a probable decrease in food quality. Crops respond to increases in temperatures with changes in duration of the growing season, early appearance of phenological phases and potential shifts of cultivation areas toward higher latitudes and altitudes for better growing conditions. However, impacts vary significantly depending on the geographical area and specific crops in question.

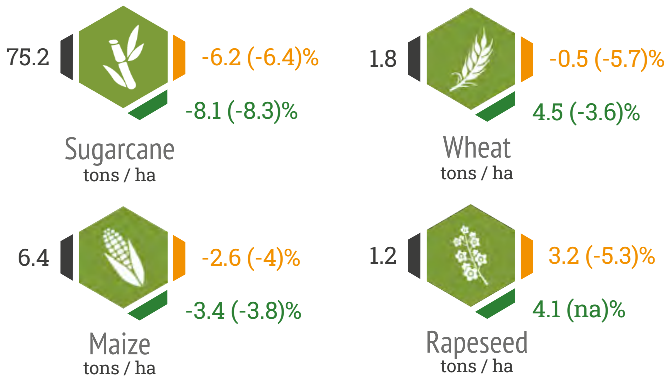


CROP PRODUCTIVITY

Crop productivity refers to the harvested yield of a crop per unit of land area. It is strongly influenced by climate and other environmental and management factors.

Climate change is expected to have an impact on the productivity of several major crops, although this may in part be offset by the fertilizing effect of higher CO_2.

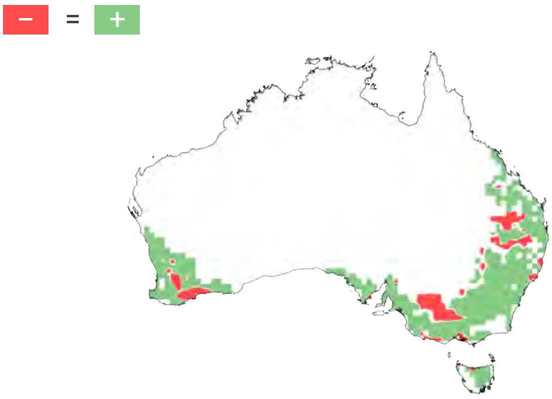
Impacts are estimated using a range of model projections based on low to high emission scenarios and reported as percentage changes between the 30-year average around the historical period and the 30-year average around 2050.



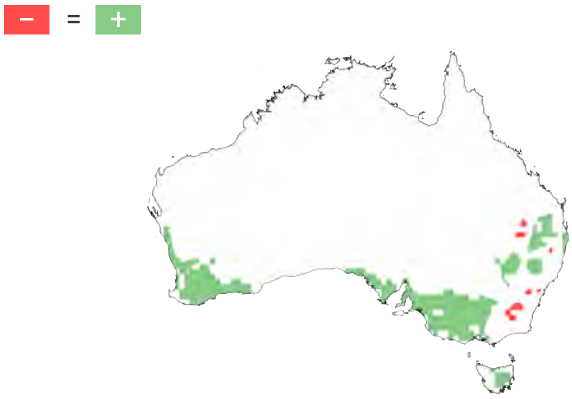
2050

Productivity change with (without) the CO_2 fertilization effect. Estimates assume sufficient water and nutrient supplies, and do not include impacts of pests, diseases, or extreme events.

CHANGE IN WHEAT



CHANGE IN RAPESEED

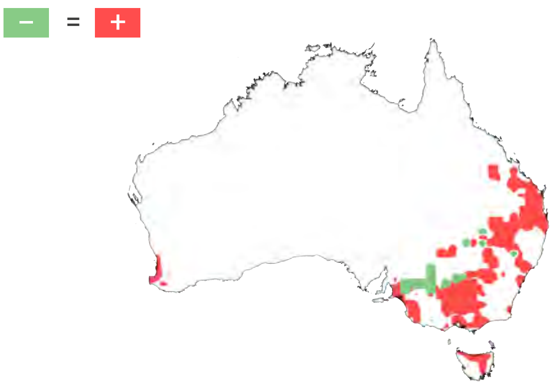


Increasing temperatures and precipitation decline may negatively affect cereal yields, although this may in part be offset by the stimulating effect of higher CO_2. Although projections are characterized by uncertainty in future precipitations, they do reveal an average decrease over the warmer and northern wheat growing areas. Sugarcane, and other C4 crops such as maize, may suffer a strong decline. Sea level rise over coastal areas may also severely effect sugarcane production. Rapeseed cultivation may largely benefit from climate change, with general increases of up to 10% in productivity. Increasing temperatures could severely alter phenology and reduce chill accumulation in the colder periods needed to synchronize flowering and fruiting of tree crops. High temperatures would also have detrimental effects on fruit quality and burn some leafy horticultural crops.

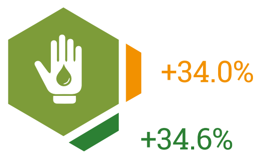
ADAPTATION IN AGRICULTURE AND WATER RESOURCES

Climate change may have some positive effects on some of the most widely used crops. However, higher temperatures will generally require an increase in irrigation due to higher plant evapotranspiration and expansion of irrigated areas. One of the major issues affecting future Australian agriculture could be recurrent droughts and deteriorating water security. Agriculture may become even more reliant on irrigation in the southeast and southwest of Australia, where water resources are already largely overallocated. In contrast, the northern regions are projected to become wetter.

CHANGE IN WATER DEMAND



Agriculture
Water Demand
% of change



2050

A substantial increase in water demand, from 30 to 35%, to maintain agricultural production, will require adaptation practices and crop varieties that enhance water-use efficiency and limit stress on water resources.

AUSTRALIA FORESTS

FORESTS IN AUSTRALIA

Australian native forests are distributed along the coasts and dominated by eucalypts, playing an important economic, cultural, and environmental role. However the ability of these forests to absorb carbon dioxide and fight global warming is severely undermined by fires. Australia is also home to the third largest mangrove area in the world.

1990

132 Mln ha
Million hectares
Forested area

167 Tons/ha
Tons of Carbon per hectare
Carbon stock

2020

134 Mln ha
Million hectares
Forested area

164 Tons/ha
Tons of Carbon per hectare
Carbon stock

FORESTED AREA AND CARBON STORAGE

Forests cover approximately 17% of Australian lands with a constant trend in recent decades. According to Australian Government plantations, commercial and conservative forests store an estimated 10.5 Gt of carbon (not considering soil). Overall, forests in Australia can be considered as a carbon sink.

FOREST PRODUCTIVITY

Forest productivity or Net Primary Production is the net carbon captured by plants. It is the difference between the carbon gained by Gross Primary Production - net photosynthesis measured at the ecosystem scale - and carbon released by plants' respiration. It is expressed per unit land area.

2050

Productivity anomaly
Tons of Carbon per hectare per year

+0.14

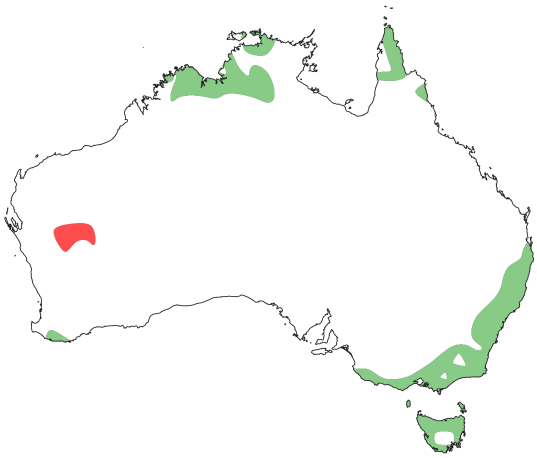
+0.02

Potential increase only in the south east and particularly in Tasmania.

+ Fertilizing effect of increasing atmospheric CO_2, especially for plantations
+ Climate warming is likely to lengthen the growing season

Potential decrease in Western Australia, especially for the native forests of the Mid-West (open woodlands).

+ Extreme heat may limit forest growth in summer



KEY SPECIES UNDER CLIMATE CHANGE

DIEBACKS
EUCALYPTUS
Large drought-induced diebacks in southwestern Eucalyptus forests

RISK
MEDITERRANEAN WOODLANDS
Forests of the Brigalow Belt and the Mediterranean Woodlands are at great risk

VULNERABILITY
SUBTROPICAL FORESTS
Subtropical Moist Forest region shows high vulnerability

VULNERABILITY
MANGROVES
Extreme vulnerability of mangrove ecosystems in the Gulf of Carpentaria and western coast

FIRES IN AUSTRALIA

Fire is a structural ecological process that provides several types of ecosystem services and impacts on socio-ecological systems, including human health, carbon budgets, and climate change. Changes in global fire activity are influenced by multiple factors such as land-cover change, policies, and climatic conditions. Fire also releases large quantities of greenhouse gases into the atmosphere, contributing to a vicious cycle.

During the last two decades the total forest area affected by fire was approximately 144 million hectares.

BURNING
144 MILLION HECTARES OF FOREST

EMITTING
112.5 TERAGRAMMES OF CARBON PER YEAR

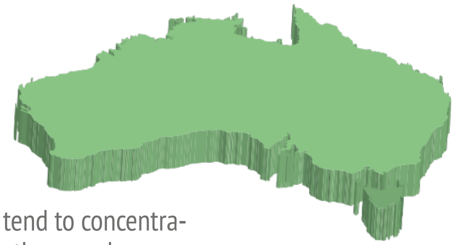
SAVANNA FIRE EMISSIONS CONTRIBUTED TO 86.6% OF TOTAL FIRE RELATED CARBON EMISSIONS

COSTING
4.7 BILLION USD IN BUSHFIRE RELATED INJURIES AND FATALITIES BETWEEN 1967 AND 2013

WHERE DO FIRES OCCUR?

Wildfires in Eucalyptus forests and savannas are the most common, as well as low intensity grass fires in winter and medium intensity shrub fires in spring.

Fire frequency varies by two orders of magnitude among the fire pyroregions. It is highest in the eucalyptus savanna woodlands of the monsoon tropics and lowest in the temperate and tropical rain forests.



Forest fires tend to concentrate in the Northern and Western Australia, North-East Queensland, and South New South Wales and Victoria.

The 2019/2020 fire season registered at least 34 deaths as a direct consequence of bushfires and around 10 million people across three states were exposed to extremely unsafe smoke and ash levels.

FUTURE BURNED AREA

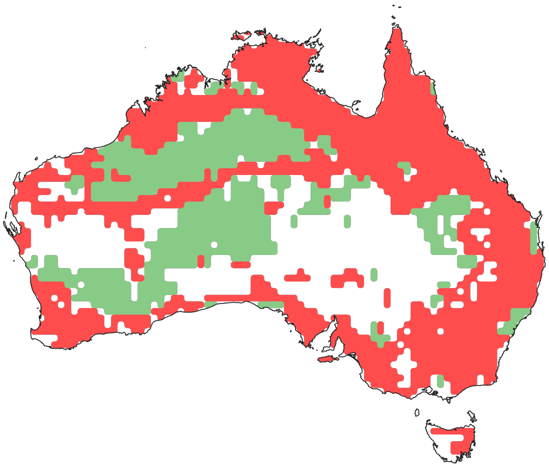
Under a low emissions scenario, Australia might experience a generalized increase in burned area in northern tropical savannas and, to a less extent, in eastern temperate forests. In contrast, northern and southern desert burned area is expected to decrease. Under a medium emissions scenario the distribution of burned area is expected to be similar, except for an increase occurring in northern desert and in mediterranean areas.

Burned Area
km² per year

2050

+12,507

+6,138



Decrease in burned areas for a low emissions scenario

Increase in burned areas for a low emissions scenario

+ Prolonged fire season at the end of the century, particularly in central, northern and western areas.

+ Increasing amount of days with weather conditions considered conducive to fires and number of fires per area.

VARIATION OF SPECIFIC FIRE INDICATORS

% of change
Average fire danger

2050

+15-40%

+8-15%

days
Average fire season lenght

+20

+10

Billion US$
Losses in timber production

2050

21.1

21.5

FUTURE FIRE EMISSIONS

Under a low emissions scenario, fire emissions are expected to increase in the coastal areas of northern and south-eastern regions, whilst decreasing in central and eastern inland areas. Under a medium emissions scenario, fire emissions are expected to increase over eastern and western inland areas.

Fire Carbon emission
Teragrams of Carbon per year

2050

+10.9

-13.3

AUSTRALIA URBAN

OVERVIEW

Total population is projected to increase by nearly 30% by 2050, becoming over 90% urbanized.

72% of Australians live in the country's five largest cities with populations ranging between 1 and 5 million people. By 2035, the two largest cities will have over 5 million inhabitants each.

Built up areas cover 0.16% of the country (12,323.78 square kilometers).

Population in Urban Areas

2020: 21,903,705

2050: 30,186,022

Graphs refer to data provided by United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization

Urbanization Rate

2020: 86.2%

2050: 91.0%

OVERVIEW OF KEY CLIMATE IMPACTS IN URBAN AREAS

Climate change impacts on cities include heatwaves, extreme rainfall and intense cyclones, harsh fire weather, and severe storm surges associated with sea level rise. Urban built environments, major infrastructure and productivity will increasingly experience the damaging effects of these climate impacts.

HEATWAVES AND HEAT STRESS

Cities are subject to higher temperatures because of the Urban Heat Island (UHI) effect. Built up areas absorb solar radiation during the day and release the heat at night, warming the surrounding air. In Australia, the magnitude of urban overheating is determined by a combination of the UHI effect and dualistic atmospheric circulation systems - cool sea breeze and hot desert winds.

The number of heatwave days is increasing in all capital cities. The length of the longest heatwave is also growing in half of the cities while it remains unchanged in the other half. 5 of the capital cities also observed an increase in heatwave intensity, whereas all experienced an increase in the average intensity of the peak day, ranging from 1°C in Darwin to 4.3°C in Adelaide.

Further, heatwaves have been occuring earlier in all but 1 of the capital cities from 1950-2011. Future scenarios of **+1.5°C**, **+2°C** and **+4°C** mean temperature increase indicate that the frequency and duration of heatwaves will increase for the entire country. This will lead to an increase in the number of cooling degree days.

2050 — Cooling Degree Days (% of change): +60.6% / +23.0% / +14.4%

2100 — Heatwave frequency (% of change): +63.3% / +24.0% / +11.2%

2050 — Heatwave duration (% of time): +3,980% / +320% / +87%

HEAT, HEALTH AND AIR POLLUTION

Heat related health impacts from increasing air temperatures in urban areas are accentuated by air pollution. Wildfire smoke is an important source of PM2.5 and poses risks to human health. Australia is getting warmer, and in many parts drier, thereby providing ideal conditions for wildfires, especially in southern and eastern Australia.

A harsher fire-weather climate is projected for Adelaide, Brisbane, Canberra, Hobart, Melbourne and Sydney, as well as in Perth (in the west). In 2017, nearly 25% of Australians were exposed to levels exceeding WHO guideline values for PM2.5.

COASTAL FLOODING

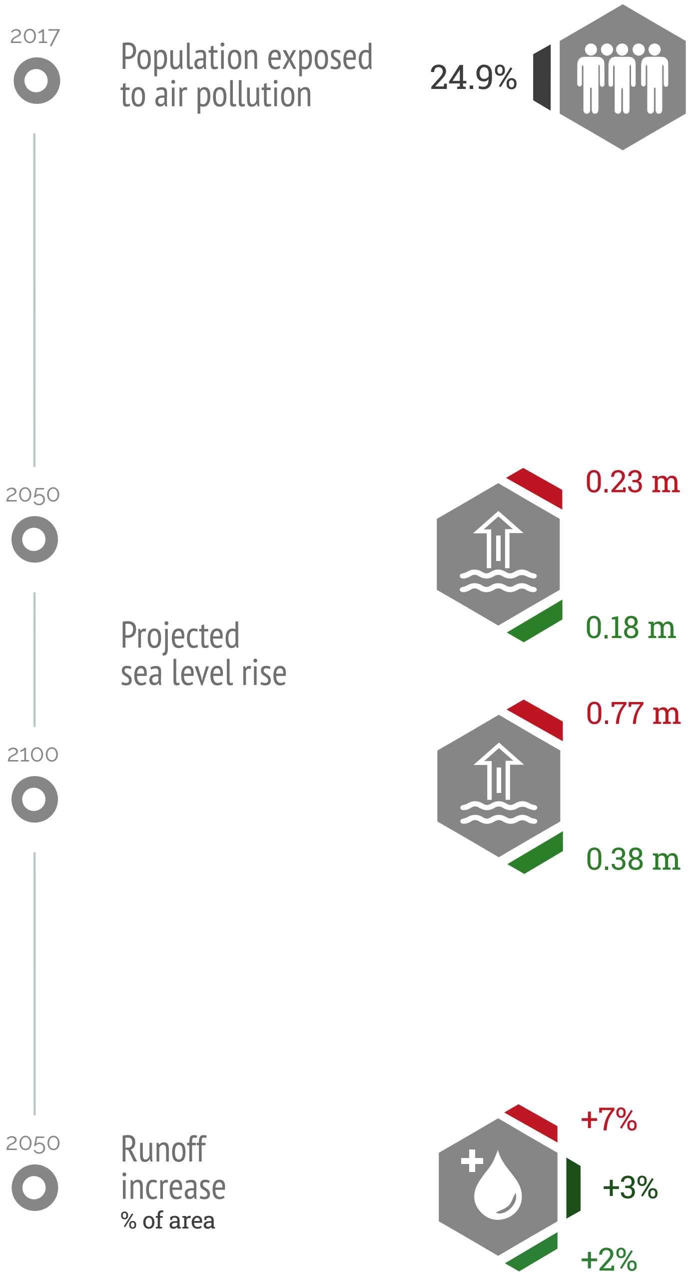
Sea level rise will lead to the increased flooding of low-lying coastal areas leading to erosion, loss of beaches, and higher storm surges. As coastlines continue to develop – around 85% of the population live within 50 kilometers of the coast – sea level rise will affect more coastal communities, infrastructure, industry and the environment.

Sea level rise in Australia has been consistent with global increases at an average rate of 2.1 millimetres per year over the past 50 years. Geographical variations show higher observed sea level rise in the north and rates similar to the global average observed in the south and east.

EXTREME PRECIPITATION **EVENTS**

Northern Australia is becomming wetter across all seasons. The intensity of short-duration extreme rainfall events has increased by 10% or more in some regions, with larger increases in the north. Conversely, southwest and southeast Australia have experienced drier conditions.

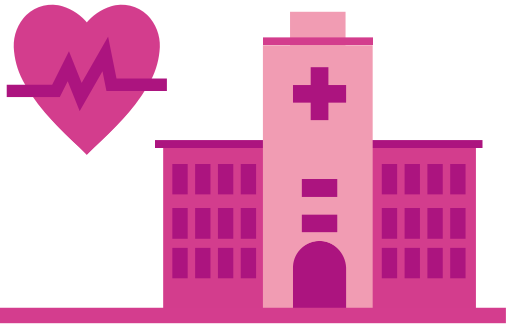
Many regions of the south and east are projected to experience a decrease in cool season rainfall, likely increasing the time spent in drought. However, heavy rainfall is expected to become more intense throughout Australia. Fewer tropical cyclones are projected, but more of those that do occur are projected to be of high intensity, with large yearly variations.



SURFACE SEALING AND FLOODS

Heavy precipitation in cities is problematic due to the high level of sealed surfaces. Soil sealing increases run off and reduces the amount of water absorbed by soil. Where there are large amounts of impervious ground cover, short duration extreme rainfall events can lead to increased flooding, even resulting in flash floods.

AUSTRALIA HEALTH



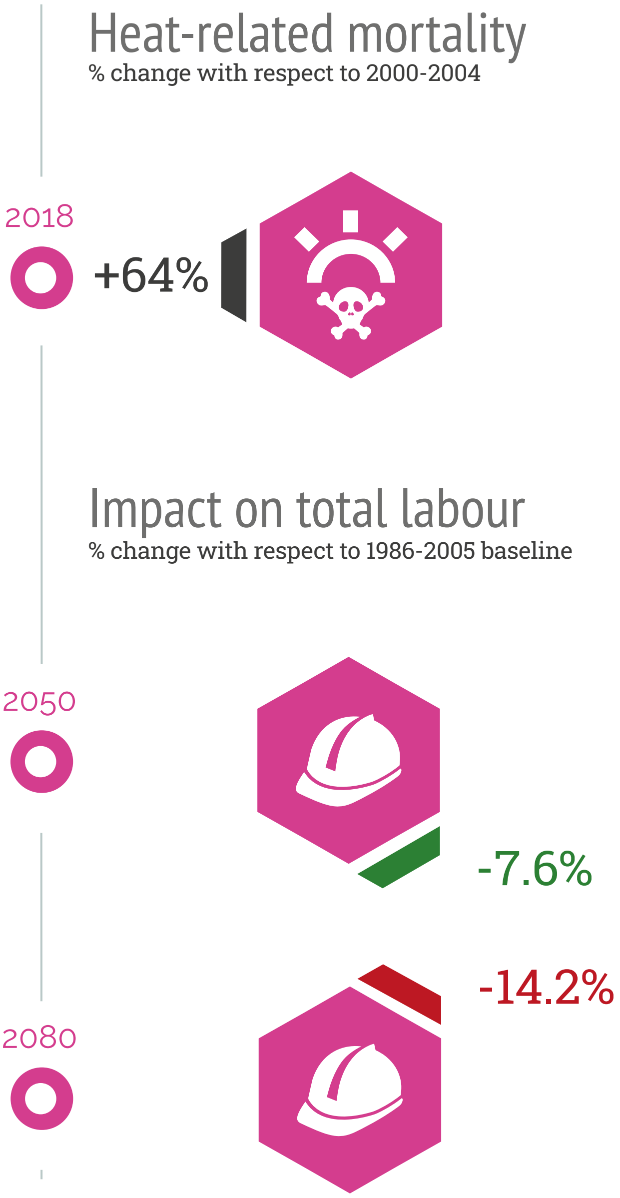
OVERVIEW

Australia is highly vulnerable to climate change due to its unique geoclimatic features. Australia is the driest inhabited continent on earth and has the greatest variability of rainfall of any country. More than 5,332 people died between 1844 and 2010 due to heat exposure, Australia's greatest current climate-related health burden. Winter cold-related deaths arise predominantly through respiratory diseases, often with contributing socio-economic determinants, rather than direct exposure. Further escalation of Australia's hot and erratic climate will lead to more extreme climate-related disasters including heatwaves, droughts, fires, and storms, as well as shifts in disease burdens.

HEAT RELATED MORTALITY

Continuous warming, as well as increased frequency and intensity of bush fires is already harming the health and well-being of Australians and will only get worse. As heatwaves increase in both frequency and intensity, the health impacts among Australians are increasing significantly. These impacts include long-term health, cardiovascular and respiratory diseases.

Estimates show that heatwave-related excess deaths in Australia will increase by 471% under a high emissions scenario by 2080. In 2018, there was a 64% increase in heat-related deaths in Australia from a 2000 to 2004 baseline. 35.7% of Australia's heat-related mortality during 1991 to 2015 can be attributed to human-induced climate change.



IMPACTS ON LABOUR

Labour is directly affected by changes in environmental conditions. Warming affects both the number of hours worked (labour supply) and on the productivity of workers during their working hours (labour productivity). Both labour supply and productivity are projected to decrease under future climate change in most parts of the world, and particularly in tropical regions.

Parts of sub-Saharan Africa, south Asia, and southeast Asia are at highest risk under future warming scenarios. Future climate change will reduce global total labour in the low-exposure sectors by 18 percentage points and by24.8 percentage points in the high-exposure sectors under a 3.0°C warming scenario

The changing climate, especially temperature increases, is putting the livelihoods of Australians at risk. For example, in the agriculture and construction sectors, there was a 46.3% decline in potential hours of labour lost in 2019 compared to a 1990-94 baseline. Total labour in Australia is expected to decline by 7.6% under a low emissions scenario, and by 14.2% under a medium emissions scenario.

CLIMATE CHANGE AND DENGUE

Dengue has spread throughout the tropical world over the past 60 years and now affects over half the world's population. Globally, vectorial capacity for both dengue vectors (A. aegypti and A. albopictus) has been rising steadily since the 1980s, with nine of the ten highest years occurring since 2000.

Climatic stressors are one important driver of the current distribution and incidence of dengue. Climate change is likely to expand the geographical distribution and suitability of several vector-borne human infectious diseases including dengue. The risk of dengue transmission is increased by warming climates, as the growth and development of mosquitoes are significantly influenced by temperature, precipitation, and humidity.

CLIMATE CHANGE AND ZIKA

Zika virus has spread to at least 49 countries and territories since 2013. Climate change impacts on transmission suitability risk have increased over the years and future warming over 1.3 billion additional people could face suitable transmission temperatures for Zika by 2050.

DENGUE AND ZIKA: POPULATION AT RISK

Changes to the distribution and abundance of mosquitoes have resulted in more Australians contracting dengue fever in areas where they were not previously at risk.

Under a medium emissions scenario, 83.3% of the population will be at risk of transmission-suitable mean temperature for dengue by 2050, whereas 85.9% will be at risk under a high emissions scenario. In the case of Zika, 47.2% of the population will be at risk of transmission-suitable mean temperature for Zika under a medium emissions scenario by 2050, whereas 56% will be at risk under the high emissions scenario.

CLIMATE CHANGE AND MALARIA

Although Malaria transmission has largely been eradicated in Australia since the 1980s, climate change will likely expand the potential range of the major vectors. Since 1950, there has been a 14% increase in the capacity of mosquitos to transmit disease to humans. The risk of malaria is projected to increase in the future. 36.9% of the Australian population will be at risk of malaria under a low emissions scenario in 2050, whereas 40.4% will be at risk under a high emissions scenario.

POLLUTION AND PREMATURE MORTALITY

Australia's air pollution is exacerbated by bushfires, which are projected to increase in frequency and coverage. Pollution from bushfires caused an estimated 2,000 people to be admitted to hospitals with respiratory problems and about 1,300 people to emergency departments with asthma-related conditions.

Dengue suitability

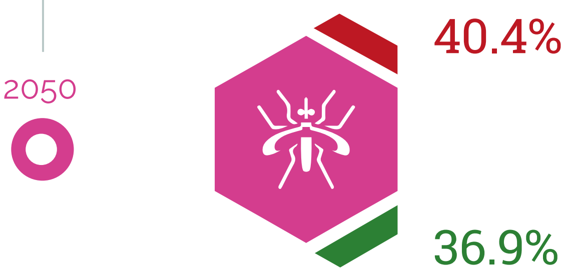
% of population at risk

Zika suitability

% of population at risk

Malaria suitability

% of population at risk



AUSTRALIA ENERGY

ENERGY SYSTEM IN A NUTSHELL

Australia is among the top exporters of coal and natural gas. Total energy production is three times (320%) total primary energy supply. However a major transformation of the energy system towards low carbon technologies is under way. The energy intensity of the economy is slightly below world average while carbon intensity of energy production is declining, but remains very high.

0.11
ktoe/US$
Energy intensity

6.8%
AC Share in
electricity consumption

CLIMATE CHANGE TODAY

ENERGY SECURITY

Energy security is threatened by the impacts of climate change. Extremely high temperatures, bushfires and storms all place stress on power stations and energy infrastructure whilst also increasing energy demand as air conditioning use increases.

STORMS

Extreme storms, tornadoes and heat waves have already damaged transmission towers and caused widespread power outages.

HEAT

In 2016, severe weather damaged transmission infrastructure causing a statewide blackout in South Australia; disruptions lasted for up to 2 weeks. The bushfires of 2019-2020 destroyed power lines and poles, transmission lines and cross state interconnectors. Along the east coast tens of thousands of homes lost power. Rural and isolated areas with no backup sources were particularly affected.

ENERGY SUPPLY

Australia is highly dependent on fossil fuels. In 2019, oil accounted for almost 33% of total primary energy supply, followed by coal (31%) and natural gas (29%). In comparison, renewable energy sources accounted for 7%. Coal is a key resource, but mostly exported. Despite being a net exporter of energy, Australia relies on imports for the majority of oil products.

ENERGY DEMAND

Energy is used for transport (41% in 2018, mainly on road), followed by industry (27%), residential (13%), and the tertiary sector (10%). Agriculture and forestry demand is very low. The transport sector is highly reliant on oil products, with very small shares of gas, biofuels, and electricity. Overall energy consumption has increased slightly, while energy demand for transport has increased significantly: by 60% in the last 30 years. Air conditioning accounts for 6.8% of final residential electricity consumption.

FUTURE ENERGY DEMAND

Energy demand is expected to increase due to changing demographics and increasing temperatures. Peak and average demands are influenced by climate. Higher levels of air-conditioner use will increase peak energy demands, exacerbating the risks of power outages.
Overall, total energy demand is projected to increase as increases in summer cooling needs outweigh any decreases in winter heating needs, resulting in an increase in electricity demand of 249 PJ (or 69 million KWh) by 2050 under a medium emissions scenario.

Net change in energy demand due to changes in HDD/CDD
Billion KWh

2050

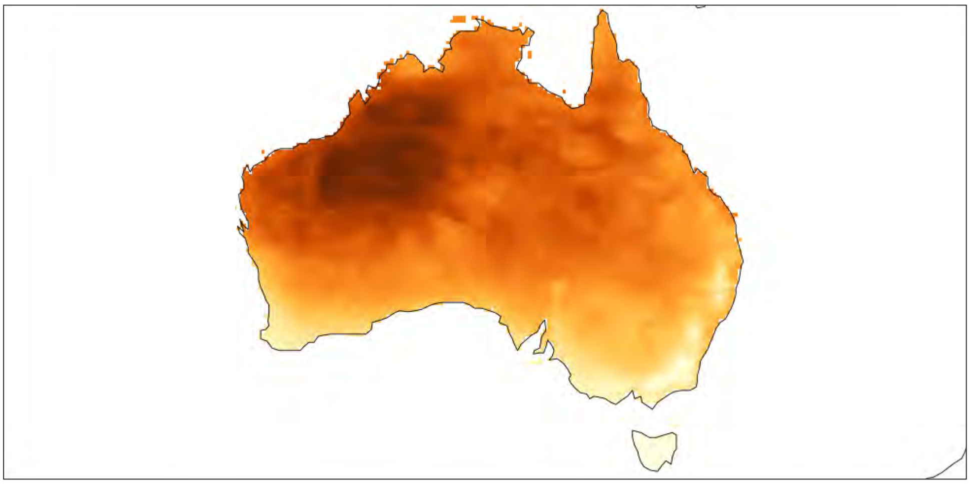
+ 69.13

COOLING NEEDS

Major increases in cooling needs in the cities of central-north states and territories (such as Cairns). Southern coastal cities will face more moderate increases in cooling needs. Under a high emissions scenario, Brisbane and Adelaide will experience the largest increases in energy demand where the increase in summer cooling needs will outweigh the decreases in winter heating needs. In Sydney and Melbourne, average demand will only increase slightly, as their consumption is less sensitive to increasing temperature.

COOLING DEGREE DAYS

0 732

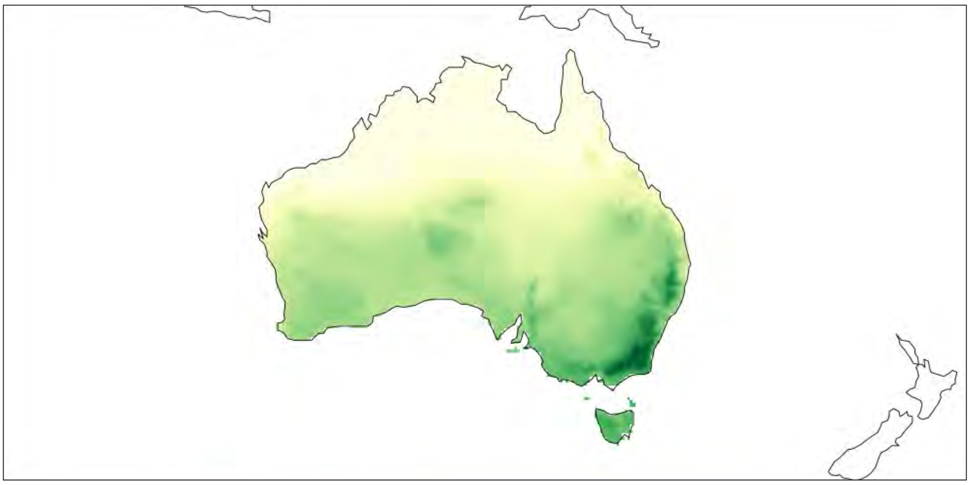


HEATING NEEDS

Winter demand is expected to be higher in southern states. Negligible changes are expected in the northern states and territories; some moderate heating degree day decreases in the central elevations, which are however hardly inhabited. Significant decreases in heating needs along the Great Dividing Range and the densely populated coastal areas of Victoria and South Wales, with the major metropolitan areas of Sydney and Melbourne, and in the Australian capital territory with Camberra.

HEATING DEGREE DAYS

-546 0



FUTURE ENERGY SUPPLY

The future Australian energy mix is likely to be determined by the evolution of energy policies and hence is outside the scope of this report. Australia has not yet set any targets to achieve net zero emissions, but policies do encourage renewable energy growth, particularly for electricity generation. Rising energy security concerns (due to the large share of ageing fossil fuel power stations in the system) were behind new investments in power generation capacity, focused on natural gas as a transition fuel. This is likely to result in a marginal decrease in the relevance and associated vulnerabilities of fossil fuels over the next decade, while carbon-free sources and their vulnerabilities will become slightly more relevant.

Change in Hydropower generation
% of change

2050

-4%

-1.97%

EXPECTED IMPACTS OF CLIMATE CHANGE

As Australia's temperatures rise and the climate becomes drier, there will be increased risks to power stations and energy infrastructure. The risks of bushfires, heat waves and increased peak demands, is expected to increase the risks of energy system failures such as black outs and the risks of damaged infrastructure. A modest reduction in hydropower generation potential is expected.

AUSTRALIA ECONOMY

OVERVIEW

Australia ranks 14th in terms of GDP in the G20 group. The COVID 19 crisis affected the economy with a 2.4% real GDP decline in 2020. This trend has reversed in 2021 with a 4.5% growth in real GDP.

IMPACTS ON GDP

The available estimates for economic impact of climate change on the whole Australian economy vary according to the scenarios considered, the time horizon, the direct impacts covered, and the specificities of the estimation method used.

The projected overall macroeconomic impacts range from 0.17% under a low emissions scenario by 2050 to 6.93% under a high emissions scenario by 2100.

GDP Loss

% change w.r.t baseline

2050

2.1/3.03%

0.17/1.89%

2100

2.71/6.93%

0.56/1.93%

SECTORAL ECONOMIC IMPACTS

IMPACTS ON INDUSTRY AND INFRASTRUCTURE

Sea level rise and coastal floods, hurricanes, and forest fires are the major sources of damage to Australian infrastructure. More than half (52%) of Australian coastline is prone to recession under sea level rise.

Rebuilding critical infrastructure after natural disasters between 2015 and 2050 will require 17 billion AUD.

It is also estimated that infrastructure worth over 226 billion AUD in "commercial, industrial, road and rail, and residential assets are exposed to flooding and erosion hazards at a sea-level rise of 1.1metre" a level consistent with a high emissions scenario for 2100.

The increased exposure to extreme events is likely to raise insurance costs for housing and reduce property values. For Australia, this is estimated to result in losses of 571 billion AUD by 2030, 611 billion AUD by 2050 and 770 billion AUD by 2100.

IMPACTS ON AGRICULTURE

Australia is vulnerable to severe droughts, heatwaves, extensive forest fires, hurricanes and floods, which have severely impacted natural areas, agricultural land, agricultural yields and food production. These phenomena are expected to intensify this century.

Major expected effects on crops relate to variations in the land suitable for the production of wheat, rice and grapes. Suitable areas are expected to shift southward and shrink.

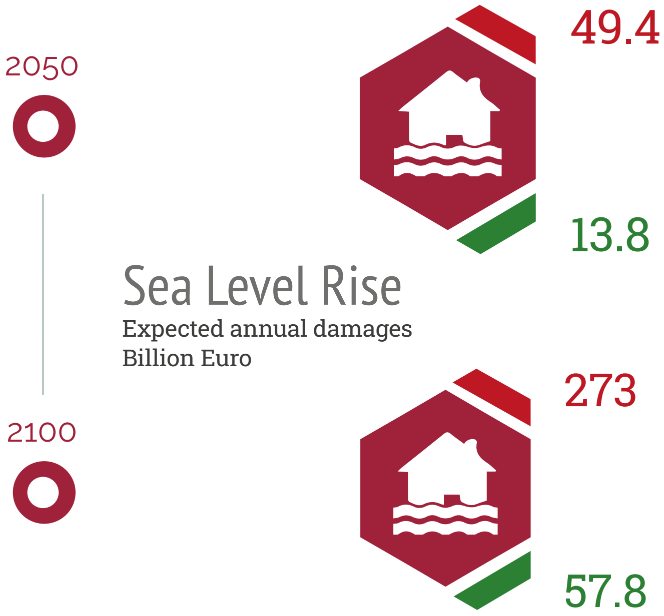
Contractions in the land suitable for cattle grazing is also expected, together with a reduced ability of cattle to withstand increasing temperatures and heatwaves.

Regional projections envisage a loss for the agricultural sector in the state of Victoria of up to 300 million AUD (189 million EUR) by 2050, under "very extreme" heatwave scenarios.

SEA LEVEL RISE DAMAGES

Damage from coastal flooding is projected to be particularly severe. By mid century, expected annual damage to assets from coastal flooding is projected to be 13.8 billion EUR under a low emissions scenario and 49.4 billion EUR under a high emissions scenario.

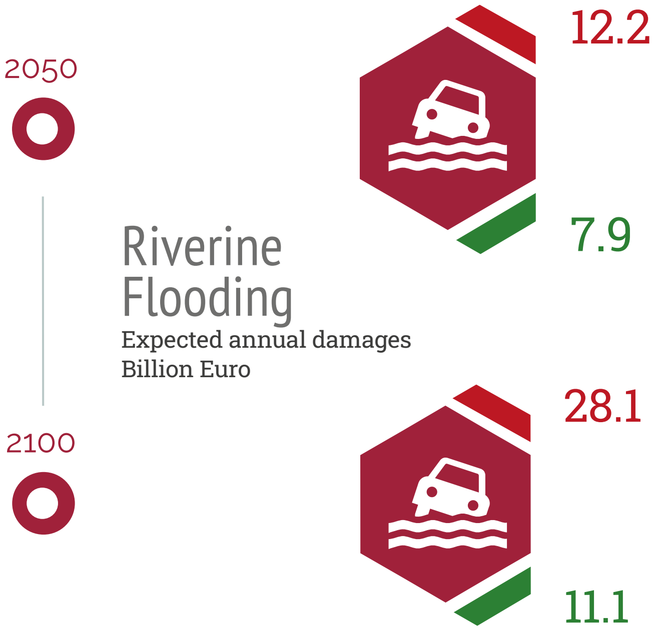
By the end of the century, projected damage related losses may increase to 57.8 billion EUR under a low emissions scenario and 273 billion EUR under a high emissions scenario.



RIVER FLOODING DAMAGES

River flooding is also expected to cause annual damages ranging from 7.9 billion to 12.2 billion EUR by mid century under a low emissions scenario and a high emissions scenario, respectively.

By the end of the century these costs rise to 11.1 billion EUR under a low emissions scenario and 28.1 billion EUR under a high emissions scenario.



IMPACTS ON TOURISM

Tourism is a very important economic sector in Australia. Previously to the COVID 19 crisis, it was the second most valuable export earner (43.3 billion AUD in 2016, just behind iron ore exports with 47.7 billion AUD; these are 27.3 and 30 billion EUR, respectivley) and an important source of jobs (4.9% of the Australian workforce in 2015).

The high vulnerability of this sector stems from its dependence from nature-based destinations, such as the five major attractions identified by international visitors (beaches, wildlife, the Great Barrier Reef, unspoilt wilderness, forests and national parks).

Beach erosion and sea level rise, poisonous jellyfish blooming, coral bleaching, risks of an increase in tropical mosquito-borne diseases, wildfires, storms and floods threaten these attractions.

IMPACTS ON ENERGY

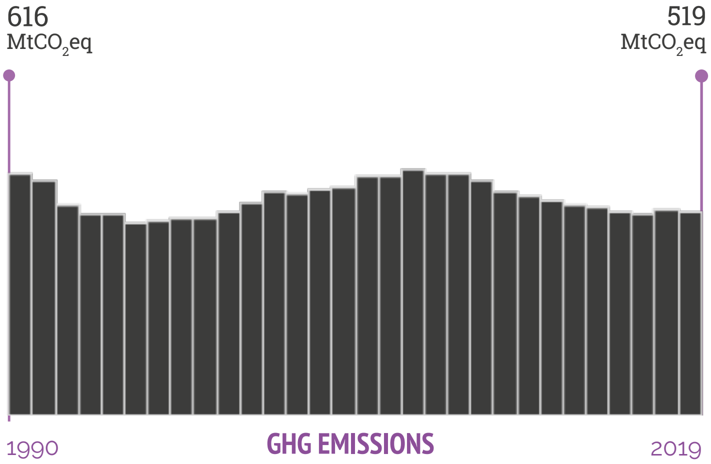
As with all other economic sectors, energy supply and energy networks in Australia will undergo more intense stress from extreme weather events.

Economic impacts of shifts in household and firm energy demand (see chapter on energy) are difficult to predict and will mostly lead to redistribution effects. In the case of Australia, the magnitude of the increase in demand for cooling is expected to far exceed the one of decrease in heating demand, leading to a significant increase in energy bills.

AUSTRALIA
POLICY

OVERVIEW

Australia is the world's 6th largest country, with a population density of 3.2 people per square kilometre. It accounts for 1.3% of global emissions and in 2018 registered one of the highest rates of GHG emissions per capita.



INTERNATIONAL COMMITMENTS

In its 2020 NDC update, Australia reiterated its previous target to reduce greenhouse gas emissions by 26 to 28% below 2005 levels by 2030.

CLIMATE POLICY COMMITMENTS CHRONOLOGY

2007 — **Kyoto Protocol - 1st period**

8% of average GHG increase over the four year period 2008-2012

2016 — **Paris Agreement - 1st NDC**

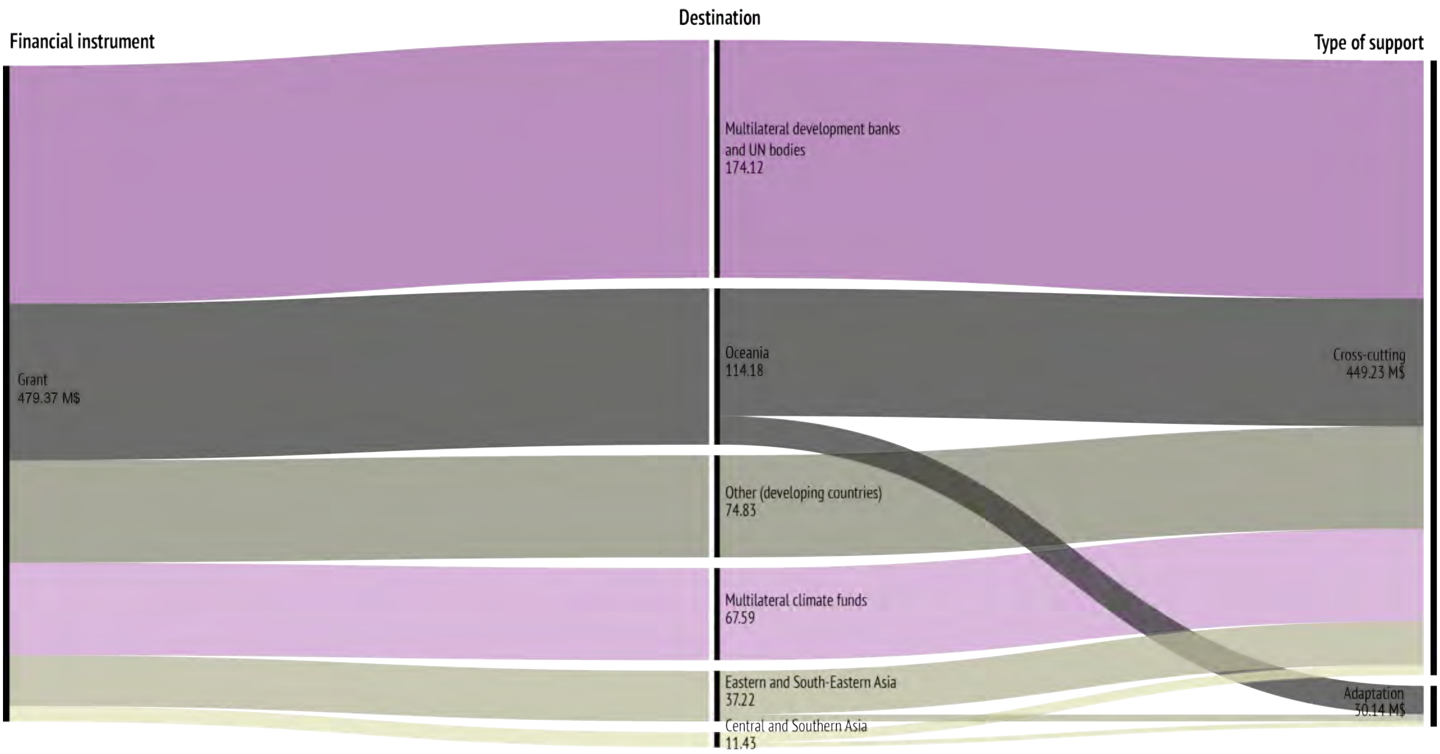
Between 26% and 28% of GHG reduction at 2030, with respect to 2005 level

2020 — **Paris Agreement - NDC update**

Submitted. Commitments unchanged

INTERNATIONAL CLIMATE FINANCE ASSISTANCE

The 4th Biennial Report data shows that in 2017 and 2018 Australia provided 479.33 million USD to climate action in the form of grants mainly targeting multilateral institutions and Oceanian countries for cross-cutting and adaptation projects.



SUSTAINABLE RECOVERY POLICY

According to the Global Recovery Observatory, in 2020 the proportion of green spending to total recovery spending was 2%.

Total Spending	Recovery Spending	Green Spending
328.51 billion $	128.92 billion $	2.51 billion $

DOMESTIC ADAPTATION POLICY

On 2 December 2015, the Australian Government released a National Climate Resilience and Adaptation Strategy. The department of Agriculture, Water and the Environment announced that it will release a new National Climate Resilience and Adaptation Strategy in late 2021, which will focus on climate adaptation and resilience only.

- ○ Domestic Adaptation Policy
  - ○ Inclusion of Adaptation in NDCs
  - ○ Integrated Adaptation & Mitigation Policy
  - ● Dedicated Adaptation Strategy
  - ○ Dedicated Adaptation Plan
- ● Subordinate Adaptation Policies
  - ● Sectoral Adaptation Plans
  - ● Subnational Adaptation Plans

○ Policy not in place ● Active policy

ADAPTATION POLICY HIGHLIGHTS

TRANSNATIONAL INITIATIVES

Reef Joint Field Management Program

The Program plans and delivers field operations within the Great Barrier Reef World Heritage Area (WHA). This includes Commonwealth and State marine parks and island national parks

Climate and Oceans Support Program in the Pacific

The project aims to help fourteen Pacific national meteorological services make seasonal forecasts and use climate science to make information accessible to their governments and communities and support planning in agriculture, water security and health

NATIONAL INITIATIVES

Electricity Sector Climate Information (ESCI) project

Specific information and data are delivered to the electricity sector to manage risks from extreme weather events and increase the reliability and resilience of electricity systems

CoastAdapt

The National Climate Change Adaptation Research Facility developed an online tool to support local governments and businesses to identify, assess and respond to climate risks in the coastal zone

SUBNATIONAL INITIATIVES

Melbourne Climate Change Adaptation Strategy and Action Plan

The plan addresses the main risks of extreme weather events (heat waves and flash flooding) with the aim to reduce their impacts on the City's current and evolving conditions

Climate Futures for Tasmania

The project delivers locally specific climate information that reflects the highly variable topography of Tasmania and many strong regional variations at a finer scale resolution

ENERGY TRANSITION

The overall Energy Transition indicator for Australia is a little below the G20 average. In particular, this position is driven by a low performance in Renewables (almost 8 points below the average value) due to a low ratio with respect to both energy and electric mix. Also, the Emissions and Fossil Fuels indicators contribute negatively due to a more traditional type of energy mix.

Nevertheless, this situation does not consider recent significant developments and new policy measures implemented by Australia in renewables. On the other hand, Australia has a good performance in infrastructural efficiency and a good electrification of consumption.

	G20 Average	Country
Energy Transition	58.7	56.3
Fossil Fuels	45.3	38.2
Renewables	19.7	13.0
Efficiency	84.9	89.9
Electrification	70.8	72.0
Emissions	72.9	68.4

G20 AVERAGE / COUNTRY

Only actively pursuing an energy transition based on decarbonization and electrification – from policy and regulation, to health and education – will enable countries to benefit the most from future opportunities and fight climate change whilst ensuring an equitable distribution of wealth.

The Energy Transition indicators were developed by Enel Foundation in cooperation with SACE, and provide a retrospective analysis based on historical data.