



Photo: Tourism Queensland

Climate change in the Central Queensland Region



This regional summary describes the projected climate change for the Central Queensland (CQ) region.

Projected average temperature, rainfall and evaporation for 2030, 2050 and 2070 under low, medium and high greenhouse gas emissions scenarios are compared with historical climate records.



Key findings

Temperature

- Average annual temperature in CQ has increased 0.5 °C over the last decade (from 21.6 °C to 22.1 °C).
- Projections indicate an increase of up to 4.5 °C by 2070, leading to annual temperatures well beyond those experienced over the last 50 years.
- By 2070, Rockhampton may have four times the number of days over 35 °C (increasing from an average of 16 per year to an average of 64 per year by 2070), while Barcaldine may have nearly twice the number of hot days (increasing from an average of 87 per year to an average of 163 per year by 2070).

Rainfall

- Average annual rainfall in the last decade fell by nearly 14 per cent compared with the previous 30 years. This is generally consistent with natural variability experienced over the last 110 years, which makes it difficult to detect any influence of climate change at this stage.
- Models have projected a range of rainfall changes from an annual increase of 17 per cent to a decrease of 35 per cent by 2070. The ‘best estimate’ of projected rainfall change show a decrease under all emissions scenarios.

Evaporation

- Projections indicate annual potential evaporation could increase 7–15 per cent by 2070.

Extreme events

- The 1-in-100-year storm tide event is projected to increase by 51 cm in Gladstone and 32 cm at Cape Clinton if certain conditions eventuate. These conditions are a 30 cm sea-level rise, a 10 per cent increase in cyclone intensity and frequency, as well as a 130 km shift southwards in cyclone tracks.

A regional profile

Climate and landscape

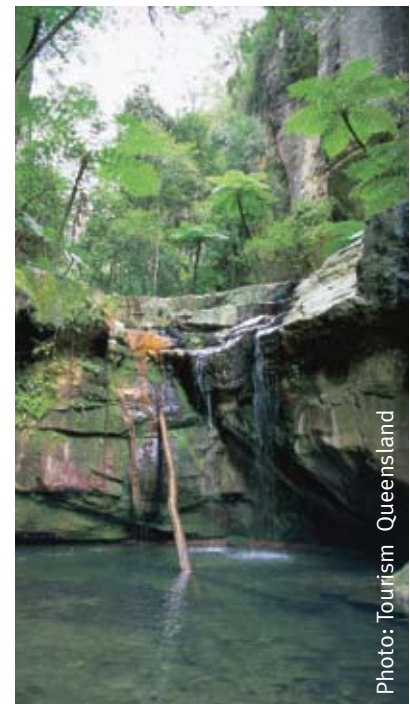
The Central Queensland region has a sub-tropical climate with hot, moist summers and warm, dry winters, with occasional frost in the south. Rainfall in the Central Queensland region is highly seasonal, with most rain occurring during the summer months (October–March).

This region has a diversity of landforms including the beaches of the Capricorn coast, gem fields such as those at Sapphire, west of Emerald, and the central highlands including Carnarvon Gorge.

Demographics

In 2007, the region’s population was 210 294 and is projected to increase beyond 293 000 by 2026.

(OESR, 2007; DIP, 2008)



Important industries of the region

Agricultural, mining, process and service industries are the economic backbone of the region. The region is predominantly agricultural, with significant mining industries, which contribute up to 32 per cent of employment in some areas (e.g. Bowen Basin). Agricultural industries include beef and grain production, and irrigated cotton, grapes and citrus.

Key industries in Rockhampton include beef production, mining services, minerals processing and manufacturing industries, while Gladstone is the hub for processing and exporting coal, gas, silica sand and limestone resources, via world-class port facilities.

The region also has a number of production facilities including the world's largest alumina refinery and Australia's largest aluminium smelter, Queensland's largest manufacturer of cement, Australia's second largest meat processor and operational plans for the world's largest magnesium metal production facility.

Climate change has the potential to significantly affect biodiversity in coastal areas through alteration of habitat. The management of the regions infrastructure and tourism activities is also likely to be adversely affected by projected increases in temperature, sea-level rises and changes to the rainfall patterns. Additional demands on regional water supplies will come from increasing agricultural, industrial, commercial and mining activity and these demands will likely be exacerbated by the changing climate.

(Extracted from the Central Queensland Regional Plan)

Understanding the climate and how it changes

Queensland's climate is naturally variable; however, climate change will lead to shifts beyond this natural variability. To assess the risk of human-induced climate change requires an understanding of the current climate using historical data and future climate scenarios. These future scenarios are prepared using data from Global Climate Models.

Method

Historical climate data

Historical climate data collected by the Bureau of Meteorology (BoM) were aggregated across the CQ region. The fluctuations and trends in the observed data are presented including extremes in temperature and the frequency of cyclones.

Greenhouse emission scenarios

The World Meteorological Organization (WMO) and the United Nations established the Intergovernmental Panel on Climate Change (IPCC) in 1988. The IPCC assesses the latest scientific, technological and socio-economic literature on climate change.

To estimate the potential impacts of future climate change on Queensland climate change projections were developed using the IPCC low (B1), medium (A1B) and high (A1FI) greenhouse gas emissions scenarios. The low-range scenario (B1) assumes a rapid shift to less fossil fuel intensive industries. The mid-range (A1B) scenario assumes a balanced use of different energy sources. The high (A1FI) scenario assumes continued dependence on fossil fuels.

Greenhouse gas emissions are currently tracking above the highest IPCC emissions scenario (A1FI). The low and medium scenarios are presented to show the potential benefits of action to reduce greenhouse gas emissions.

Climate change projections

Queensland climate change projections were produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BoM) based on the results from 23 Global Climate Models. Projections were provided for 2030, 2050 and 2070. However, as the climate can vary significantly from one year to the next, these projections show changes in average climate for three future 30-year periods centered on 2030, 2050 and 2070. Sea-level rise is also considered.

Current climate

Temperature (BoM, 2008)

Historical temperature records indicate the average temperature in the CQ region has risen, with this increase accelerating over the last decade (1998–2007). The average annual temperature was 21.6 °C in the 30-year period 1971–2000, which is a 0.2 °C increase on the 1961–1990 average. However, over the last decade it has risen by a further 0.5 °C, suggesting an accelerated rise in temperature.

Average maximum temperature has risen in the Central Queensland region

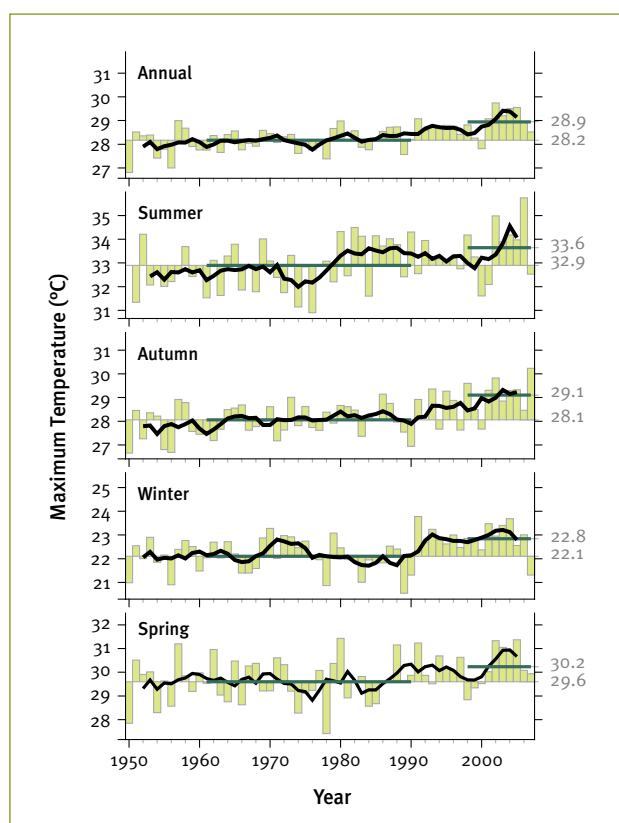


Figure 1: Historical annual and seasonal maximum temperatures for the Central Queensland region for the period 1950–2007, compared to the base period 1961–1990

The black line is a five-year running average. The mean, for both the baseline of 1961–1990 and the last decade 1998–2007 are shown by the green lines and indicated numerically at the right of the graph. Note: vertical scales may differ between graphs.

Data source: BoM, 2008

The increase in annual maximum temperature is presented in Figure 1. The trend over time is represented by the black line in each graph. The change in maximum temperatures is greater in the autumn, with the average over the last decade increasing by 1.0 °C compared to the 1961–1990 average.

Temperature extremes (BoM, 2008)

Extremes in temperature (such as a number of days exceeding 35 °C) are single events that usually do not extend past a couple of days. Due to the influence of regional topography, proximity to the ocean and prevailing winds, location-specific data are required when considering changes in these extreme events over time.

Historical temperature records for Rockhampton (Figure 2) show that since the late 1970s, in most years, the number of days for each year where the maximum temperature exceeds 35 °C has tended to increase. However, for Barcardine (Figure 3) there has been a small increase. Due to its inland location, Barcardine currently experiences more extreme temperature days than coastal Rockhampton.

The number of days over 35 °C has risen in Rockhampton

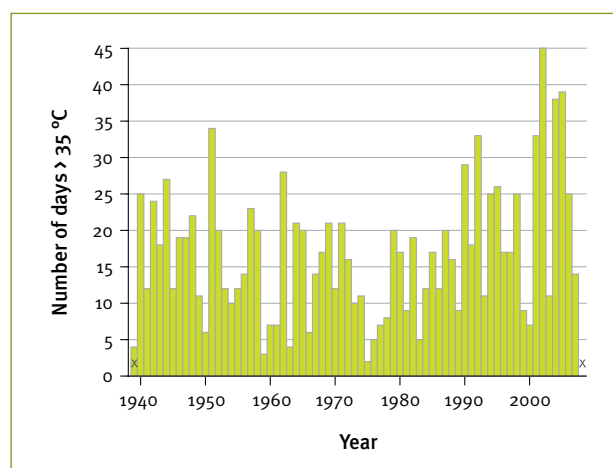


Figure 2: Number of days where the temperature exceeded 35 °C for Rockhampton

Blank spaces are those years where the maximum temperature did not exceed 35 °C. 'X' denotes the year for which the full data set is not available (i.e. the actual values may in fact be greater than what is shown).

Data source: BoM, 2008

There has been a small increase in the number of days over 35 °C in Barcaldine

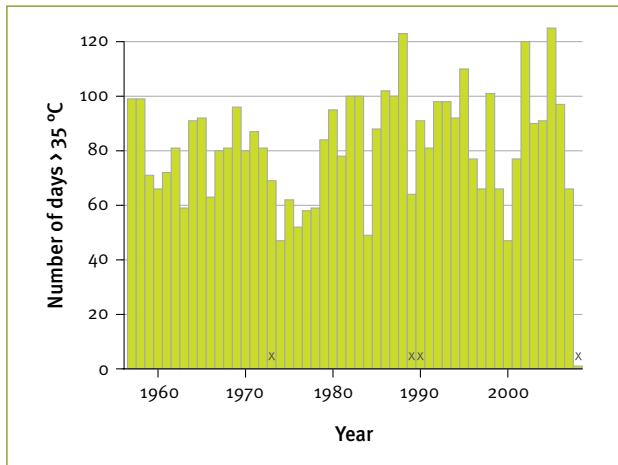


Figure 3: Number of days over 35 °C in Barcaldine

Blank spaces are those years where the maximum temperature did not exceed 35 °C.

'X' denotes the year for which the full data set is not available (i.e. the actual values may in fact be greater than what is shown).

Data source: BoM, 2008.

Rainfall (BoM, 2008)

Annual and seasonal average rainfall is strongly influenced by natural variability, local factors such as topography and vegetation, and broader scale weather patterns, for example El Niño-Southern Oscillation (ENSO) events. To understand how this natural temporal variation changes rainfall patterns, long term rainfall records are required. The BoM has been collecting rainfall data for the Central Queensland region since 1897.

The variability in annual and seasonal rainfall is outlined in Figure 4. Since 1990, only three years have received rainfall greater than the 1961–1990 average.

Figure 4 shows the dominant summer rainfall pattern with a 1961–1990 average rainfall around 300 mm, compared to an autumn average (the next most dominant rainfall period) of around 170 mm.

Over the most recent decade, there has been a 38 per cent decline in the average autumn rainfall compared to the 1961–1990 average. Summer average rainfall has declined by 14 per cent; however, there has been a fairly consistent decrease since the 1970s with only eight summers in this period above the 1961–1990 average. These recent conditions are similar to those experienced historically (e.g. autumn

rainfall around the early 1920s and late 1960s) and, as such, they may be due to the natural climate variation.

The changes in the summer and autumn rainfall are the major contributors to the overall 13 per cent decline in the annual rainfall for the region over the last decade (1998–2007).

Historical rainfall shows high variability

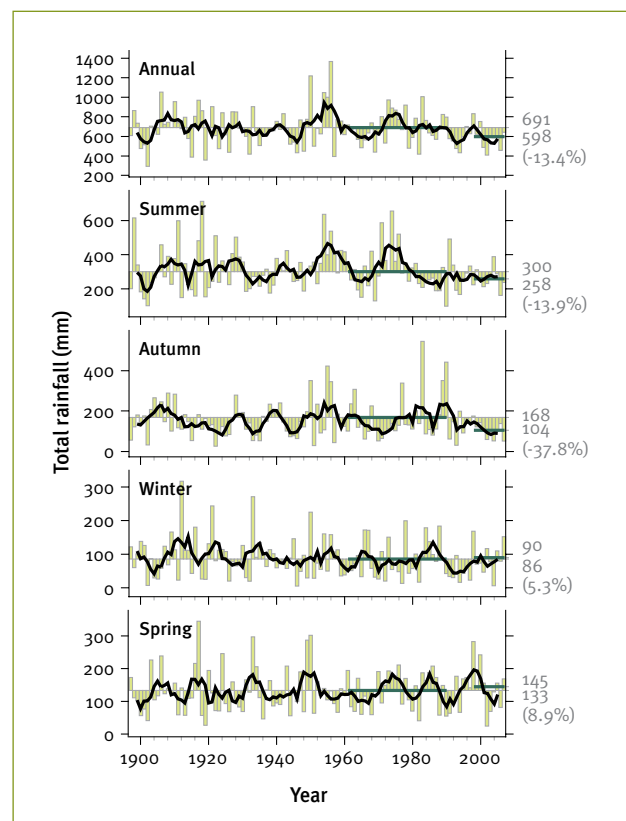


Figure 4: Historical annual and seasonal total rainfall for the Central Queensland region for the period 1897–2007

The black line is a five-year running average.

The mean for both the baseline 1961–1990 and the last decade 1998–2007 are shown by the green lines and indicated numerically at the right of the graph.

The difference in rainfall between the baseline and last decade is shown in per cent.

Note: vertical scales may differ between graphs.

Data source: BoM, 2008.

Evaporation

Potential evaporation is a measure of the evaporative (or drying) power of the atmosphere. The potential evaporation rate assumes that there is an unlimited supply of water to evaporate (either from the soil, or from water bodies). Although potential evaporation can differ from actual evaporation, a change in potential evaporation gives a good indication of the change in the evaporative power of the atmosphere.

Networks to measure potential evaporation are not as well developed as those that measure temperature and rainfall and there are insufficient data available to indicate the changes over time. Averaged over the Central Queensland region, the annual mean potential evaporation over the period 1971–2000 (1997 mm) is nearly three times the annual mean rainfall over the same period (692 mm), which is a contributing factor to the depletion of soil moisture.

Cyclones

Strong winds, intense rainfall and ocean effects such as extreme waves combine to make the total cyclone hazard. This hazard is greatest in Queensland between January and March, but tropical cyclones in Queensland can occur anytime over the period from November to April.

Although the CQ region is further south than the main area of tropical cyclone development and occurrence, tropical cyclones still have an impact on the region (Figure 5), either from those that do track further southwards or from the heavy rain and strong easterly winds through the region that accompany cyclones to the north.

There is a relationship between the impact of cyclones on eastern Australia and the El Niño–Southern Oscillation (ENSO) phenomenon. Cyclone activity in Australia decreases during an El Niño pattern and increases in a La Niña pattern (CSIRO & BoM, 2007). This relationship is reflected in Figure 5, with very few cyclones in the last three decades (in fact, there were none in the last decade) compared to the La Niña dominant decades commencing in the 1940's and 1960's. There is also a greater tendency for cyclones to track further southward in La Niña dominant decades.

Fewer cyclones have occurred over the last three decades under El Niño weather patterns

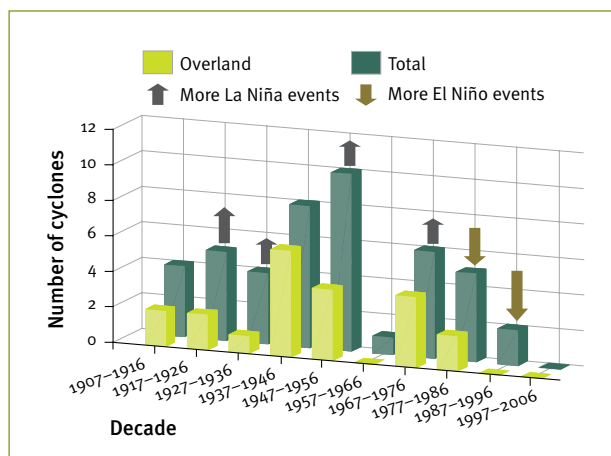


Figure 5: Total and overland number of tropical cyclones for the Central Queensland region for the period 1907–2006.

Adapted from BoM, 2008.

Projected climate change in Central Queensland

Global Climate Models simulate the earth's climate system using a complex set of mathematical rules that describe the physical processes of the atmosphere, ocean, land and ice. They are currently considered to be the best tools for projecting climate change. CSIRO has recently released climate change projections for Australia (CSIRO & BoM, 2007) based on the results from 23 Global Climate Models. Projections for the Central Queensland region have been extracted from this dataset for the Queensland Climate Change Centre for Excellence (QCCCE). The projections presented here are relative to the base period of 1980–1999.

The Global Climate Models show little difference under the low, medium and high emissions scenarios to 2030. Therefore, the 2030 climate change projections for CQ have been calculated on a mid-range emissions scenario.

However, the projections diverge at 2050 under different emissions scenarios. Therefore, the 2050 and 2070 projections are based on low and high emissions scenarios.

The full range of projected changes for temperature, rainfall and potential evaporation for Central Queensland in 2030, 2050 and 2070 are described in Table 2. The numbers shown in brackets in Table 2 indicate the range of the results from the Global Climate Models.

Overview of climate projections

In summary, the ‘best estimate’ changes to temperature and rainfall under the three emissions scenarios are:

2030 (medium emissions scenario)

- **Annual and seasonal temperature:** annual mean temperature (the average of all daily temperatures within a given year) is projected to increase by 1.0 °C. There is little variation in projections across the seasons.
- **Annual and seasonal rainfall:** annual rainfall (the total rainfall received within a given year) is projected to decrease by three per cent (-21 mm). The largest seasonal decrease of six per cent is projected for spring (-9 mm).
- **Annual and seasonal potential evaporation:** across all seasons the annual ‘best estimate’ increase is projected to be around 3–4 per cent (60–80 mm), with some models projecting up to a six per cent increase in autumn (27 mm) and winter (18 mm).

2050 (low and high emissions scenarios)

- **Annual and seasonal temperature:** annual temperature is projected to increase by 1.2 °C and 2.0 °C respectively under the low and high emissions scenarios. There is little variation in projections across the seasons.
- **Annual and seasonal rainfall:** annual rainfall is projected to decrease by four per cent (-28 mm) and seven per cent (-48 mm) under the low and high emissions scenarios respectively. The largest seasonal decrease of 12 per cent (-17 mm) under the high emissions scenario is projected for spring.
- **Annual and seasonal potential evaporation:** under a high emissions scenario an increase in annual potential evaporation of up to nine per cent (180 mm) is projected with the best estimate being seven per cent (140 mm). Autumn is projected to have the greatest increase of up to 12 per cent (54 mm).

2070 (low and high emissions scenarios)

- **Annual and seasonal temperature:** annual temperature is projected to increase by 1.7 °C and 3.2 °C under the low and high emissions scenarios respectively. There is little variation in projections across the seasons.

- **Annual and seasonal rainfall:** annual rainfall is projected to decrease by six per cent (-42 mm) and 10 per cent (-69 mm) under the low and high emissions scenarios respectively. The largest seasonal decrease under a high emissions scenario of 19 per cent (-28 mm) is projected for spring.

- **Annual and seasonal potential evaporation:** under a high emissions scenario, annual evaporation is projected to increase by as much as 15 per cent (300 mm). Autumn is projected to be the season most impacted, with increases up to 19 per cent (85 mm) projected in some models.

Temperature extremes

Global Climate Models indicate that increasing greenhouse gas concentrations in the atmosphere will increase the likelihood of a record high temperature in a given region. The Global Climate Models project a rise in extreme temperatures (CSIRO & BoM, 2007). Table 1 shows the projected number of days above 35 °C for two observing stations in Central Queensland with good historical records.

Under a high emissions scenario in 2070 for Rockhampton, the number of hot days above 35 °C are projected to increase from 16 day to 64 days. Under the same scenario for Barcaldine, hot days above 35 °C are projected to nearly double from 87 days to 163 days.

Station Name	Current	2030 Mid	2050 Low	2050 High	2070 Low	2070 High
Rockhampton	16	26 (22–33)	29 (24–36)	40 (31–58)	36 (27–47)	64 (42–100)
Barcaldine	87	110 (100–121)	115 (103–129)	134 (116–156)	125 (112–145)	163 (136–192)

Table 1: Number of hot days per year above 35 °C projected for 2030 (mid emissions scenario) and 2050 and 2070 (low and high emissions scenarios).

Current number of days calculated using a base period of 1971–2000.

Variable	Season	(1971–2000) Current historical mean*	2030 [†]	2050 [†]			2070 [†]		
			Emissions Scenarios						
			medium	low	high	low	high		
			Projected Changes [#]						
Temperature °C	Annual	21.6 °C	+1.0 [+0.7 to +1.4]	+1.2 [+0.8 to +1.7]	+2.0 [+1.3 to +2.8]	+1.7 [+1.1 to +2.3]	+3.2 [+2.2 to +4.5]		
	Summer	26.9 °C	+1.0 [+0.6 to +1.4]	+1.2 [+0.8 to +1.8]	+2.0 [+1.3 to +2.9]	+1.6 [+1.0 to +2.4]	+3.2 [+2.0 to +4.7]		
	Autumn	22.0 °C	+1.0 [+0.6 to +1.4]	+1.2 [+0.8 to +1.7]	+1.9 [+1.3 to +2.8]	+1.6 [+1.1 to +2.4]	+3.1 [+2.0 to +4.6]		
	Winter	15.2 °C	+1.0 [+0.6 to +1.4]	+1.2 [+0.8 to +1.7]	+2.0 [+1.3 to +2.8]	+1.6 [+1.1 to +2.3]	+3.1 [+2.1 to +4.5]		
	Spring	22.5 °C	+1.0 [+0.7 to +1.5]	+1.3 [+0.8 to +1.8]	+2.1 [+1.4 to +3.0]	+1.7 [+1.2 to +2.5]	+3.3 [+2.2 to +4.8]		
Rainfall %	Annual	692 mm	-3 [-13 to +5]	-4 [-15 to +6]	-7 [-24 to +10]	-6 [-20 to +9]	-10 [-35 to +17]		
	Summer	295 mm	-2 [-12 to +8]	-2 [-14 to +10]	-3 [-23 to +16]	-3 [-19 to +13]	-5 [-34 to +26]		
	Autumn	162 mm	-4 [-19 to +10]	-5 [-21 to +12]	-8 [-34 to +20]	-7 [-29 to +16]	-13 [-48 to +32]		
	Winter	80 mm	-5 [-17 to +8]	-5 [-20 to +10]	-9 [-31 to +16]	-7 [-27 to +13]	-14 [-45 to +25]		
	Spring	145 mm	-6 [-20 to +6]	-7 [-22 to +7]	-12 [-36 to +12]	-10 [-31 to +10]	-19 [-51 to +19]		
Potential evaporation %	Annual	1997 mm	+3 [+2 to +5]	+4 [+2 to +6]	+7 [+4 to +9]	+5 [+4 to +8]	+10 [+7 to +15]		
	Summer	661 mm	+3 [+2 to +5]	+3 [+2 to +4]	+6 [+3 to +10]	+5 [+3 to +8]	+10 [+5 to +15]		
	Autumn	449 mm	+4 [+2 to +6]	+4 [+2 to +6]	+7 [+4 to +12]	+6 [+3 to +10]	+12 [+6 to +19]		
	Winter	300 mm	+4 [+2 to +6]	+4 [+2 to +7]	+8 [+4 to +12]	+6 [+4 to +10]	+12 [+7 to +19]		
	Spring	588 mm	+3 [+2 to +5]	+4 [+2 to +6]	+6 [+3 to +9]	+5 [+3 to +8]	+10 [+6 to +15]		

Table 2. Summary of projections for Central Queensland*

* To enable the projections for each of the regions to be referenced against historical climate, observational means have been calculated using a 30-year base period of 1971–2000.

Projections represent the change in temperature, relative change in rainfall and potential evaporation relative to the model base period of 1980–1999. The numbers in brackets are the 10th and 90th percentiles and depict the range of uncertainty; the number outside the brackets is the 50th percentile (i.e. the best estimate). The changes are the average change over the region.

† These projections show changes in average climate for three future 30-year periods centred on 2030, 2050 and 2070.

Data source: CSIRO & BoM 2007. Regional summaries prepared by QCCCE.

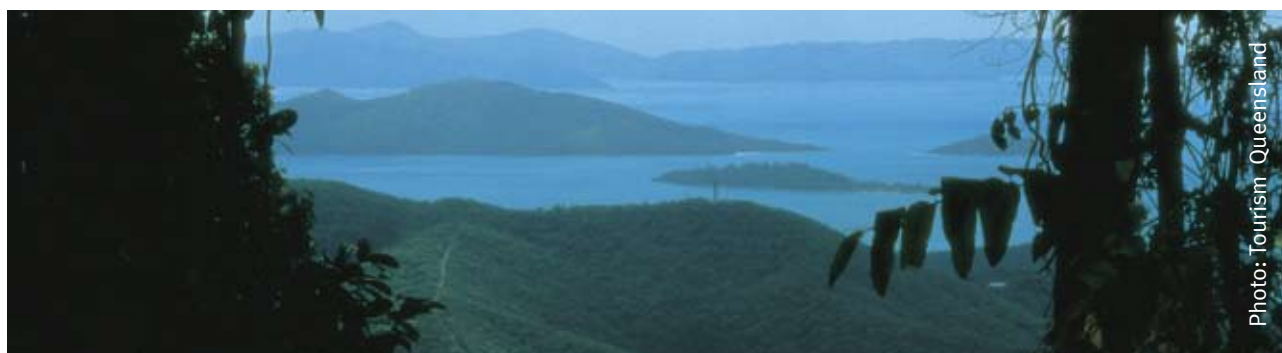


Photo: Tourism Queensland

Cyclones and sea-level rise

Extreme weather events, such as cyclones, have a complex link to ocean surface temperatures, characteristics of a region and global climate patterns such as the ENSO, making it difficult to predict their frequency of occurrence. This results in discrepancies in cyclone frequencies between different climate models.

Recent studies have projected a slight decrease (nine per cent) in tropical cyclone frequency off the east coast of Australia by 2070 (Abbs et al, 2006); however, they also simulate an increase in the number of long-lived and severe (Category 3–5) eastern Australian tropical cyclones. Under three different studies the number of severe tropical cyclones is projected to increase by 56 per cent by 2050 (Walsh et al, 2004), 22 per cent by 2050 (Leslie et al, 2007) and 140 per cent by 2070 (Abbs et al, 2006).

Projected southward shifts in the primary regions of cyclone development through the coming century (Abbs et al, 2006; Leslie et al, 2007) could result in a greater cyclone impact in the CQ region. With projected increases in future cyclones and projected rise in mean sea levels (CSIRO & BoM, 2007), storm surges will be able to penetrate further inland, greatly increasing the risk of damage to natural ecosystems, infrastructure and the risk of erosion in low-lying coastal regions.

The 1-in-100-year storm tide event is projected to increase by 51 cm in Gladstone and 32 cm at Cape Clinton if certain conditions eventuate. These conditions are a 30 cm sea-level rise, a 10 per cent increase in cyclone intensity and frequency, as well as a 130 km shift southwards in cyclone tracks (Hardy et al, 2004).

According to the IPCC, global sea-level is projected to rise by 18 to 59 cm by 2100, with a possible additional contribution from melting ice sheets of 10 to 20 cm (IPCC, 2007).

Impacts of climate change on the Central Queensland region

Projections for the Central Queensland region include a decline in rainfall, with increasing temperature and evaporation, in conjunction with more extreme climate events and sea-level rise. The temperature projections for inaction on climate change suggest a temperature increase well outside the range of temperatures ever experienced over the last 50 years. The projections for temperature and number of hot days are all in the same direction—increasing.

The CQ region has significant areas of land under irrigation for agricultural/horticultural production and therefore a high rural water demand. As its regional population increases, coastal developments and the expansion in mining and industrial activity all add to the pressure on the water resources. Any further reductions in water availability as a result of climate change will place great pressure on consumptive uses and exacerbate competition with environmental water uses.

In addition to the impacts on the water resource, climate change is expected to have long-term impacts on agriculture, human health, infrastructure, economic activity and coastal and marine ecosystems. For example:

- In the winter of 2050, under the high emissions scenario, the predicted decline in rainfall (-9 per cent), increasing high temperatures (+2.0 °C) and an increase in evaporation (+8 per cent) could result in challenges in supplying sufficient water to meet demand.
- The projected higher temperatures and more hot days above 35 °C can result in significant health impacts such as heat exhaustion and increased mortality among vulnerable sectors of the community such as the very young or old. These conditions could also result in the spread of vector-borne disease south, with Dengue Fever possibly reaching Rockhampton by 2050.
- Furthermore, increased temperatures are likely to cause more regular coral bleaching in the Great Barrier Reef. These bleaching events are very likely to become more severe as temperatures increase and such events could occur annually by 2050. As a consequence of this, the Great Barrier Reef is very unlikely to survive in its present form. The degradation of the reef will not only be a loss of great intrinsic value, it will also come at a great cost to the tourism industry (NRM, 2004).

- In addition, the increasing concentration of carbon dioxide is causing increased acidification of the sea water which, in turn, impacts the coral formation (De'ath et al, 2009). This adds a further dimension to the Great Barrier Reef's vulnerability to climate change.
- As a high proportion of the population of central Queensland reside in close proximity to the coast, there is a significant risk from cyclones. Increases in extreme storm events are expected to cause more flash flooding, affecting industry and infrastructure, including water, sewerage and stormwater, transport and communications. The riskiest areas are those closest to the coast, which can incur flash flooding, wind damage and considerable structural damage from falling trees, affecting industry, infrastructure and roads.

All of these potential impacts combine to multiply the challenges that the people of Central Queensland face in planning for a productive and sustainable future for the region. Successfully addressing these challenges will require knowledge of the changes that are likely, including an understanding of which changes can be mitigated and which will need to be addressed by adaptation.



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