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Research that matters.

# HeatWatch Queensland

## Extreme heat in the Sunshine State

***Increasing extreme heat will have profound impacts on people, industries and ecosystems in Queensland.***

Discussion paper

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# Summary

The projected rise in extremely hot days as a result of global warming presents a serious risk to the health and wellbeing of the Queensland community.

There has already been a clear increase in numbers of these extreme heat days over recent decades, as demonstrated in our profiles on:

- The Gold Coast;
- Brisbane;
- The Sunshine Coast;
- Roma;
- Gladstone;
- Rockhampton;
- Mackay;
- The Whitsundays; and
- Townsville.[1]

Exposure to extreme heat can lead to serious illness and death. At temperatures above 35 degrees, the human body's ability to cool itself reduces, which can lead to a cascading series of Heat Related Illnesses (HRI) and ultimately heatstroke that can cause organ failure and death. Heatwaves have caused more deaths in Australia since 1890 than cyclones, bushfires, floods, earthquakes and severe storms combined.[2]

In parts of Queensland, the extreme heat risk is exacerbated by high humidity. Combined with 70% humidity, conditions over 35 degrees are considered "dangerous" by government agencies such as the US Government National Oceanic and Atmospheric Administration. Temperatures of 35 degrees combined with 80% humidity are considered "extremely dangerous".

The workforce in Queensland is also particularly vulnerable to increasing extreme heat with significant shares of workers employed in industries that frequently require heavy outdoor labour including mining, construction and agriculture.

[1] Full reports for Gladstone, the Gold Coast, Mackay, Rockhampton, Roma, the Sunshine Coast, Townsville and the Whitsundays are available on our HeatWatch page: http://www.tai.org.au/heatwatch

[2] McMichael et al. (2003) *Climate change and human health, risks and responses,* p 53, https://www.who.int/globalchange/publications/climchange.pdf

Cool night-time temperatures are essential for good health and to allow people to recover from hot days. 25 degrees is considered a threshold for hot nights. The number of nights over 25 degrees in parts of Queensland have increased significantly and could increase further, in some cases leaving essentially all of summer with extreme heat nights.

Extreme heat events present a risk to critical infrastructure including road, rail and electricity generation and have a major impact on productivity and economic activity.

None of this is inevitable. CSIRO modelling shows that if emissions are reduced decisively in line with the globally agreed target of 1.5 degrees above pre-industrial levels, the number of days per year over 35 degrees could peak in most locations by 2070 before reducing by 2090, ensuring relatively safe temperatures for our children and grandchildren.

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# Introduction

The intense heatwave in November 2018 triggered a bushfire crisis throughout Queensland, putting hundreds of homes at risk.[3] Australia also just experienced its hottest summer on record in 2018-19, and the first season in which temperatures have exceeded two degrees above the long-term averages.[4]

Extreme heat is already dangerous for human health, ecosystems, infrastructure and agriculture and it will worsen with climate change.

Global temperature increases of 1.5 or 2 degrees above pre-industrial levels will have dramatic impacts on human health, the ecosystem and the economy. Human-induced warming reached 1 degree above pre-industrial levels in 2017.[5] Current policy settings would see more extreme warming than 2 degrees above pre-industrial levels.

The Australia Institute's Heatwatch initiative puts current Australian research about temperature increases due to global warming into context, using data from BoM and the CSIRO.

HeatWatch uses extreme heat days (days over 35 degrees) along with other thresholds like 40 degrees to highlight the effects of global warming. This includes a dramatic increase in days where it is uncomfortable or dangerous to operate outside – affecting industries like construction, sport and other outdoor activities.

The special HeatWatch Queensland Report looks at the likely projections and impacts for key locations in the state and was prepared for the inaugural Queensland Climate Week. This report aggregates key findings from eight Queensland HeatWatch reports: Gladstone, the Gold Coast, Mackay, Rockhampton, Roma, the Sunshine Coast, Townsville and the Whitsundays. New analysis for Brisbane is also included in this report. Three of the Queensland reports were presented alongside Queensland Fire and Emergency Services workshops on extreme heat. The report also draws on HeatWatch reports for the federal electorates of Capricornia, Dawson and Herbert.

[3] Daily Mercury (December 2018) *STAY INFORMED: Fires still active in Mackay Region,* https://www.dailymercury.com.au/news/stay-informed-fires-still-active-in-mackay-region/3591424/

[4] Sydney Morning Herald (2019) *'It's been extreme': Australia's summer smashes seasonal heat records,* https://www.smh.com.au/environment/weather/it-s-been-extreme-australia-s-summer-smashes-seasonal-heat-records-20190227-p510od.html

[5] IPCC (2018) *Global Warming of 1.5 °C,* p 1:4, https://www.ipcc.ch/report/sr15/

The Australia Institute will continue to focus on additional locations and welcomes interest in collaborating on local versions of the reports.

All HeatWatch reports are available on our website: http://www.tai.org.au/heatwatch

# EXTREME HEAT

Extreme heat is dangerous for human health, ecosystems, infrastructure and agriculture. At temperatures above 35 degrees, the human body's main cooling mechanism – sweating – is far less effective. Sweating exchanges heat from the body to the atmosphere, but this heat exchange process diminishes significantly beyond 35 degrees, so body temperature rises. This creates discomfort and a range of health impacts, from mild to severe, and can ultimately be fatal without intervention.[6]

Because of this, many regulators and researchers use 35 degrees as an important threshold for safety, work and climatic conditions. 35 degrees is seen as the "limit of high temperature tolerance" by the Occupational Health and Safety Representatives of the Victorian Trades Hall Council and many academic researchers note it as the point where substantial productivity is lost. The CSIRO and Bureau of Meteorology (BoM) publish 35-degree threshold predictions.[7]

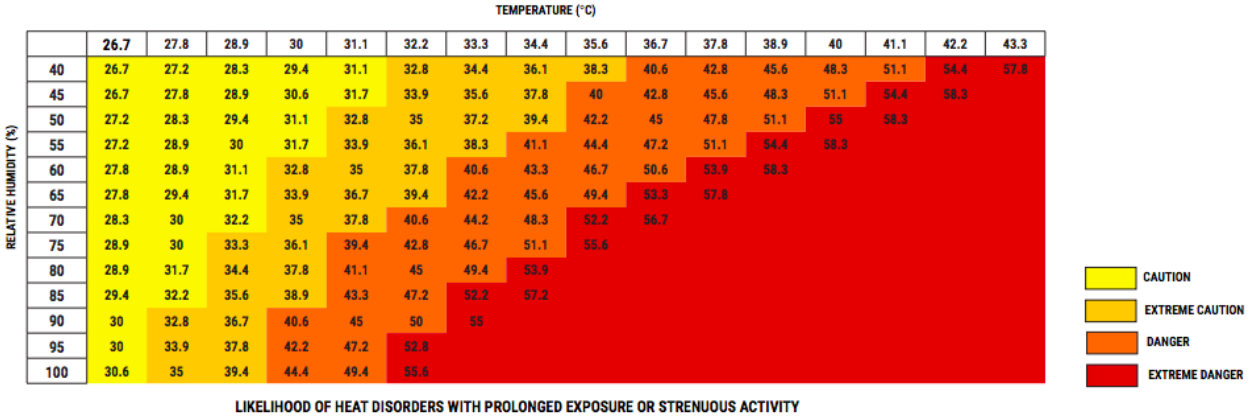
Temperature and humidity are often combined into a heat index figure to provide a simple indicator of the body's ability to cool itself. One of the most important indices is published by the US Government National Oceanic and Atmospheric Administration (NOAA). As shown in the NOAA heat stress chart in Figure 1 below, temperatures in the low thirties combined with high humidity are considered "dangerous" to human health.

NOAA's heat stress index rises to "Extreme Danger" at temperatures over 35 degrees combine with 80% humidity.

[6] Hanna and Tait (2015) *Limitations to thermoregulation and acclimatisation challenges human adaptation to global warming,* Int J Environ Res Public Health, https://academic.oup.com/heapro/article/30/2/239/561863

[7] Victorian Trades Hall Council (2018) *Heat*, http://www.ohsrep.org.au/hazards/workplace-conditions/heat; Singh et al. (2015) *Working in Australia's heat: health promotion concerns for health and productivity,* Health Promotion International, https://academic.oup.com/heapro/article/30/2/239/561863; CSIRO and BoM (2015) *Climate change in Australia: Projections for Australia's NRM Regions*, https://www.climatechangeinaustralia.gov.au/en/publications-library/technical-report/

**Figure 1: NOAA Heat Stress Index**




| | 26.7 | 27.8 | 28.9 | 30 | 31.1 | 32.2 | 33.3 | 34.4 | 35.6 | 36.7 | 37.8 | 38.9 | 40 | 41.1 | 42.2 | 43.3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 26.7 | 27.2 | 28.3 | 29.4 | 31.1 | 32.8 | 34.4 | 36.1 | 38.3 | 40.6 | 42.8 | 45.6 | 48.3 | 51.1 | 54.4 | 57.8 |
| 45 | 26.7 | 27.8 | 28.9 | 30.6 | 31.7 | 33.9 | 35.6 | 37.8 | 40 | 42.8 | 45.6 | 48.3 | 51.1 | 54.4 | 58.3 | |
| 50 | 27.2 | 28.3 | 29.4 | 31.1 | 32.8 | 35 | 37.2 | 39.4 | 42.2 | 45 | 47.8 | 51.1 | 55 | 58.3 | | |
| 55 | 27.2 | 28.9 | 30 | 31.7 | 33.9 | 36.1 | 38.3 | 41.1 | 44.4 | 47.2 | 51.1 | 54.4 | 58.3 | | | |
| 60 | 27.8 | 28.9 | 31.1 | 32.8 | 35 | 37.8 | 40.6 | 43.3 | 46.7 | 50.6 | 53.9 | 58.3 | | | | |
| 65 | 27.8 | 29.4 | 31.7 | 33.9 | 36.7 | 39.4 | 42.2 | 45.6 | 49.4 | 53.3 | 57.8 | | | | | |
| 70 | 28.3 | 30 | 32.2 | 35 | 37.8 | 40.6 | 44.2 | 48.3 | 52.2 | 56.7 | | | | | | |
| 75 | 28.9 | 30 | 33.3 | 36.1 | 39.4 | 42.8 | 46.7 | 51.1 | 55.6 | | | | | | | |
| 80 | 28.9 | 31.7 | 34.4 | 37.8 | 41.1 | 45 | 49.4 | 53.9 | | | | | | | | |
| 85 | 29.4 | 32.2 | 35.6 | 38.9 | 43.3 | 47.2 | 52.2 | 57.2 | | | | | | | | |
| 90 | 30 | 32.8 | 36.7 | 40.6 | 45 | 50 | 55 | | | | | | | | | |
| 95 | 30 | 33.9 | 37.8 | 42.2 | 47.2 | 52.8 | | | | | | | | | | |
| 100 | 30.6 | 35 | 39.4 | 44.4 | 49.4 | 55.6 | | | | | | | | | | |

Source: National Weather Service (n.d.) *Heat safety,* http://www.nws.noaa.gov/os/heat/heat_index.shtml

A future of such extreme heat days matched with high humidity represents a serious threat to the wellbeing of people in Queensland and to Australia's wider population. As well as an increase in heat-related deaths and illness, the rise in extreme heat increases irritability and psychological stress.[8] Hot weather affects patterns in domestic violence,[9] interrupts sleep patterns and reduces capacity and willingness to exercise. All carry broad ramifications, such as increased accident risk, sedentary life style-induced diabetes and cardio vascular disease.[10] Tracking and minimising the way climate change is affecting the number of hot days is of direct interest to the wellbeing of local communities, particularly in areas of high vulnerability to heatwaves.

# DATA

CSIRO and BoM have produced temperature projections under several climate change scenarios for most of terrestrial Australia. The CSIRO–BoM data is a time series from the Australian Water Availability Project (AWAP) where the average temperature was compiled in roughly five kilometre by five kilometre spatial grids between 1981 and 2010.[11] This time series uses between five and eight models to predict days over 35

[8] Queensland Health (2015) *Heatwave Response Plan* https://www.health.qld.gov.au/__data/assets/pdf_file/0032/628268/heatwave-response-plan.pdf

[9] Auliciems and Di Bartolo (1995) *Domestic violence in a subtropical environment: police calls and weather in Brisbane,* International Journal of Biometeorology 39 (1).

[10] Kjellstrom et al. (2009) *The Direct Impact of Climate Change on Regional Labor Productivity,* Archives of Environmental & Occupational Health 64 (4); World Health Organisation (2017) *Preventing noncommunicable diseases (NCDs) by reducing environmental risk factors*, http://apps.who.int/iris/bitstream/10665/258796/1/WHO-FWC-EPE-17.01-eng.pdf?ua=1

[11] CSIRO and BoM (2015) *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*

degrees, over 37 degrees and over 40 degrees in 2030, 2050, 2070 and 2090.[12] It also has a historical average for the years 1981–2010.

The report also employs the IPCC scenarios for global climate action: Representative Concentration Pathway (RCP) 2.6 ("low emissions"), RCP 4.5 ("intermediate emissions") and RCP 8.5 ("high emissions/current government policies"). RCP 2.6 equates roughly to what is required to keep the world below 1.5 degrees warming, RCP 4.5 to what is required to keep the world below 2 degrees warming, and RCP 8.5 to the "business as usual" scenario where the world fails to act decisively on climate change. RCP 8.5 is the current trajectory due to the failure of most major polluting governments to implement necessary climate policies.

Separately, BoM has weather measurement stations providing historical climate data.

[12] All eight models – ACCESS1.0, CESM1-CAM5, CNRM-CM5, GFDL-ESM2M, HadGEM2-CC, CanESM2, MIROC5 and NorESM1-M – are available for the RCP 4.5 and RCP 8.5 scenarios. Five models – CESM1-CAM5, CNRM-CM5, CanESM2, MIROC5 and NorESM1-M – are available for the RCP 2.6 scenario.

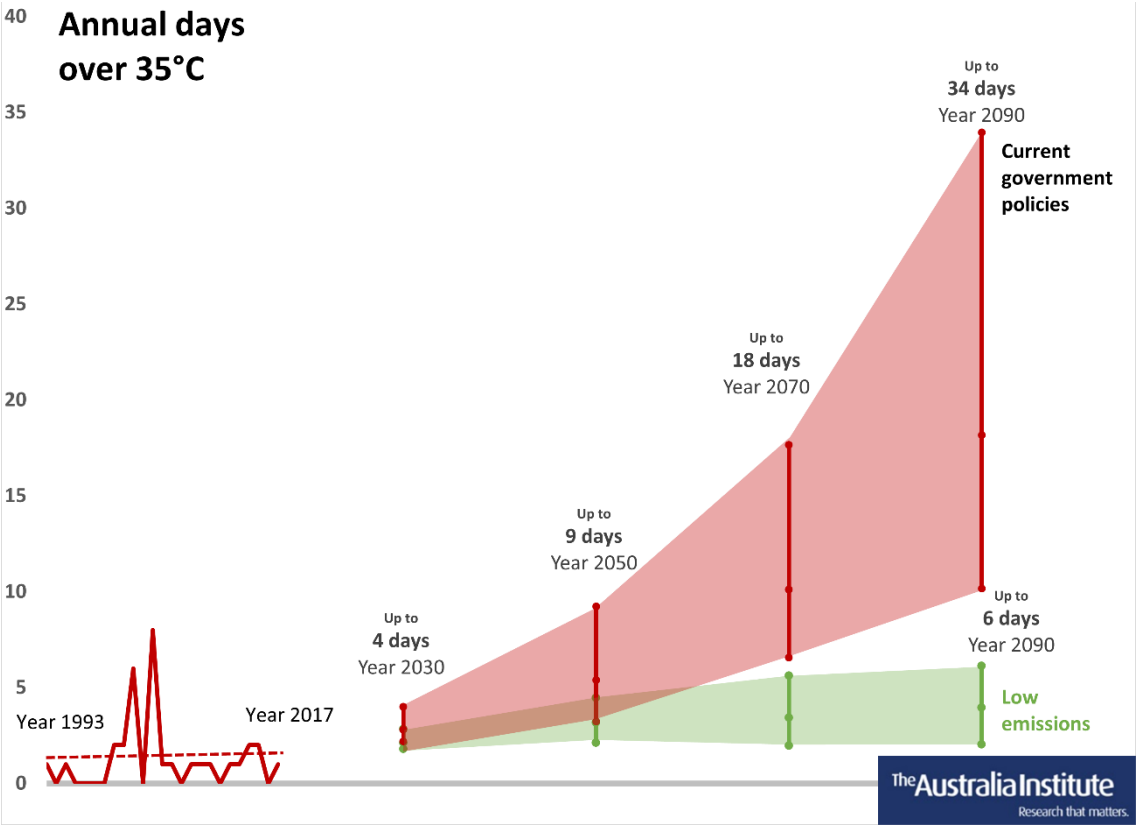
# The Gold Coast

The Gold Coast, although known for its consistent warm weather, has seen the number of extreme temperature days increase in recent years and their frequency is projected to rise dramatically unless greenhouse gas emissions are reduced.

Under current government policies, in the Gold Coast days over 35 degrees would go from a historical average of 1 days per year to up to 4 days by 2030, 9 days by 2050, 18 days by 2070 and 34 days by 2090.

The Gold Coast would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees would keep predicted days over 35 degrees to 3 days or below by 2030, increase to 4 days or below by 2050 and stabilise at 6 days or below by 2090.

**Figure 2: Forecast annual number of days over 35 degrees the Gold Coast**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

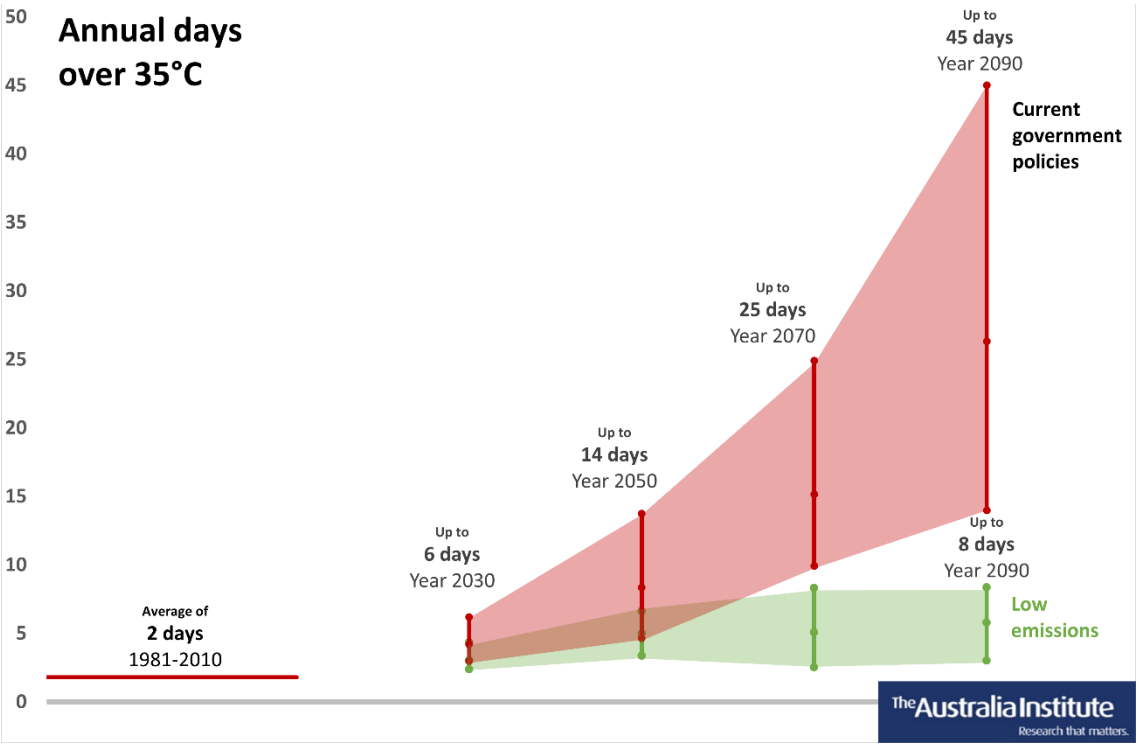
# Brisbane

Brisbane has a warm, sunny climate. However, it has relatively few very hot days. This is at risk of changing if strong climate policies are not adopted.

Under current government policies, in Brisbane days over 35 degrees would go from a historical average of 2 days per year to up to 6 days by 2030, 14 days by 2050, 25 days by 2070 and 45 days by 2090.

Brisbane would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees would keep predicted days over 35 degrees to 4 days or below by 2030, increase to 7 days or below by 2050 and stabilise at 8 days or below by 2090.

**Figure 3: Forecast annual number of days over 35 degrees Brisbane**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

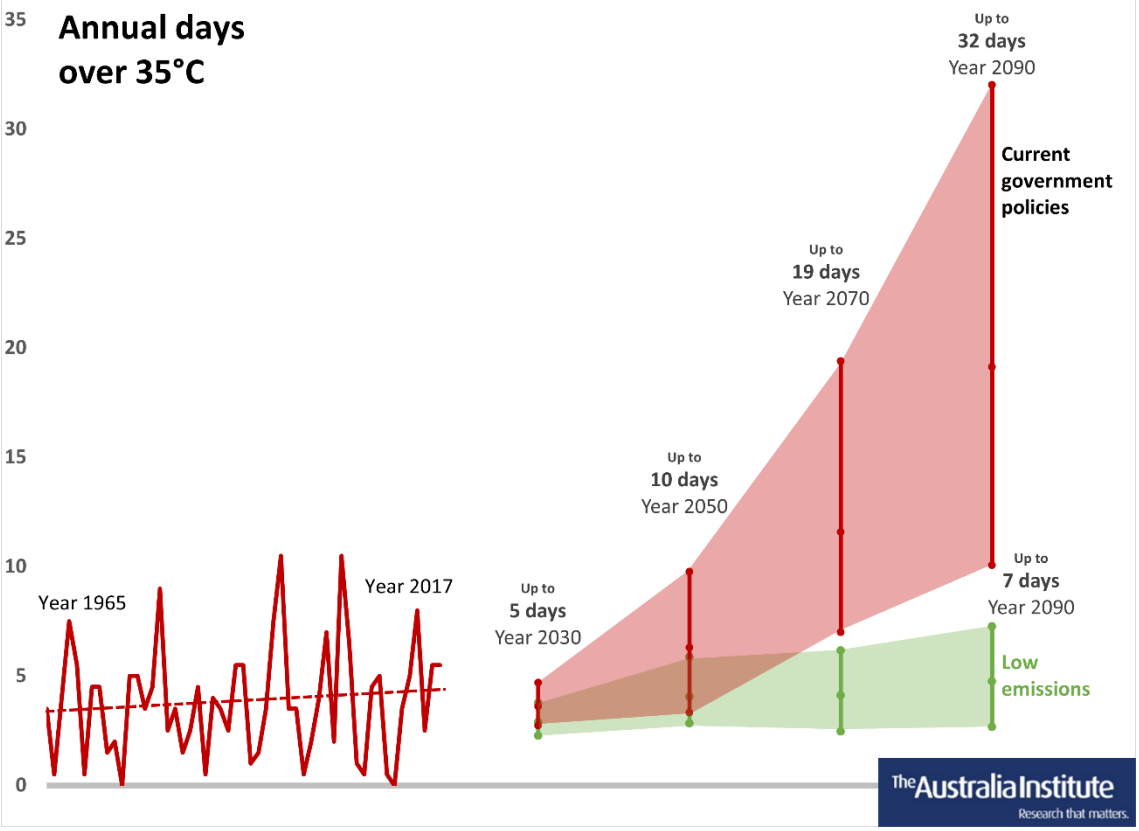
# The Sunshine Coast

The Sunshine Coast, although known for its consistent warm weather, has seen the number of extreme temperature days increase slightly in recent years and their frequency is forecast to rise dramatically unless emissions are reduced.

Under current government policies, in the Sunshine Coast days over 35 degrees would go from a historical average of 2 days per year to up to 5 days by 2030, 10 days by 2050, 19 days by 2070 and 32 days by 2090.

The Sunshine Coast would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees would keep predicted days over 35 degrees to 4 days or below by 2030, increase to 6 days or below by 2050 and stabilise at 7 days or below by 2090.

**Figure 4: Forecast annual number of days over 35 degrees the Sunshine Coast**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

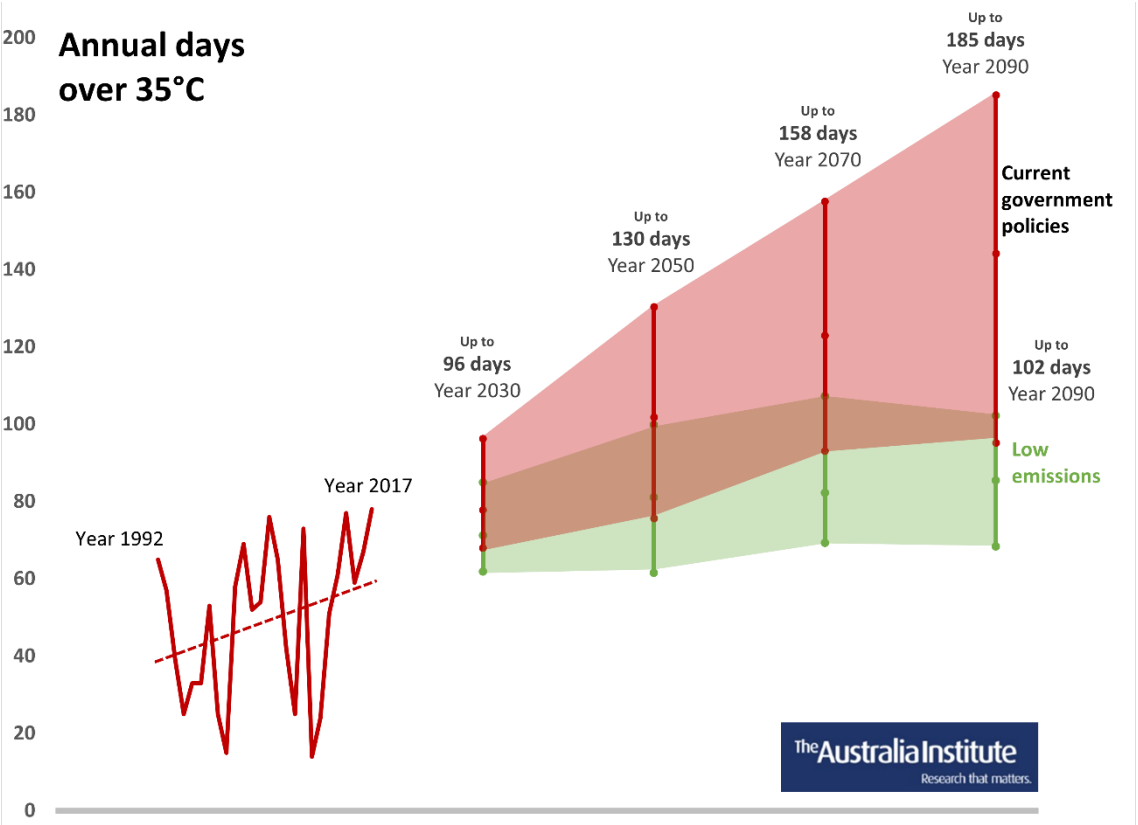
# Roma

While Roma is known for its warm weather and hot days, the average number of over 35 days has increased considerably in recent years and is forecast to increase drastically unless emissions are reduced.

Under current government policies, in Roma days over 35 degrees would go from a historical average of 53 days per year to up to 96 days by 2030, 130 days by 2050, 158 days by 2070 and 185 days by 2090.

Roma would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees would keep predicted days over 35 degrees to 85 days or below by 2030, increase to 100 days or below by 2050 and stabilise at 102 days or below by 2090.

**Figure 5: Forecast annual number of days over 35 degrees Roma**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

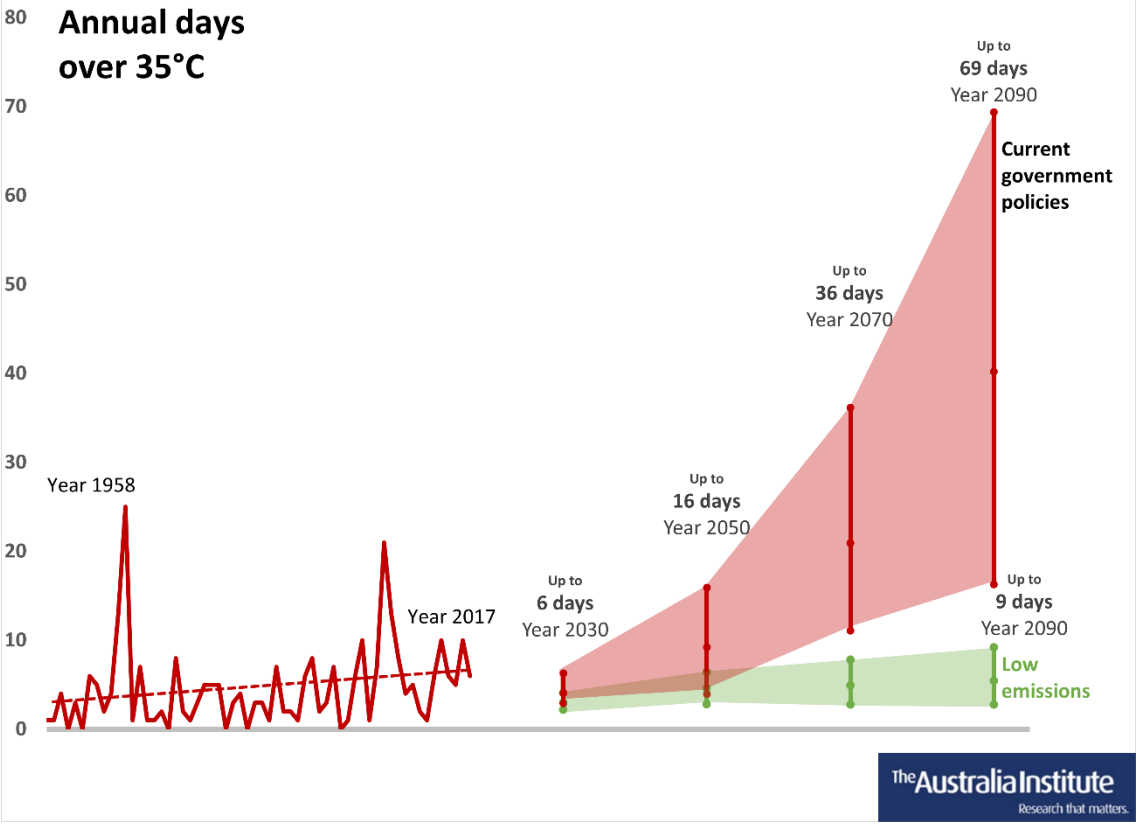
# Gladstone

While Gladstone's summer weather is consistently warm, the number of extremely hot days – days over 35 degrees Celsius – has generally been low. The average number of over 35 degree days has, however, more than doubled in recent years and is forecast to increase without a strong policy response to climate change.

Under current government policies, in Gladstone days over 35 degrees would go from a historical average of 2 days per year to up to 6 days by 2030, 16 days by 2050, 36 days by 2070 and 69 days by 2090.

Gladstone would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees would keep predicted days over 35 degrees to 4 days or below by 2030, increase to 6 days or below by 2050 and stabilise at 9 days or below by 2090.

**Figure 6: Forecast annual number of days over 35 degrees Gladstone**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

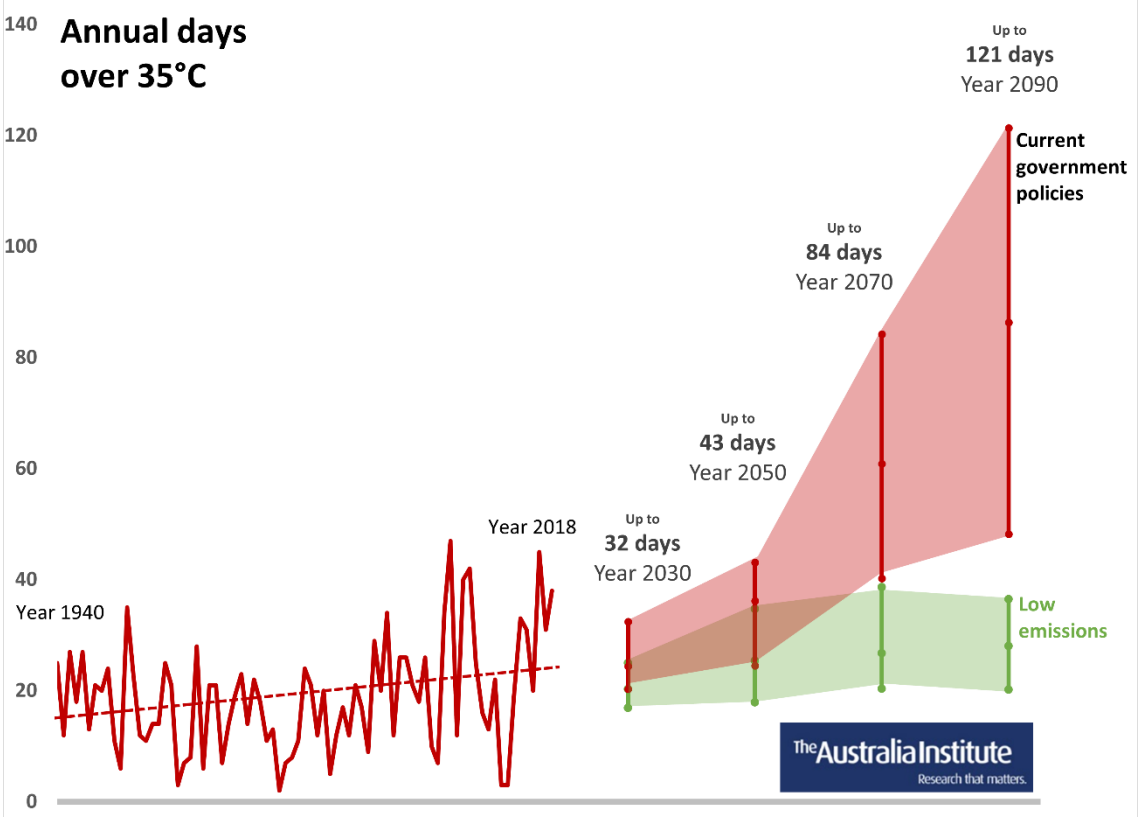
# Rockhampton

While Rockhampton is known for the consistency of its warm summer weather, the number of extremely hot days has been relatively low. The average number of over 35 degree days has, however, increased considerably in recent years and is forecast to increase drastically without a strong action on climate change.

Under current government policies, in Rockhampton days over 35 degrees would go from a historical average of 14 days per year to up to 32 days by 2030, 43 days by 2050, 84 days by 2070 and 121 days by 2090.

Rockhampton would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees would keep predicted days over 35 degrees to 25 days or below by 2030, increase to 35 days or below by 2050 and stabilise at 37 days or below by 2090.

**Figure 7: Forecast annual number of days over 35 degrees Rockhampton**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

# Mackay

Mackay has historically enjoyed a relatively pleasant coastal climate. However, this is at risk as the climate warms and the number of extreme heat events increases.

Prior to last November the temperature in Mackay had not exceeded 40 degrees since records began in 1960.

However last November Mackay experienced its most extended heatwave on record and its highest recorded temperature of 40.7 degrees, easily breaking a record set just three days before.[13] Mackay also experienced four consecutive days above previous November records, as well as breaking annual records for consecutive days over 35 and 38 degrees.[14]

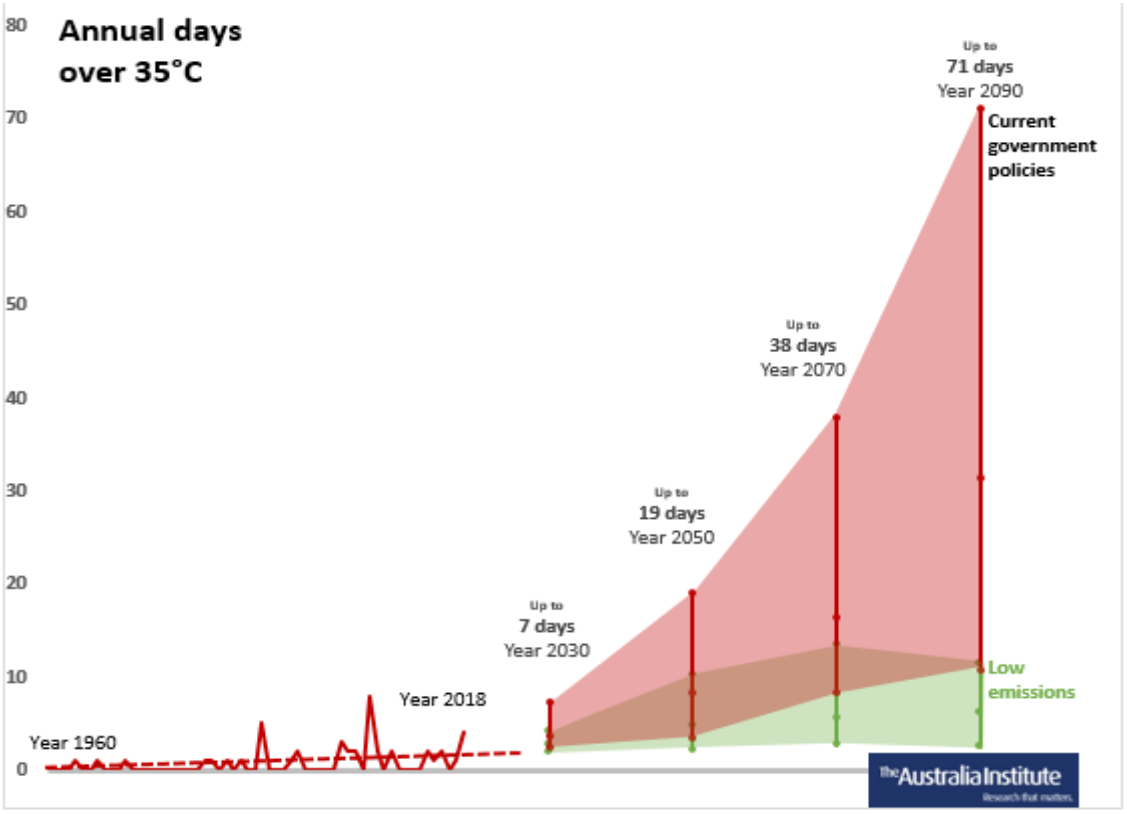
Under current government policies, in Mackay days over 35 degrees would go from a historical average of 1.5 days per year to up to 7 days by 2030, 19 days by 2050, 38 days by 2070 and 71 days by 2090. This would be concentrated in summer, where up to 57% of summer days would be over 35 degrees by 2090.

Mackay would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees would keep predicted days over 35 degrees to 2 days by 2030, increase to 10 days by 2050 and stabilise at 11 days by 2090.

[13] BoM (2018) *Climate Data online, Mackay Aero,* http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=122&p_display_type=dailyDataFile&p_startYear=2018&p_c=-218394947&p_stn_num=033045

[14] BoM (2018) *Special Climate Statement 67—an extreme heatwave on the tropical Queensland coast,* http://www.bom.gov.au/climate/current/statements/scs67.pdf

**Figure 8: Forecast annual number of days over 35 degrees Mackay**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

# The Whitsundays

The Whitsundays have historically enjoyed a relatively pleasant coastal climate. However, this is at risk as the climate warms and the number of extreme heat events increases.

Last November, Proserpine experienced its most extended heatwave on record, including its hottest day on record, when temperatures reached 44.9 degrees on November 26th. The following two days remained above the previous record of 42.9 degrees. In this period there was a record nine consecutive days over 35 degrees, almost double the previous record of five days. There were four consecutive days over 38 degrees and three over 40 degrees. There had never before been any consecutive days over 38 degrees recorded in Proserpine since records began in 1970.[15]

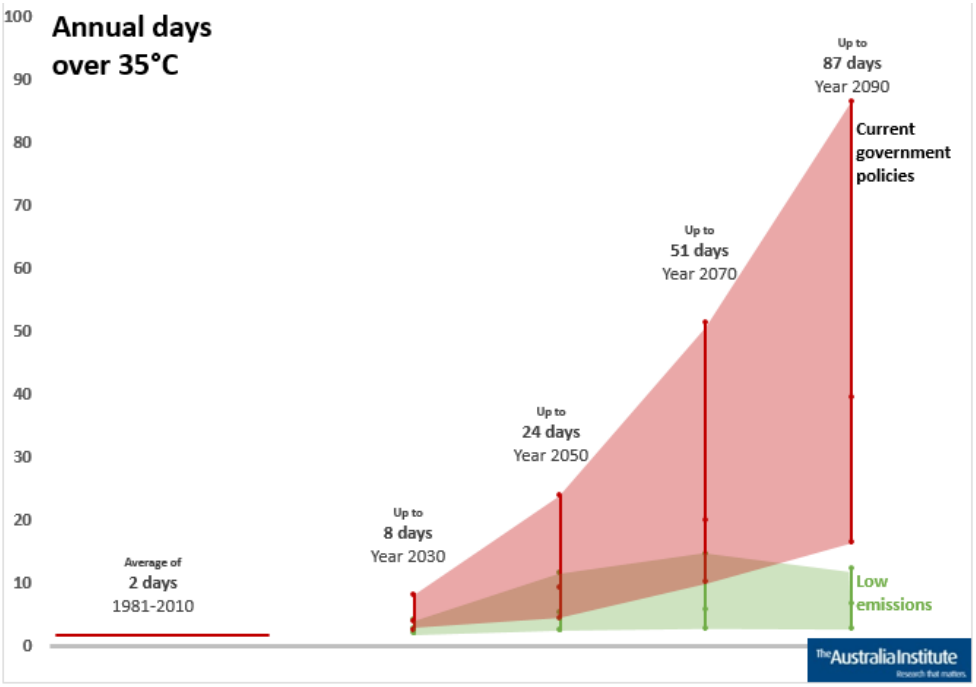
As shown in Figure 9 below, under current government policies, in Cannonvale days over 35 degrees would go from a historical average of 2 days per year (1981-2010) to up to 8 days by 2030, 24 days by 2050, 51 days by 2070 and 87 days by 2090. This would be concentrated in summer, where potentially almost every summer day could be over 35 degrees by 2090.

Proserpine is projected to have even greater increases. As shown in Figure 10 below, under current government policies, in Proserpine days over 35 degrees would go from a historical average of around 10 days per year to up to 22 days by 2030, 50 days by 2050, 84 days by 2070 and 122 days by 2090. Again, this would be concentrated in summer, where potentially almost every summer day could be over 35 degrees by 2090

The Whitsundays would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees keep predicted days over 35 degrees in Cannonvale to below 4 days by 2030, increase to up to 12 days by 2050 and stabilise at 13 days or below by 2090.

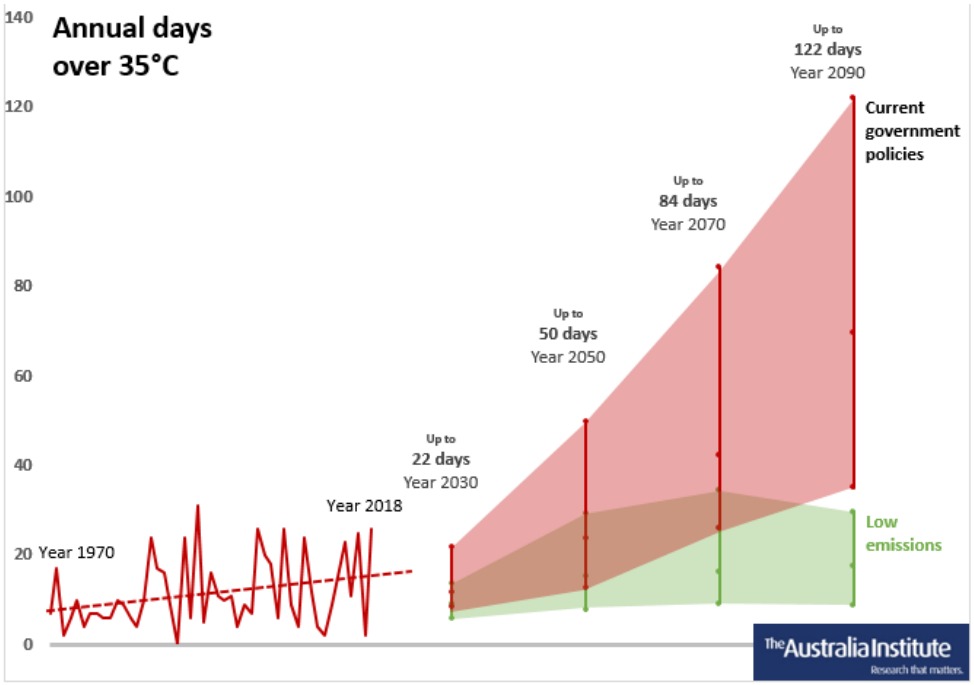
[15] BoM (2018) *Special Climate Statement 67—an extreme heatwave on the tropical Queensland coast*

**Figure 9: Forecast annual number of days over 35 degrees Cannonvale/Airlie Beach**




Source: BoM (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections,* provided on request

**Figure 10: Forecast annual number of days over 35 degrees Proserpine/Whitsunday Airport**




Source: BoM (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections,* provided on request

# Townsville

Townsville has historically enjoyed a relatively pleasant coastal climate. However, this is at risk as the climate warms and the number of extreme heat events increases.

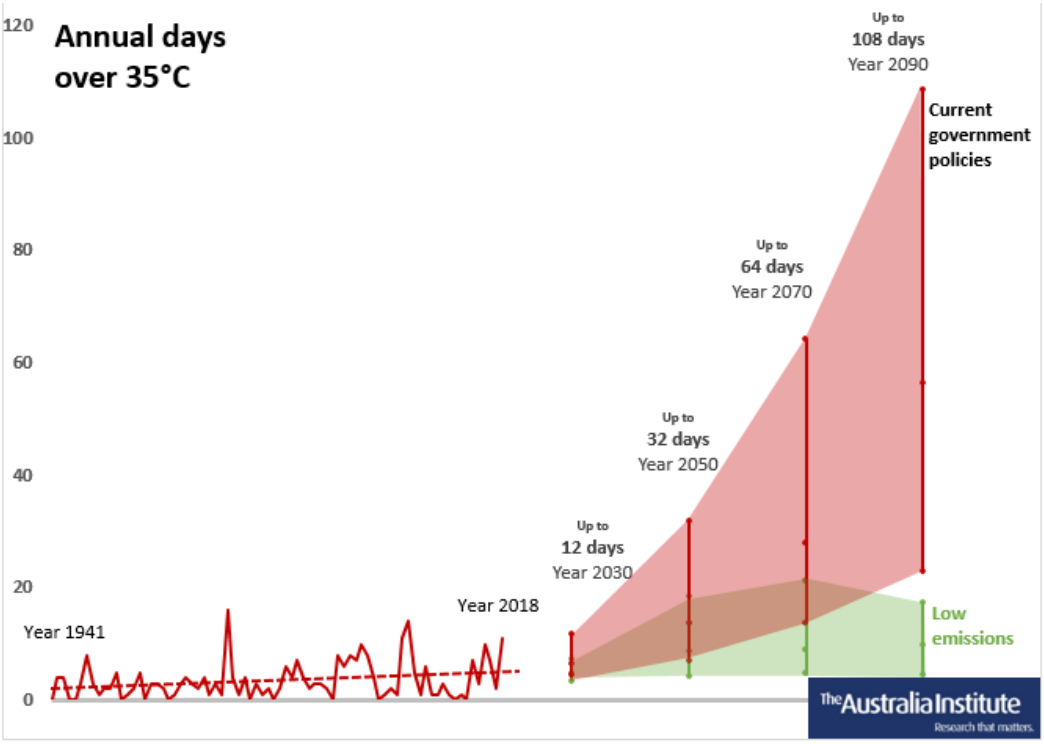
In November 2018, Townsville experienced its most extended heatwave on record, including its highest recorded November temperature of 41.7 degrees. During this heatwave Townsville experienced a record six consecutive days over 35 degrees for November and set an annual record of four consecutive days over 38 degrees. There are no previous recorded incidents of more than one consecutive day over 38 degrees since records began in 1941.[16]

Under current government policies, in Townsville days over 35 degrees would go from a historical average of 3 days per year to up to 12 days by 2030, 32 days by 2050, 64 days by 2070 and 108 days by 2090. This would be concentrated in summer, where potentially almost every summer day could be over 35 degrees by 2090.

Townsville would benefit significantly from climate policies that would keep warming below 1.5 degrees. Climate policies to keep warming below 1.5 degrees would keep predicted days over 35 degrees to 7 days or below by 2030, increase to up to 18 days by 2050 and stabilise at 17 days or below by 2090.

[16] BoM (2018) *Special Climate Statement 67—an extreme heatwave on the tropical Queensland coast,* http://www.bom.gov.au/climate/current/statements/scs67.pdf

**Figure 11: Forecast annual number of days over 35 degrees Townsville**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

# Electorates

Climate change is increasing land and ocean temperatures. These increases can be measured as an increase in average temperatures over the year as a whole. Australia has warmed by just over 1 degree as a result of greenhouse gas emissions and is projected to warm by up to over 5 degrees by the end of century if global emissions remain high.[17] The World Bank considers 4 degrees "devastating" with "extremely severe risks for vital human support systems."[18]

QLD Government projections show an increase in the annual mean temperature for QLD as a whole of up to 5.5 degrees by 2090.[19]

However, while increasing average or mean temperatures can have serious impacts on human health and activities, extreme temperature events are the most dangerous to human health, agriculture and the natural environment.

The QLD Government provides projections for the number of extreme heat days over various thresholds. These maps in the tables below show the increasing frequency of extreme temperature days over the coming decades. The darker the shade of red, the greater the increase in the amount of hot days per year in that location.

[17] BoM and CSIRO (2015) *Australia's changing climate,* https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/176/AUSTRALIAS_CHANGING_CLIMATE_1.pdf

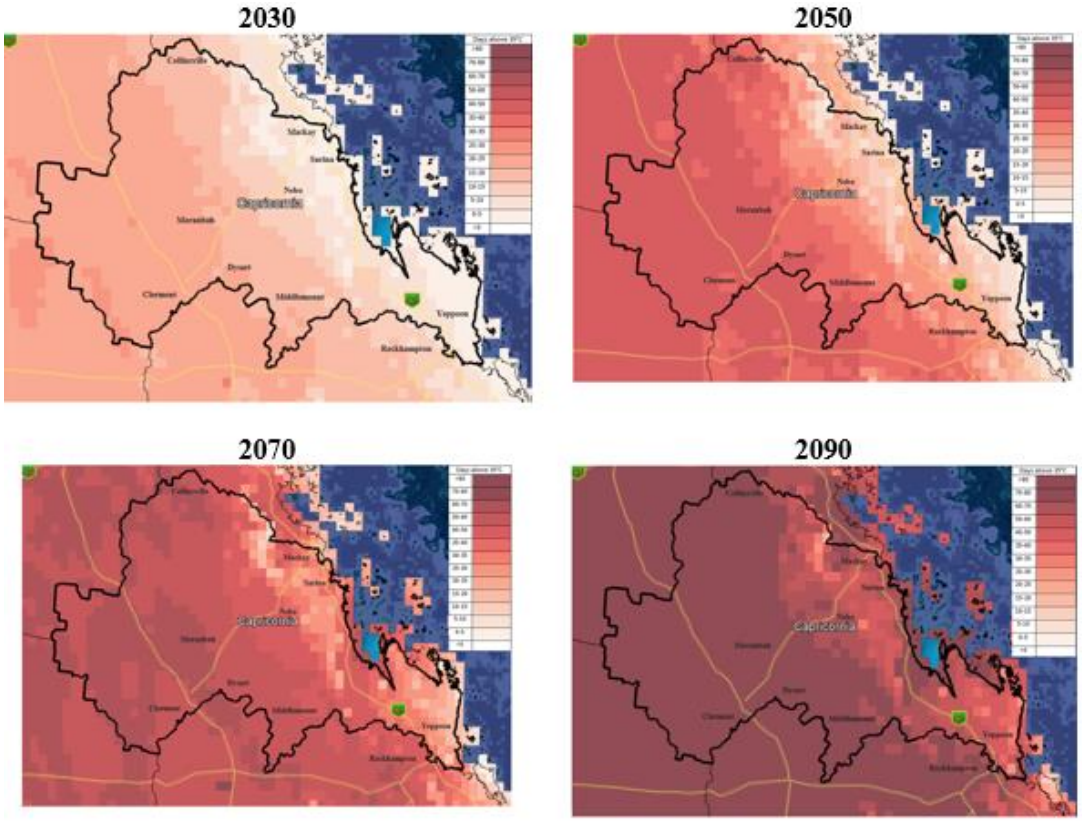
[18] World Bank (2012) *Turn down the heat: Why a 4 degrees Celsius warmer world must be avoided,* https://openknowledge.worldbank.org/handle/10986/11860

[19] Queensland Government (2018) *Future Climate Dashboard, Mean Temperature QLD,* https://app.longpaddock.qld.gov.au/dashboard/#responseTab1

# CAPRICORNIA

Capricornia is a Central Queensland electorate that stretches from Rockhampton and Yeppoon to the southern suburbs of Mackay, and inland to significant regional centres like Collinsville, Moranbah, Dysart and Clermont.

**Table 1: Increases in number of days over 35 degrees in the electorate of Capricornia.**




Source: QLD Government (2018) *Future Climate Dashboard*

## Key findings

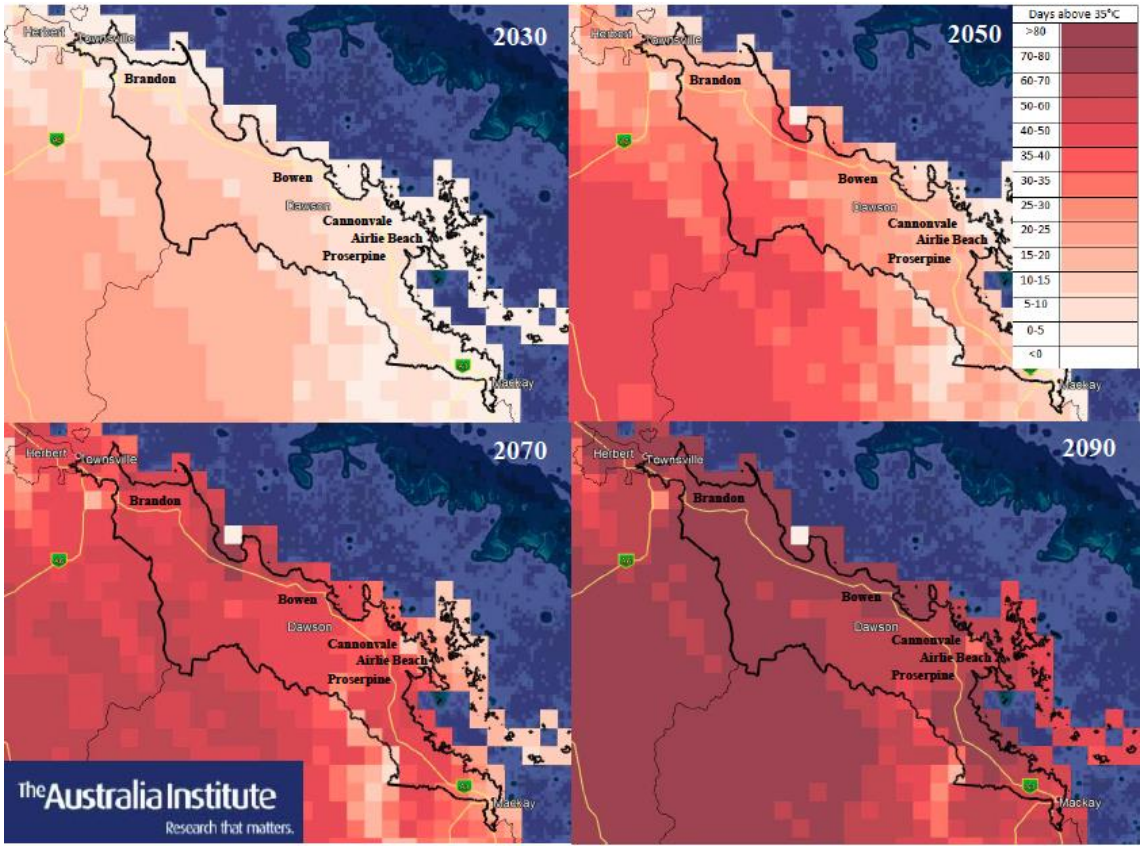
Unless strong action is taken on climate change, by 2070, well within our children's lifetime, the electorate of Capricornia is projected to experience:

- Up to 30% increase in evaporation.
- Up to 50% reduction in rainfall.
- Up to 100% increase heatwave days per year.
- A single heatwave could last up to over 35 days.
- A 90-130% increase in the frequency of droughts and floods.

# DAWSON

Dawson is a Central Queensland electorate that runs from Mackay to the southern suburbs of Townsville. It includes the Whitsundays and regional centres like Ayr, Bowen and Proserpine.

**Table 2: Increases in number of days over 35 degrees in the electorate of Dawson.**




Source: QLD Government (2018) *Future Climate Dashboard*

## Key findings

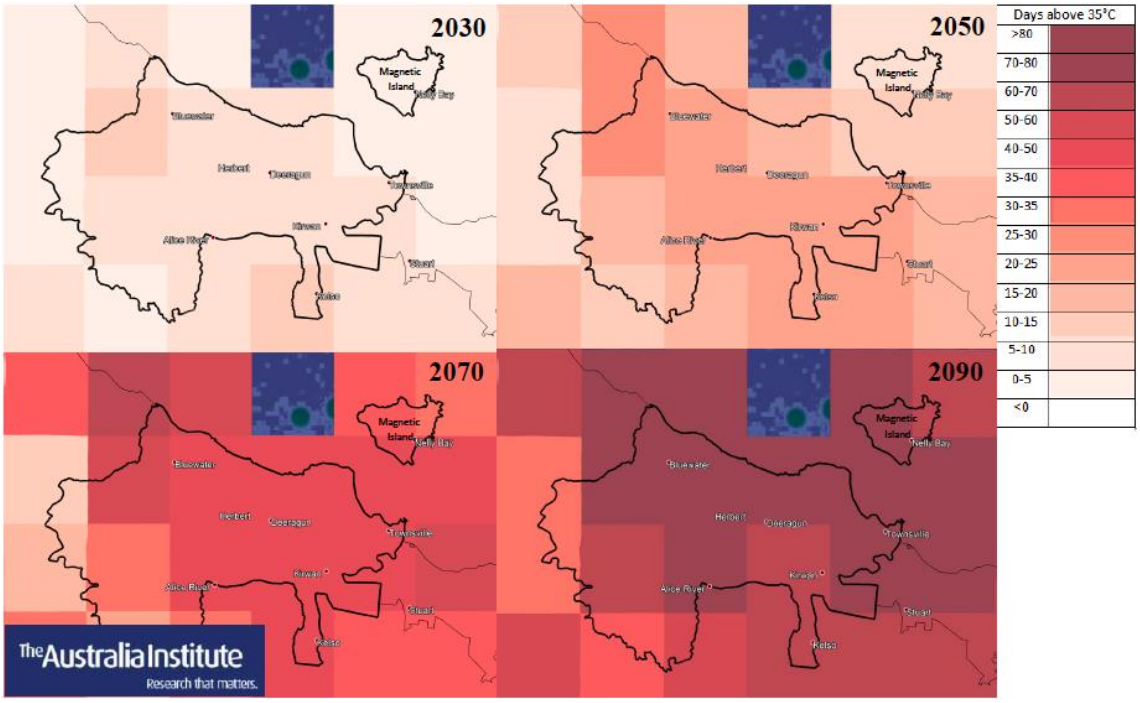
Unless strong action is taken on climate change, by 2070, well within our children's lifetime, the electorate of Dawson is projected to experience:

- Up to 25% increase in evaporation
- Up to 50% reduction in rainfall
- Up to 100% increase in heatwave days per year
- Increasing fire risk
- A 90-130% increase in the frequency of droughts and floods.

# HERBERT

Herbert is the Central Queensland electorate for Townsville, including Magnetic Island. Some Townsville suburbs are in the adjacent electorates of Dawson and Kennedy.

**Table 3: Projected increase in the number of days over 35 degrees per year in the electorate of Herbert**




Source: QLD Government (2018) *Future Climate Dashboard*

## Key findings

Unless strong action is taken on climate change, by 2070, well within our children's lifetime, the electorate of Herbert is projected to experience:

- Up to 30% increase in evaporation.
- Up to 50% reduction in rainfall.
- Up to 100% increase heatwave days per year.
- Single heatwaves lasting up to over 50 days.
- A 90-130% increase in the frequency of droughts and floods.
- Coastal inundation effecting over 4000 properties in 23 suburbs (by 2100).

# Urban Heat Island effect in Queensland

Highly urbanised areas create an environment that is divergent from the surrounding rural areas. Research has found that due to urban structures like concrete and skyscrapers – along with roads, pavement, and diminished vegetation cover – cities becomes warmer as more heat is absorbed in the materials during day and then released at night, which increases night-time temperatures.[20]

This creates an Urban Heat Island effect (UHI) not just on these surfaces but also in the atmosphere. This is more prominent during summer as temperatures rise. During the daytime UHI causes exposed surfaces like roofs to heat to temperatures up to 50 degrees hotter than the air while rural areas remain closer to the atmospheric temperatures, creating an 'island' effect in cities.[21]

UHI's influence is perhaps most important at night. Heat absorbed in urban structures during the day is slowly released after sunset compared to heat in vegetated areas. This produces much higher air temperatures overnight than in equivalent rural areas.[22] On a clear calm night, the US Environmental Protection Agency states that the temperature difference can be as high as 12 degrees between urban and rural areas.[23]

The overnight effects of UHI are consistent across climate zones and scenarios. Coastal cities also suffer from UHI despite sea breeze.[24] Studies also raise the concern that night temperature extremes carry higher risks of mortality as people are unable to recover from daytime heat stress.[25]

[20] Sharifi and Soltani (2017) *Daily variation of urban heat island effect and its correlations to urban greenery: A case study of Adelaide,* Frontiers of Architectural Research 6.
[21] United States Environmental Protection Agency (n.d.) *Learn About Heat Islands,* https://www.epa.gov/heat-islands/learn-about-heat-islands
[22] Argueso et al. (2015) *Effects of City Expansion on Heat Stress under Climate Change Conditions,* PLoS ONE 10
[23] United States Environmental Protection Agency (n.d.) *Learn About Heat Islands,* https://www.epa.gov/heat-islands/learn-about-heat-islands
[24] Santamouris et al. (2017) *Urban Heat Island and Overheating Characteristics in Sydney, Australia – an analysis of multiyear measurements,* Sustainability 9
[25] Zhao et al. (2018) *Interactions between urban heat islands and heat waves,* Environmental Research Letters 13

# Projected increases in nights over 25 degrees

When hot days are combined with hot nights, heat load and stress carry over and the body has no opportunity to cool down and recover. Studies show that there is an association between the mortality of not just stroke patients but also the general population and high night temperatures.[26]

Extreme heat nights also cause increased insomnia and lack of rest. This is exacerbated by the higher relative humidity overnight. As sleep is vital for healthy human functioning, a deficit means more susceptibility to disease, obesity, chronic illness and harm to our psychological and cognitive functioning.[27]

The number of hot days in places like Mackay and Townsville will be accompanied by an even greater increase in the frequency of extreme summer nights. Parts of this more rapid warming at night are characteristic of the climate system however, as night-time temperatures are more sensitive to a build-up of greenhouse gases.[28]

The BoM classifies nights with extreme heat as those with a minimum temperature of 25 degrees.

[26] Murage et al. (2017) *Effect of night-time temperatures on cause and age-specific mortality in London,* Environmental Epidemiology 1; Roye (2017) *The effects of hot nights on mortality in Barcelona, Spain,* International Journal of Biometeorology 61

[27] Obradovich et al. (2017) *Nighttime temperature and human sleep loss in a changing climate,* Science Advances 3

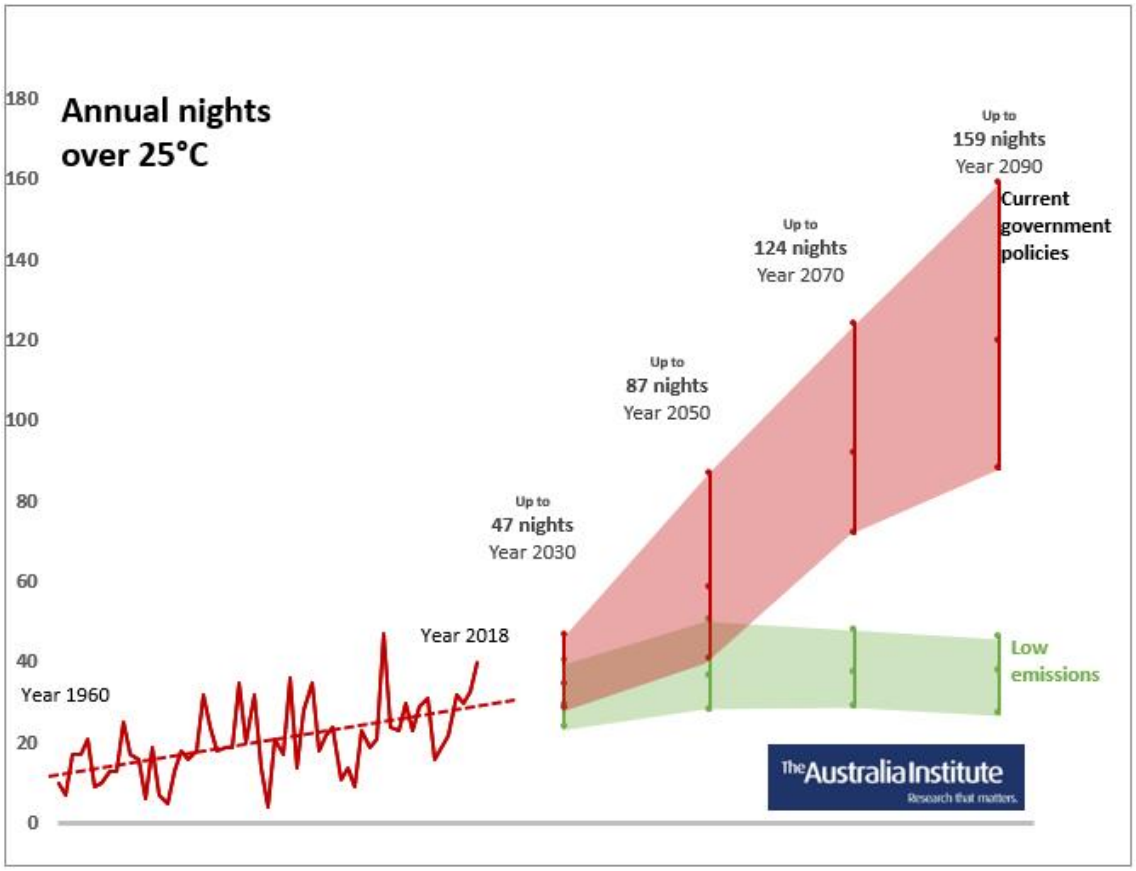
[28] Davy et al. (2016) *Diurnal asymmetry to the observed global warming,* International Journal of Climatology

# MACKAY

Under current government policies, in Mackay nights over 25 degrees would go from a historical average of 14 nights per year to up to 47 nights by 2030, 87 nights by 2050, 124 nights by 2070 and 159 nights by 2090. This would also be concentrated in summer, where up to 95% of summer nights would be over 25 degrees by 2090.

However, with strong climate policies limiting global average temperatures to 1.5 degrees as recommended by the IPCC, extreme heat nights will be significantly less frequent. Under this scenario shown in green in Figure 12 below, hot nights in Mackay peak at up to 51 nights per year over 25 degrees in 2050 and stabilise around 46 nights by 2090.

**Figure 12: Forecast annual number of nights over 25 degrees Mackay**



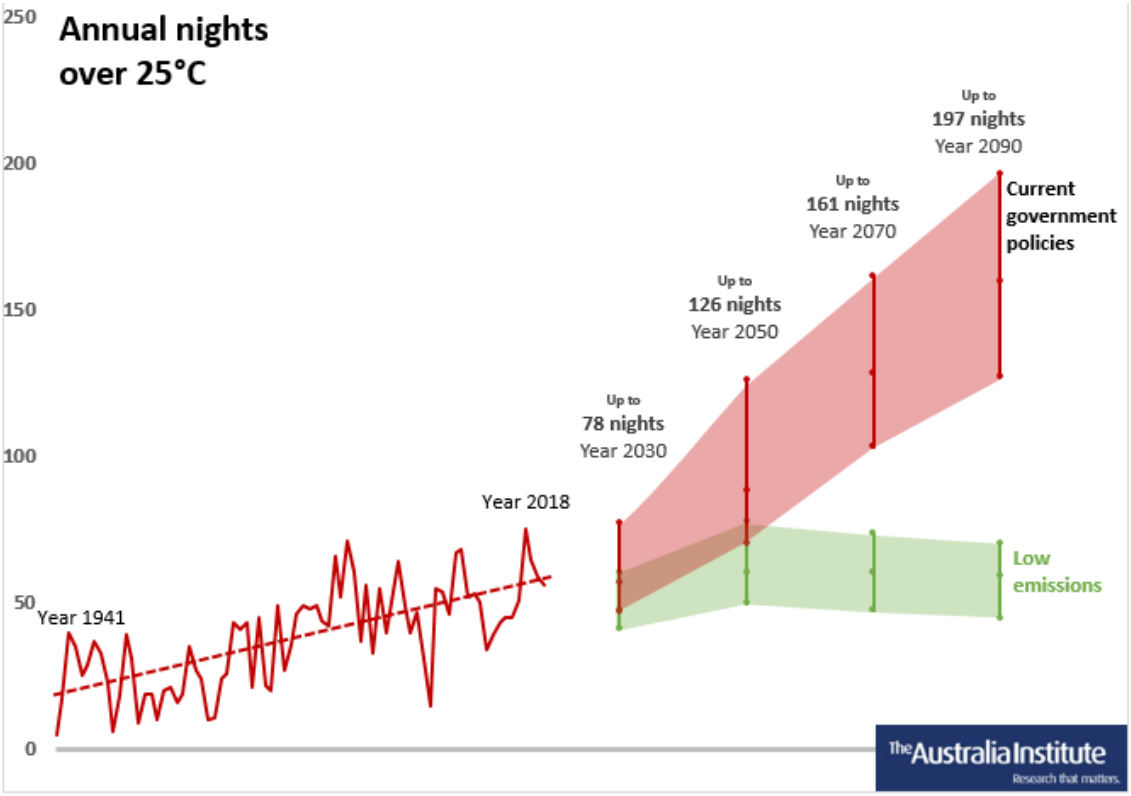

Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

# TOWNSVILLE

Under current policies, Townsville nights over 25 degrees are expected to increase from a historical average of 26 nights per year to up to 78 nights by 2030, 126 nights by 2050, 161 nights by 2070 and 197 nights by 2090. Virtually all summer nights, and much of autumn and spring, are likely to stay above 25 degrees by 2090.

However, with strong climate policies limiting global average temperatures to 1.5 degrees as recommended by the IPCC, extreme heat nights will be significantly less frequent. Under this scenario shown in green in Figure 13 below, hot nights in Townsville peak at up to 78 nights per year over 25 degrees in 2050 and stabilise around 70 nights by 2090.

**Figure 13: Forecast annual number of nights over 25 degrees Townsville**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

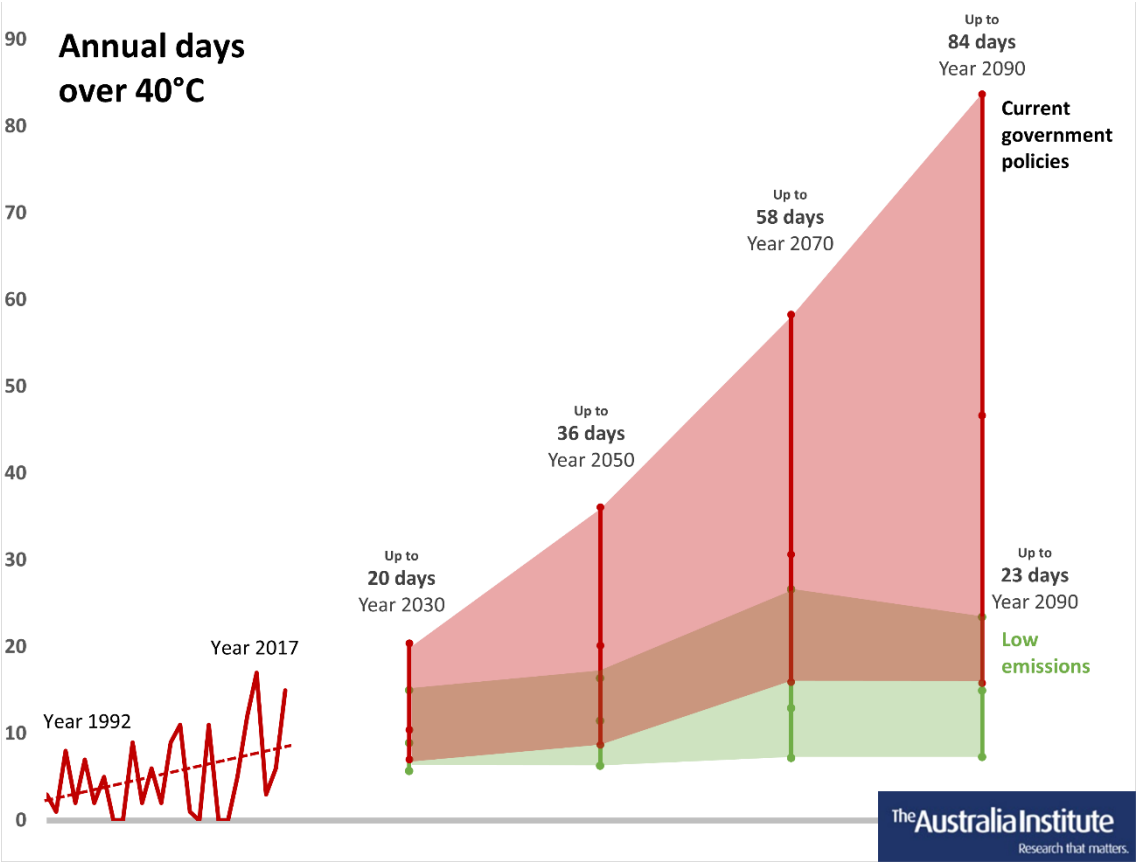
# Days over 40 degrees

In some parts of Queensland, such as Roma, the increase in days over 40 degrees will have serious consequences.

The number of days over 40 degrees in Roma is expected to increase dramatically in the coming decades according to the eight models used by the CSIRO and BoM climate models. Under a business as usual (BAU) scenario on greenhouse emissions, the CSIRO projects that Roma could experience as many as 20 days over 40 degrees per year in 2030, and up to 84 days per year by 2090. This would be over twenty times the BoM average of four days per year from 1992–2011.

Figure 14 below lays out the CSIRO predictions out to 2090 under the BAU and the RCP 2.6 scenario that includes a significant reduction in emissions.

**Figure 14: Forecast annual number of days over 40 degrees Roma**




Source: BoM (2019) *Climate data online*, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and BoM (2018) *Climate projections*, provided on request

# Health and productivity impacts of extreme heat

The impact of extreme heat on human health, particularly over extended periods, is severe. Although people living in hot areas do acclimatise to help cope with extreme temperatures, there are limits.[29] A large increase in days over 35 degrees will push past those limits.

The health impacts of increasing extreme heat can include both direct heat illnesses such as heat exhaustion and indirect illnesses such as heart failure and even death.

WorkSafe Queensland lists a range of illnesses arising directly from extreme temperatures from mild cramps, rashes, and dehydration to severe injuries such as heat stroke, exhaustion and even death if treatment is delayed.[30] As climate change worsens this can be expected to put people that are more vulnerable at increasingly greater risk.

The elderly, the very young, and those with pre-existing health conditions are most vulnerable to heat impacts. Illnesses such as angina, kidney disease, and diabetes are more likely to be triggered or exacerbated when people are unable to maintain a safe body temperature.[31]

People suffering from mental disorders are also vulnerable. This vulnerability to extreme heat can result from altered behavioral responses to high temperatures or the impact of medications.

As stated earlier, irritability and psychological stress also increase in heat. When hot days are combined with hot nights, heat load and stress carry over and the body has no opportunity to cool down and recover. Studies show that there is an association between the mortality of not just stroke patients but also the general population and

[29] Hanna and Tait (2015) *Limitations to thermoregulation and acclimatisation challenges human adaptation to global warming,* Int J Environ Res Public Health 12

[30] WorkSafe Queensland (n.d.) *Health effects,* https://www.worksafe.qld.gov.au/injury-prevention-safety/hazardous-exposures/heat-stress/health-effects

[31] Hanna et al. (2016) *The silent killer: Climate Change and the Health Impacts of Extreme Heat,* The Climate Council, https://research-management.mq.edu.au/ws/portalfiles/portal/72578140/72578105.pdf

high night temperatures.[32] The 'synergistic effect' of night humidity, increased temperatures, and urban heat island effects in heatwaves has been estimated in some studies to double general mortality risk by the end of the century under RCP 8.5.[33] Often underrated, major heatwaves have been dubbed the 'silent killer', causing more deaths in the last century in Australia than all natural disasters put together.[34]

Extreme heat nights also cause increased insomnia and lack of rest. This is exacerbated by the higher relative humidity overnight. As sleep is vital for healthy human functioning, a deficit means more susceptibility to disease, obesity, chronic illness and harm to our psychological and cognitive functioning.[35]

Productivity decreases significantly under these stresses as people are affected with the consequences of extreme heat. Workplace safety and the ability to work declines. This can also be displayed in economic terms as costs rise to account for the lack of labour productivity and changes needed in workplaces.[36]

The cost of lost productivity because of extreme heat in Australia has been estimated at almost $7 billon in 2013-14 alone.[37]

[32] Murage et al. (2017) *Effect of night-time temperatures on cause and age-specific mortality in London,* Environmental Epidemiology 1; Roye (2017) *The effects of hot nights on mortality in Barcelona, Spain,* International Journal of Biometeorology 61

[33] Zhao et al. (2018) *Interactions between urban heat islands and heat waves,* Environmental Research Letters 13

[34] Hanna et al. (2016) *The silent killer: Climate Change and the Health Impacts of Extreme Heat*

[35] Obradovich et al. (2017) *Nighttime temperature and human sleep loss in a changing climate,* Science Advances 3

[36] Climate Council (2014) *Heatwaves: Hotter, Longer, More Often,* https://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf

[37] Zander, Opperman and Garnet (2015) *Extreme heat poses a billion-dollar threat to Australia's economy,* https://theconversation.com/extreme-heat-poses-a-billion-dollar-threat-to-australias-economy-41153

# Heat stress and the Queensland workforce

Increasing extreme heat will have serious consequences for the health and safety of many of Queensland's workforce.

The workforce in Queensland is particularly vulnerable to the dangers of increasing extreme heat with around 14% of the workforce employed in the mining, construction and agricultural industries, all of which require workers to undertake strenuous work in the heat.[38]

As discussed above, at temperatures above 35 degrees, the human body's main cooling mechanism – sweating – is far less effective. Sweating exchanges heat from the body to the atmosphere, but this heat exchange process diminishes significantly beyond 35 degrees, so body temperature rises. There is a range of health impacts, from mild to severe. Heat stroke can cause permanent damage to the brain and other vital organs and can even result in death.[39]

Townsville hosts the largest garrison in the Australian Defence Force (ADF) and is home to 15,000 defence force personnel and their families.[40] Soldiers are required to train strenuously in heavy clothing which reduces air circulation essential to cooling the body, and heavy equipment which adds to the level of exertion. The tragic consequences of excessive training in the heat can be seen in the case of the death of a young soldier due to heat stress at the ADF Puckapunyal base in Victoria this year.[41]

As discussed above, at temperatures above 35 degrees, the human body's main cooling mechanism – sweating – is far less effective. The US Army Research Institute of

[38] ABS (2016) *Table Builder 2016 Australian Census,* https://auth.censusdata.abs.gov.au/webapi/jsf/tableView/tableView.xhtml

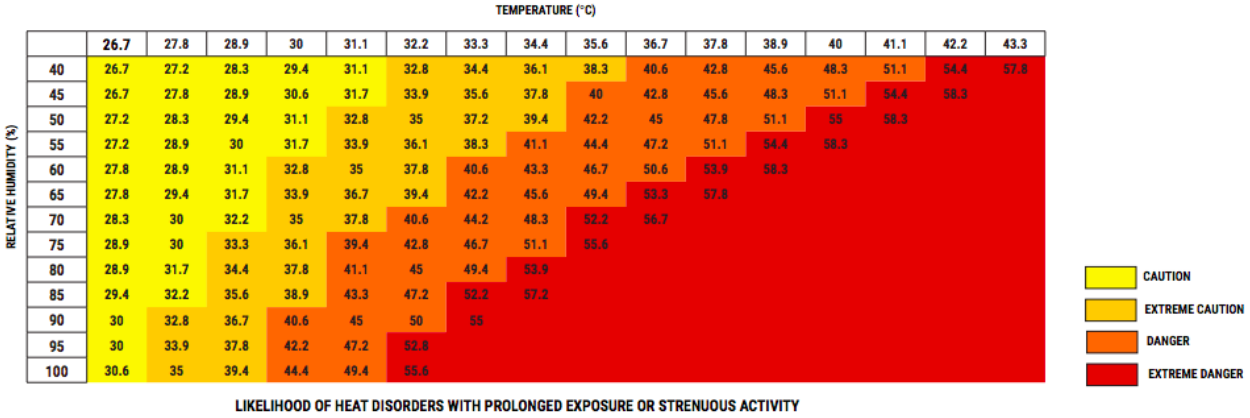
[39] Hanna and Tait (2015) *Limitations to thermoregulation and acclimatisation challenges human adaptation to global warming,* Int J Environ Res Public Health, https://academic.oup.com/heapro/article/30/2/239/561863; Australian Mining Review (2017) *WA miners urged to guard against heat stress,* https://www.miningreview.com.au/wa-miners-urged-guard-heat-stress/

[40] Townsville City Council (2017) *Defence Fact Sheet: Australian Defence Force,* https://www.townsville.qld.gov.au/__data/assets/pdf_file/0018/9360/Defence-Fact-Sheet-17.pdf

[41] Smith (2019) *Australian soldier dies during exercise at Puckapunyal Army base in Victoria,* https://www.news.com.au/national/victoria/news/australian-soldier-dies-during-exercise-at-puckapunyal-army-base-in-victoria/news-story/452c965683ad8e2ecdb7f2017dff98c9

Environmental Medicine advises that all outdoor work with physical exertion be cancelled when the combination of humidity and temperature hits a heat stress threshold (known as a wet-bulb globe temperature) of 32 degrees (see the NOAA Heat Stress Index in Figure 15).[42]

**Figure 15: NOAA Heat Stress Index**




| | 26.7 | 27.8 | 28.9 | 30 | 31.1 | 32.2 | 33.3 | 34.4 | 35.6 | 36.7 | 37.8 | 38.9 | 40 | 41.1 | 42.2 | 43.3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 26.7 | 27.2 | 28.3 | 29.4 | 31.1 | 32.8 | 34.4 | 36.1 | 38.3 | 40.6 | 42.8 | 45.6 | 48.3 | 51.1 | 54.4 | 57.8 |
| 45 | 26.7 | 27.8 | 28.9 | 30.6 | 31.7 | 33.9 | 35.6 | 37.8 | 40 | 42.8 | 45.6 | 48.3 | 51.1 | 54.4 | 58.3 | |
| 50 | 27.2 | 28.3 | 29.4 | 31.1 | 32.8 | 35 | 37.2 | 39.4 | 42.2 | 45 | 47.8 | 51.1 | 55 | 58.3 | | |
| 55 | 27.2 | 28.9 | 30 | 31.7 | 33.9 | 36.1 | 38.3 | 41.1 | 44.4 | 47.2 | 51.1 | 54.4 | 58.3 | | | |
| 60 | 27.8 | 28.9 | 31.1 | 32.8 | 35 | 37.8 | 40.6 | 43.3 | 46.7 | 50.6 | 53.9 | 58.3 | | | | |
| 65 | 27.8 | 29.4 | 31.7 | 33.9 | 36.7 | 39.4 | 42.2 | 45.6 | 49.4 | 53.3 | 57.8 | | | | | |
| 70 | 28.3 | 30 | 32.2 | 35 | 37.8 | 40.6 | 44.2 | 48.3 | 52.2 | 56.7 | | | | | | |
| 75 | 28.9 | 30 | 33.3 | 36.1 | 39.4 | 42.8 | 46.7 | 51.1 | 55.6 | | | | | | | |
| 80 | 28.9 | 31.7 | 34.4 | 37.8 | 41.1 | 45 | 49.4 | 53.9 | | | | | | | | |
| 85 | 29.4 | 32.2 | 35.6 | 38.9 | 43.3 | 47.2 | 52.2 | 57.2 | | | | | | | | |
| 90 | 30 | 32.8 | 36.7 | 40.6 | 45 | 50 | 55 | | | | | | | | | |
| 95 | 30 | 33.9 | 37.8 | 42.2 | 47.2 | 52.8 | | | | | | | | | | |
| 100 | 30.6 | 35 | 39.4 | 44.4 | 49.4 | 55.6 | | | | | | | | | | |

Source: National Weather Service (n.d.) *Heat safety,* http://www.nws.noaa.gov/os/heat/heat_index.shtml

Despite Worksafe Queensland warnings that working in extreme heat can lead to serious injury and death,[43] there is no temperature level threshold for halting heavy outdoor work in Queensland. The death of a CSG worker near Roma in Queensland as a result of heat in 2016 prompted the Queensland Government Coroner to recommend one be adopted.[44]

[42] Hanna (2016) *Microclimates and heat islands: Climate change exacerbates occupational heat exposures,* http://greenhouse.asnevents.com.au/assets/Greenhouse/Presentations/1420HannaMR2Wed.pdf

[43] WorkSafe Queensland (n.d.) *Health effects,* https://www.worksafe.qld.gov.au/injury-prevention-safety/hazardous-exposures/heat-stress/health-effects

[44] Briggs (2016) *Coroner calls for temperature threshold to stop outdoor work in extreme heat,* https://www.abc.net.au/news/2016-04-20/coroner-calls-temperature-threshold-to-stop-outdoor-work-heat/7342464

# Mining workers

Extreme heat presents a significant health risk to mining workers. The Australasian Mining Safety Journal describes the risks as follows:

> When environmental temperatures exceed that of dry skin, sweating becomes the primary source of thermoregulation. However, as temperatures continue to rise, particularly in humid environments with poor airflow, this may not be enough. The body's core temperature rises, resulting in a continuum of ailments, collectively known as heat illness. This ranges from the relatively mild heat rash and muscle cramps, to heat exhaustion and the potentially fatal heat stroke.
>
> Heat illness can present as headache, nausea or vomiting, irritability, clammy skin, dizziness, fatigue, elevated heart rate, and rapid breathing rate. This translates to lower productivity, poor morale and higher rates of accidents in the workplace. When left untreated, heat illness can progress to heat stroke, where confusion, further reduced muscle coordination, convulsions and ultimately a loss of consciousness can occur.[45]

There are also factors that compound the heat risks of mining in particular including having to wear heavy protective clothing that can reduce air circulation to the skin, long shifts and that water is not always readily available.

A survey of mine workers in Northern Australia found heat stress symptoms were experienced by 87% of open cut mine workers and 79% of underground mine workers. Around 80% of workers experienced these symptoms more than once. The survey also found that only 27% were well hydrated with 10% significantly dehydrated.[46]

[45] Australasian Mining Safety Journal (October 2015) *Handling the heat,* https://www.amsj.com.au/handling-the-heat/

[46] Hunt et al. (2012) *Symptoms of heat illness in surface mine workers,* https://eprints.qut.edu.au/54048/

# Tourism

Tourism is a significant industry in Queensland, accounting for 138,000 direct jobs and 79,000 indirect jobs.[47] Tourism in the state is based firmly on outdoor attraction, with the Great Barrier Reef particularly significant. The attractiveness of destinations to tourists is largely dependent on the climate.

If the dramatic rise in extreme temperature days projected to occur on our current emissions trajectory occur, the attractiveness of Queensland as a destination is likely to be significantly diminished. According to the Tourism Climatic Index, the entirety of Queensland would be "unfavourable" for tourism by the 2080s under some warming scenarios.[48] This will have flow on effect to the many businesses and workers in the states' tourism industry whether or not they are directly exposed to the heat.

In addition, climate change directly threatens the Great Barrier Reef, which has experienced catastrophic bleaching in recent years and is the tourist attraction most endangered by global warming. Each year, 2.2 million international tourists and 1.7 million domestic tourists visit the Great Barrier Reef; Reef tourism contributes $5.7 billion per year.[49] If the Reef continues to experience severe bleaching, tourist numbers could fall by over one million per year.[50]

Climate change will also reduce the attractiveness of other Queensland tourism. The deadly box jellyfish is increasingly found in southerly, sub-tropical waters, perhaps because of waters warming due to climate change. Coastal beaches are vulnerable to erosion, which requires increasingly costly nourishment to address.[51] Extreme weather, including cyclones, droughts and floods, also threatens tourism as well as agriculture, industry and human life.[52]

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[47] Tourism Research Australia (2017) *State Tourism Satellite Accounts 2016-17,* https://www.tra.gov.au/Economic-analysis/Economic-Value/State-Tourism-Satellite-Account/state-tourism-satellite-account

[48] Climate Council (2018) *Icons at risk,* p 12–14, https://www.climatecouncil.org.au/resources/tourism-2018/

[49] Climate Council (2018) *Icons at risk,* p 16–21

[50] Campbell and Swann (2016) *Great barrier bleached,* http://www.tai.org.au/content/great-barrier-bleached

[51] Climate Council (2018) *Icons at risk,* p 30–31

[52] Queensland Government (2018) *Building a resilient tourism industry,* https://www.qld.gov.au/__data/assets/pdf_file/0036/68697/building-resilient-tourism-industry-qld-ccr-plan.pdf

# Agriculture

The impact of climate change has far reaching effects not just on human health and productivity, but also on animals and crops as they struggle to adapt.

Excessive heat load, or heat stress, is the response of cattle when they are unable to dissipate body heat effectively due to sustained extreme temperatures. Cattle ordinarily maintain their body temperature within a narrow range over the course of a day and cool down at night. When exposed to high heat load the animal attempts to make physiological changes and adjustments to cope and survive.[53]

Under these conditions, heat-stressed cattle will eat less, seek shade, breathe with their mouths open, and pant, salivate and splash water if it is available.[54] The stress also generally results in a loss of performance (growth and reproduction). Eventually, if the heat load becomes excessive, critical functions may no longer be maintained and clinical disease, collapse and even death can result.

Crop yields too are under threat from climate change. The wheat industry is worth more than $5 billion per year nation-wide and is Australia's most valuable crop. However, 'potential' wheat yields have fallen in Australia between 1990 and 2015 by a dramatic 27%.[55] Researchers attribute this decline to reduced rainfall and to the rising temperatures associated with climate change.[56] High temperatures can also damage crop reproduction and indirectly increase plant water stress.[57]

The CSIRO projects that, as global warming continues, the ability of different regions of Australia to grow food will change. Yields in areas such as Roma that are drier are also projected to decline as the 'cropping belt' moves south towards the wetter southern fringes in Western Australia and Victoria.[58]

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[53] Barnes et al. (2004) *Physiology of heat stress in cattle and sheep,* http://www.livecorp.com.au/LC/files/dc/dcfff517-e032-4d6e-8dc5-5be26b9ba845.pdf
[54] Coventry and Phillips (2000) *Heat Stress in Cattle,* https://dpir.nt.gov.au/__data/assets/pdf_file/0015/233070/788.pdf
[55] The Conversation, *Changing climate has stalled Australian wheat yields: study,* https://theconversation.com/changing-climate-has-stalled-australian-wheat-yields-study-71411
[56] Hochman et al. (2017) *Climate trends account for stalled wheat yields in Australia since 1990,* Global Change Biology, https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.13604
[57] Climate Council (2014) *Heatwaves: Hotter, Longer, More Often,* https://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf
[58] CSIRO (n.d.) *Crops ready for a different future climate,* https://research.csiro.au/climate/themes/agriculture/crops-ready-different-future-climate/

# Infrastructure and industry

Extreme heat can cause failures to critical infrastructure, particularly transport and electricity supply. Coal and gas power stations in particular are highly vulnerable to extreme heat, experiencing both reduced output and an increased level of breakdowns. This is exacerbated by high electricity demand as a result of increased use of air-conditioning during extreme heat conditions. During the February 2017 heatwave in South Australia, 17% of gas generation (438 MW) failed to deliver during the peak demand period on the heatwave day (8th of February),[59] leading to widespread blackouts.[60]

In urbanised environments, air-conditioning can be critical to people's wellbeing during extreme heat. Electricity blackouts during heatwaves lead to the loss of air-conditioning when it is most essential. During the 2009 Heatwave in Melbourne on the evening of the 30th of January, 500,000 people were left without power on a day that reached 44 degrees. There were 374 deaths recorded as a result of this heatwave overall. The estimated economic cost of the heatwave was $800 million.[61]

An efficient transport system is fundamental to the functioning of all large cities. Transport is also vulnerable to extreme heat. Roads can melt[62] and rail can buckle.[63]

Some public transport does not have air-conditioning, or the air-conditioning can break down, causing distress to commuters.[64]

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[59] Ogge and Aulby (2017) *Can't stand the heat; The energy security risk of Australia's reliance on coal and gas generators in an era of increasing heatwaves*, http://www.tai.org.au/sites/defualt/files/P454%20Can%27t%20stand%20the%20heat%20FINAL%202.31.pdf

[60] Harvey and Shepherd (February 2017) *Rolling blackouts ordered as Adelaide swelters in heatwave,* https://www.news.com.au/national/south-australia/rolling-blackouts-ordered-as-adelaide-swelters-in-heatwave/news-story/13394f19db1ee94a59f4036fccdc1ba7

[61] NCCARF (2010) *Impacts and adaptation responses of infrastructure communities to heatwaves,* https://www.nccarf.edu.au/business/sites/www.nccarf.edu.au.business/files/attached_files_publications/Pub%2013_10%20Southern%20Cities%20Heatwaves%20-%20Complete%20Findings.pdf

[62] Cheer (January 2018) *Traffic delays after 10 kilometers of Victoria's Hume Freeway melts,* https://www.sbs.com.au/news/traffic-delays-after-10-kilometres-of-victoria-s-hume-freeway-melts

[63] Lauder (2009) *Melbourne railway buckles under heat,* http://www.abc.net.au/worldtoday/content/2008/s2477350.htm

[64] Robertson (January 2017) *Eastern Australia swelters under heatwave as hottest January on record looms,* https://www.theguardian.com/australia-news/2017/jan/18/eastern-australia-swelters-under-heatwave-as-hottest-january-on-record-looms

# Natural disasters

The cost of natural disasters in Australia has been estimated by Deloitte Access Economics, in a report for the Australian Business Roundtable, a group of major Australian businesses.

It found the total economic cost of natural disasters in Australia over the decade to 2016, averaged $18.2 billion per year and is expected to rise to around $39 billion per annum by 2050 in present value terms. This is a conservative estimate of future disaster costs as it does not include projected climate change impacts.[65]

QLD is by far the most vulnerable state to natural disasters, with total economic costs of $6.2 billion per year currently which are expected to rise to $18.3 billion per year by 2050.[66]

The cost of individual natural disasters that make up these costs is very high. For instance, the Queensland 2011 floods alone were estimated to have cost around $14 billion.[67] The Queensland government estimated the floods, fires and heatwaves of the 2018-19 Queensland "Summer of Disasters" imposed $1.5 billion in costs on the state.[68] These costs will come out of other spending in the budget and could impact on services.

The total costs will be far higher. The $1.5 billion figure does not include insured and uninsured losses to private property, Commonwealth Government contributions to disaster relief and reconstruction or the wider economic and social costs.

To help cover rising disaster costs, the Commonwealth Government has set up a new $3.9 billion Disaster Recovery Fund. This was strongly criticised by the Australian

[65] Deloitte Access Economics (2017) *The economic cost of the social impact of natural disasters,* http://australianbusinessroundtable.com.au/assets/documents/ABR_building-resilience-in-our-states-and-territories.pdf

[66] Deloitte Access Economics (2017) *The economic cost of the social impact of natural disasters*

[67] Deloitte Access Economics (2017) *The economic cost of the social impact of natural disasters*

[68] Sagunto (February 2019) *Summer of disasters' reveals the cost of climate change for Queensland taxpayers,* https://www.abc.net.au/news/2019-02-19/climate-change-and-the-cost-of-qlds-summer-of-disasters/10826122

insurers with the Actuaries Institute calling it “short-sighted and disappointing” as it is focused too much on recovery over resilience.[69]

As previously mentioned, BOM has found that “pacific rainfall disruptions” that include floods and drought in eastern Australia have already increased in frequency by 30% as a result of climate change and are projected to increase by 90% by mid-century and 130% by 2100.[70]

The BOM and CSIRO have also found that the frequency and intensity of extreme fire weather has increased significantly over much of Australia over recent decades and that climate change is contributing to these changes.[71]

Given the high cost of individual disasters, the projected increase in the frequency and intensity of these events will have a large impact on the overall cost of natural disasters in Queensland.

For example, if “rainfall disruptions” causing a $14 billion flood or a $12.5 billion drought occur twice as often, there will be double the cost to the community.

[69] Fernyhough (April 2019) *Insurers slam budget's 'short-sighted' climate measures,* https://www.afr.com/news/politics/national/insurers-slam-budget-s-short-sighted-climate-measures-20190403-p51a93

[70] BoM (2017) *Droughts and flooding rains already more likely as climate change plays havoc with Pacific weather,* http://www.bom.gov.au/climate/updates/articles/a023.shtml

[71] BoM (2019) *State of the Climate 2018,* http://www.bom.gov.au/state-of-the-climate/

# Conclusion

Queensland is now experiencing an increase in extreme heat events, affecting people's ability to work and enjoy the outdoors, to play and watch sport. Of more concern, an increase in days of temperature over 35 degrees will have severe impacts on human health, including increased rates of heat-related deaths.

Fortunately, none of this this inevitable. The CSIRO projections clearly show that if greenhouse gas emissions are reduced in line with the Paris Agreement target of limiting global temperature increases to below 1.5 degrees, the increase in extreme temperature days will be a small fraction of the increase projected for the current global emissions trajectory.

Australia makes a vastly disproportionate contribution to global warming. It is one of the lowest ranked countries in the world on taking action to reduce climate change. Australia was ranked 55 out of 60 in a recent global survey, just above Saudi Arabia and the United States.[72] As well as having one of the highest rates of domestic greenhouse gas emissions per person in the world, Australia has a staggering 44 tonnes per person of exported greenhouse gas emissions each, greater then Saudi Arabia (35.5 tonnes per person) and around sixty times higher than the US.[73]

Stopping any further expansion of Australia's coal and gas exports, gradually phasing out existing exports and reducing emissions produced at home are all essential to the global effort. This should include an ambitious domestic emission reduction target, equivalent to doubling the size of the federal government's current goal of cutting emissions 26% by 2030.[74]

At a state level, the Queensland government has shown initiative organising the inaugural Climate Week, encouraging renewables through a 50% target by 2030, and setting up dedicated renewable energy corporation in Clean Co. Yet if Queensland is serious about averting the impacts of extreme heat and climate change, a lot more is required.

[72] Germanwatch et al (December 2018) *Climate Change Performance Index 2019* https://www.climate-change-performance-index.org/

[73] Thwaites and Kestin (July 2018) *Australia ranked worst in world on climate action,* https://reneweconomy.com.au/australia-ranked-worst-world-climate-action-49472/

[74] Campbell and Merzian (2018) *Advance Australia's fair share: assessing the fairness of emissions targets* http://www.tai.org.au/content/advance-australias-fair-share