Climate change in the
Far North Queensland Region

This regional summary describes the projected climate change for the Far North Queensland (FNQ) 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.

Toward Q2 Tomorrow's Queensland

Queensland Government

Photo: Tourism Queensland

Key findings

Temperature

- There has been minimal change in the average annual temperature in FNQ over the last decade (from 24.4 °C to 24.5 °C).
- Projections indicate an increase of up to 3.9 °C by 2070, leading to annual temperatures well beyond those experienced over the last 50 years.
- By 2070, Cairns may have more than eight times the number of days over 35 °C (increasing from an average of four per year to an average of 34 per year by 2070).

Rainfall

- Average annual rainfall in the last decade fell by more than two per cent compared to 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 22 per cent to a decrease of 26 per cent by 2070. The 'best estimate' of projected rainfall change shows 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 37 cm in Cairns 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 Far North Queensland region has a diversity of climates based on distance from the coast and elevation, but is generally hot and humid with a distinct 'wet' season (December–March).

Rainfall is associated with moist onshore south-east trade winds, monsoonal lows or tropical cyclones.

The Wet Tropics is at the extremely wet end of the hydrological spectrum, in contrast with many other tropical forest regions of the world, such as Amazonia and Southeast Asia where rainfall events are less extreme and more evenly spread throughout the year.

Photo: Tourism Queensland

Demographics

The region is centred on the coastal city of Cairns. It includes Daintree and Mossman to the north, Innisfail to the south and the Atherton Tablelands to the west.

In 2007, the region's population was 226 266 and is projected to increase beyond 293 900 by 2026.

(OESR, 2007; DIP, 2008)

Important industries of the region

The major industries are land and marine-based tourism, as well as fisheries, horticulture and fibre crops. Other value adding industries are aviation, biotechnology, marine training, electronics, general light manufacturing, steel fabrication and boat building.

Mining activities have also recently emerged near Herberton (zinc) and Mareeba (metallic and non-metallic).

Cairns is the major tourism, business and service hub for the region.

Far North Queensland contains a number of world heritage-listed areas, including the iconic Great Barrier Reef, and the Wet Tropics and Daintree rainforests, which are major world biodiversity hotspots and significant international tourist destinations.

(Extracted from the Far North 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 FNQ region. The fluctuation 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 FNQ region has risen slightly, with a further increase over the last decade (1998–2007).

The average annual temperature was 24.4 °C in the 30-year period from 1971–2000, which is a 0.1 °C increase on the 1961–1990 average. Over the last decade it has risen by a further 0.1 °C.

Average maximum temperature has risen slightly in the Far North Queensland region

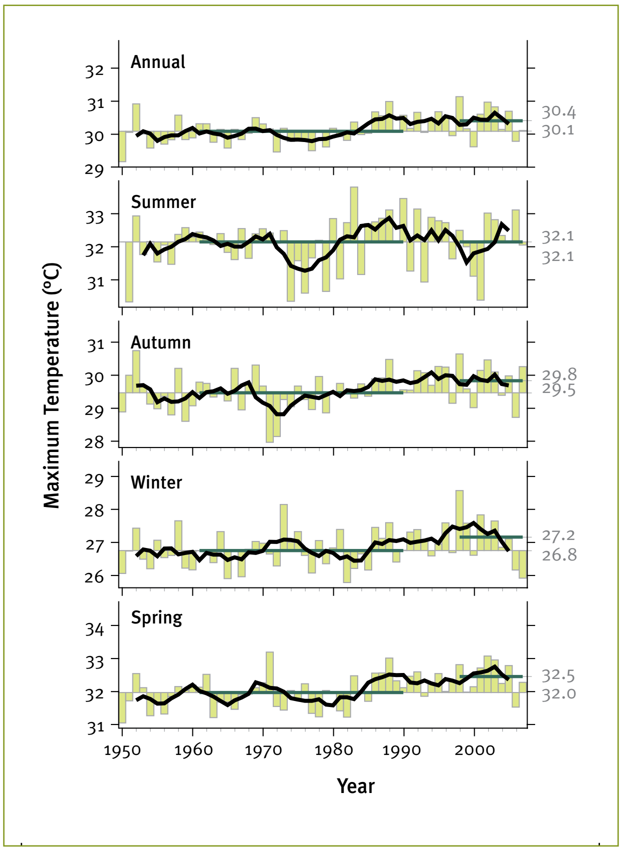

Figure 1: Historical annual and seasonal maximum temperatures for the Far North Queensland region for the period 1950–2007, compared to the base period 1961–1990

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 spring, with the average over the last decade increasing by 0.5 °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 Cairns (Figure 2) show that there has not been the increase in the number of hot days that is seen in other Queensland locations over recent decades.

No observable change in the number of days over 35 °C in Cairns

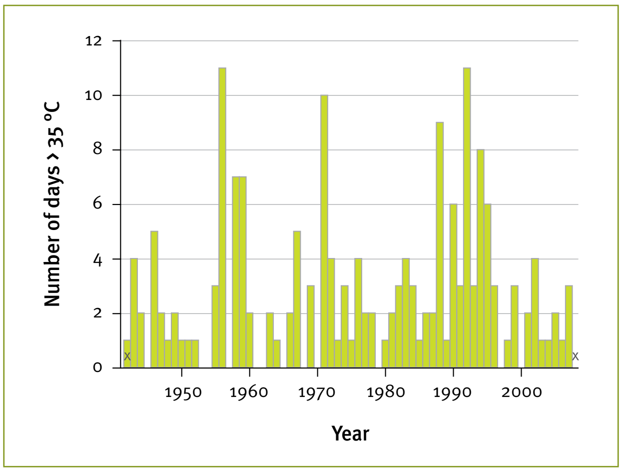

Figure 2: Number of days where the temperature exceeded 35 °C for Cairns

Blank spaces are those years where the maximum temperature did not exceed 35 °C.
'X' denotes 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 FNQ region since 1897.

The variability in annual rainfall is shown in the top graph in Figure 3. The graph shows that rainfall in recent years has been well within that expected from natural variability.

Figure 3 shows the dominant summer rainfall pattern with a 1961–1990 average rainfall around 660 mm, compared to an autumn average (the next most dominant rainfall period) of around 350 mm.

Over the most recent decade, there has been a 21 per cent increase in the average winter rainfall compared to the 1961–1990 average. Summer average rainfall has increased by 10 per cent. This increase is due to consistently wet summers through the latter half of the 1990s and is well within the bounds of natural variability.

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 Far North Queensland region, the annual mean potential evaporation over the period 1971–2000 (1999 mm) is significantly greater than the annual mean rainfall over the same period (1250 mm), which contributes to the depletion of soil moisture.

Historical rainfall shows high variability

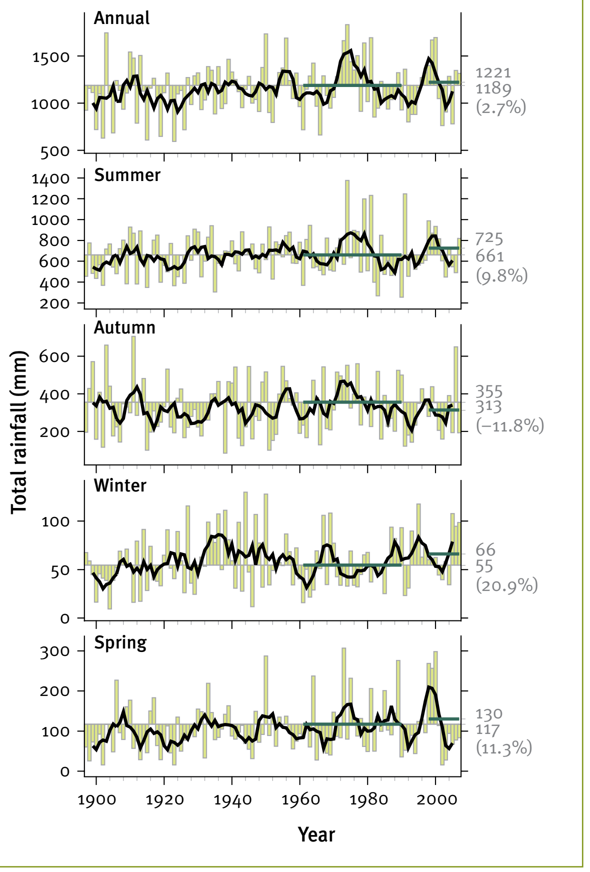

Figure 3: Historical annual and seasonal total rainfall for the Far North Queensland region for the period 1897–2007

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

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.

On average, 4.7 tropical cyclones per year affect the Queensland Tropical Cyclone Warning Centre Area of Responsibility. This area includes all of Queensland, a large portion of the Gulf of Carpentaria, Northern NSW and extends out to 600 km off the Queensland coast.

There is a relationship between the impact of cyclones on eastern Australia and the El Niño Southern Oscillation (ENSO) phenomenon. Overall cyclone activity in Australia decreases during an El Niño pattern and increases in a La Niña pattern. However, for northern Queensland regions, such as FNQ, this trend is not evident, despite the El Niño-Southern Oscillation phenomenon (ENSO) (Figure 4).

Occurrence of cyclones across the FNQ region

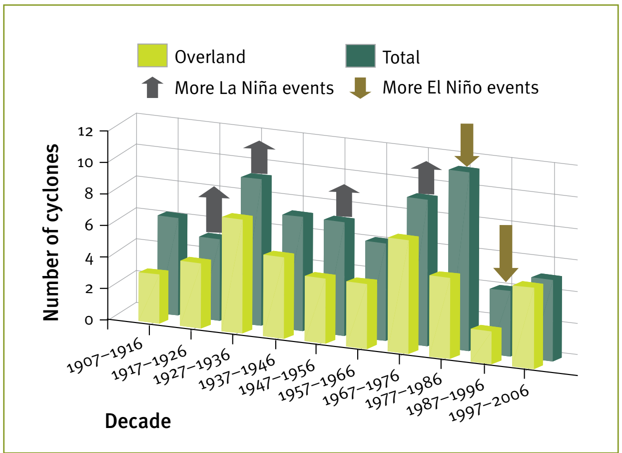

Figure 4: Total and overland number of tropical cyclones for the Far North Queensland region for the period 1907–2006

Adapted from BoM, 2008

Projected climate change in Far North 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 Far North Queensland region have been extracted from this dataset for the Queensland Climate Change Centre of Excellence (QCCCE). The projections presented here are relative to the base period of 1980–1999.

The Global Climate Models show little difference under the high, medium and low emissions scenarios to 2030. Therefore, the 2030 climate change projections for Far North Queensland 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 Far North Queensland in 2030, 2050 and 2070 are described in Table 2. The numbers shown in brackets 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 0.9 °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 one per cent (-13 mm). The largest seasonal decrease of five per cent (-7 mm) is projected for spring.
- **Annual and seasonal potential evaporation**: across all seasons the annual 'best estimate' increase is projected to be around three per cent (60 mm), with some models projecting up to a five per cent increase in autumn (21 mm), summer (27 mm) and winter (20 mm).

2050 (low and high emissions scenarios)

- **Annual and seasonal temperature**: annual temperature will increase by 1.1 °C and 1.8 °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 one per cent (-13 mm) and two per cent (-25 mm) under the low and high emissions scenarios respectively. The largest seasonal decrease of 10 per cent (-13 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 six per cent (120 mm). Summer is projected to have the greatest increase of up to 11 per cent (58 mm).

2070 (low and high emissions scenarios)

- **Annual and seasonal temperature**: annual temperature is projected to increase by 1.5 °C and 2.8 °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 two per cent (-25 mm) and three per cent (-38 mm) under the low and high emissions scenarios respectively. The largest seasonal decrease under a high emissions scenario of 16 per cent (-21 mm) is projected for spring.
- **Annual and seasonal potential evaporation**: under a high emissions scenario, annual potential evaporation is projected to increase by as much as 15 per cent (300 mm). Autumn, summer and winter are projected to be the seasons most impacted with increases up to 17 per cent (73 mm, 90 mm and 67 mm respectively) 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 an observing station in the FNQ region with good historical records.

Under a high emissions scenario in 2070 for Cairns, the number of hot days above 35 °C is projected to increase by more than eight times, from four days to 34 days.

Station Name	Current	2030 Mid	2050 Low	2050 High	2070 Low	2070 High
Cairns	4	6 (5–8)	7 (5–11)	13 (8–26)	10 (7–18)	34 (14–76)

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.

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).

With projected increases in the intensity of 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 and infrastructure and the risk of erosion in low-lying coastal regions.

The 1-in-100-year storm tide event is projected to increase by 37 cm in Cairns 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).

Variable	Season	(1971–2000)	2030†	2050†		2070†	
			Emissions Scenarios				
		Current historical mean*	medium	low	high	low	high
			Projected Changes#				
Temperature °C	Annual	24.4 °C	**+0.9** [+0.6 to +1.2]	**+1.1** [+0.8 to +1.5]	**+1.8** [+1.2 to +2.4]	**+1.5** [+1.0 to +2.0]	**+2.8** [+2.0 to +3.9]
	Summer	27.1 °C	**+0.9** [+0.6 to +1.3]	**+1.1** [+0.7 to +1.6]	**+1.8** [+1.2 to +2.6]	**+1.5** [+1.0 to +2.2]	**+2.9** [+2.0 to +4.2]
	Autumn	24.5 °C	**+0.9** [+0.6 to +1.2]	**+1.1** [+0.7 to +1.5]	**+1.8** [+1.2 to +2.5]	**+1.5** [+1.0 to +2.0]	**+2.9** [+2.0 to +4.0]
	Winter	20.5 °C	**+0.9** [+0.6 to +1.2]	**+1.1** [+0.7 to +1.5]	**+1.7** [+1.2 to +2.5]	**+1.4** [+1.0 to +2.0]	**+2.8** [+1.9 to +4.0]
	Spring	25.6 °C	**+0.9** [+0.6 to +1.2]	**+1.0** [+0.7 to +1.5]	**+1.7** [+1.2 to +2.4]	**+1.4** [+1.0 to +2.0]	**+2.8** [+1.9 to +3.9]
Rainfall %	Annual	1250 mm	**-1** [-9 to +7]	**-1** [-11 to +8]	**-2** [-17 to +14]	**-2** [-14 to +11]	**-3** [-26 to +22]
	Summer	709 mm	**-1** [-9 to +9]	**-1** [-11 to +11]	**-2** [-18 to +18]	**-1** [-15 to +15]	**-2** [-27 to +28]
	Autumn	350 mm	**-1** [-14 to +12]	**-2** [-16 to +15]	**-3** [-26 to +24]	**-2** [-22 to +20]	**-4** [-39 to +39]
	Winter	58 mm	**-1** [-16 to +14]	**-1** [-18 to +17]	**-2** [-29 to +27]	**-1** [-25 to +23]	**-2** [-42 to +44]
	Spring	134 mm	**-5** [-22 to +10]	**-6** [-24 to +12]	**-10** [-38 to +20]	**-8** [-33 to +17]	**-16** [-53 to +33]
Potential evaporation %	Annual	1999 mm	**+3** [+2 to +5]	**+3** [+2 to +5]	**+6** [+4 to +9]	**+5** [+4 to +8]	**+10** [+7 to +15]
	Summer	531 mm	**+3** [+2 to +5]	**+3** [+2 to +4]	**+7** [+3 to +11]	**+5** [+3 to +9]	**+11** [+5 to +17]
	Autumn	428 mm	**+4** [+2 to +5]	**+4** [+2 to +7]	**+7** [+5 to +10]	**+6** [+4 to +9]	**+11** [+7 to +17]
	Winter	395 mm	**+3** [+2 to +5]	**+4** [+3 to +6]	**+7** [+4 to +10]	**+6** [+4 to +9]	**+11** [+7 to +17]
	Spring	642 mm	**+3** [+2 to +4]	**+3** [+2 to +5]	**+6** [+4 to +8]	**+5** [+3 to +7]	**+9** [+6 to +13]

Table 2. Summary of projections for Far North 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.

Impacts of climate change on the Far North Queensland region

Projections for the Far North Queensland region include a slight decline in rainfall with increasing temperature and evaporation, in conjunction with more extreme climate events, such as cyclonic weather 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 FNQ region is particularly vulnerable to the impacts of climate change as changes in temperature or rainfall could have significant impacts on the cane, dairy, beef and horticulture industries. People will also be affected, as the rate of heat-related health problems increases and increased exposure to catastrophic events, such as cyclones and flooding endanger lives and property.

As the communities of FNQ are built around the tourism, agriculture and fisheries sectors, there are many activities that are likely to be adversely affected by the projected increases in temperature and changing rainfall patterns. Some examples are:

- Possible changes in the frequency and intensity of extreme climatic events will present continual challenges to the region. For example, more extreme storm events will have greater impacts, affecting the local community and infrastructure (transport, communications and public services), and may place stress on emergency services.
- Tropical diseases such as the Ross River virus are also expected to increase under climate change. Changes in rainfall, high tides and maximum temperatures have all been shown to be key determinants of Ross River Virus transmission (Tong et al, 2004). The number of cases of dengue fever in Australia is projected to increase from 310 000 in 2000, to 540 000 by 2030 under the high global emissions scenario.
- In Cairns, heat-related deaths are projected to grow annually, from approximately one to 4–5 by 2020 and 11–26 heat-related deaths by 2050.
- In Far North Queensland, the tourism industry is reliant on healthy reef and rainforest environments. These environments are particularly vulnerable to the impacts of climate change.
- 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.

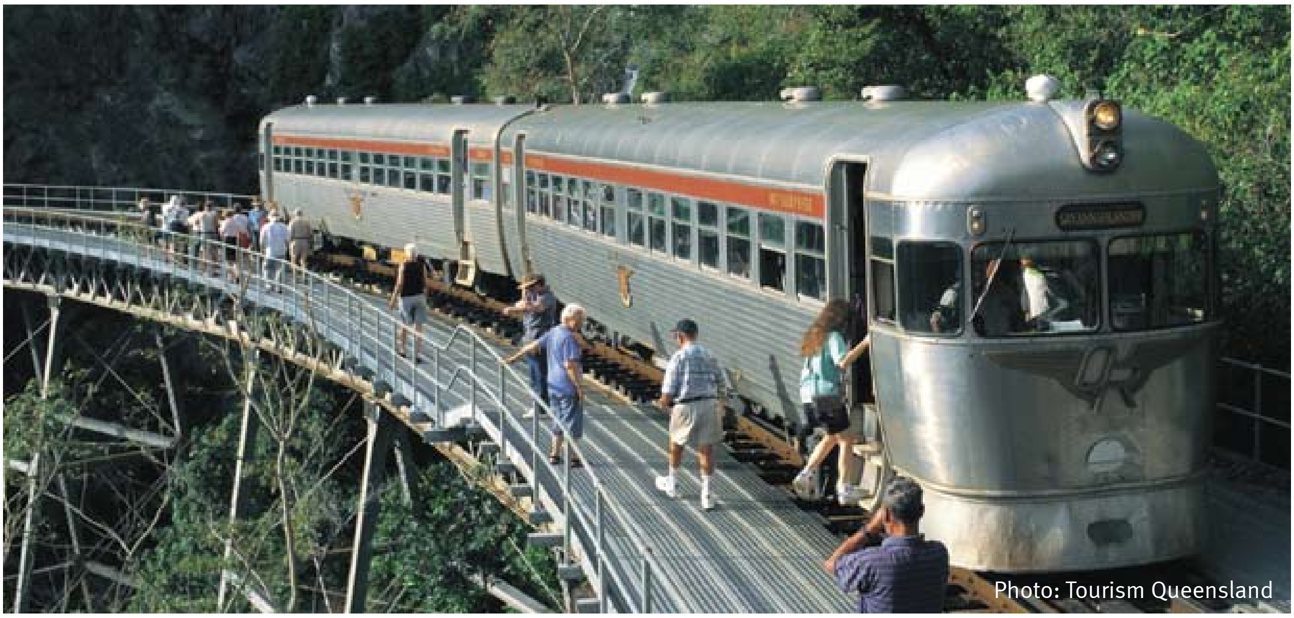

Photo: Tourism Queensland

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Photo: Tourism Queensland