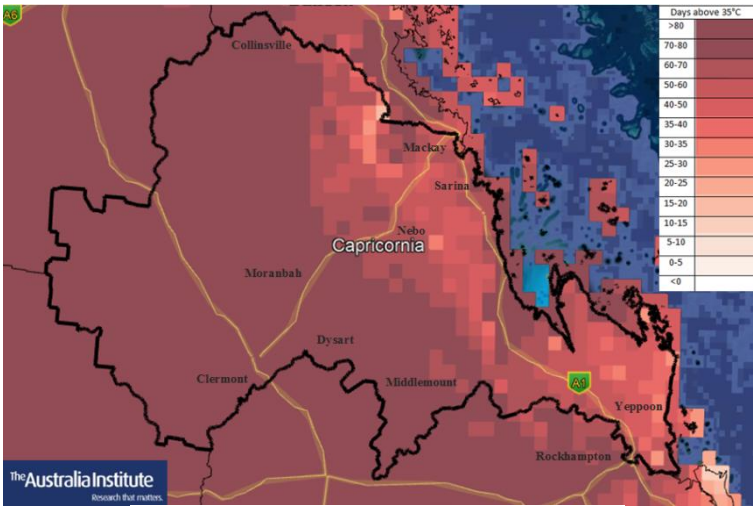

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Climate Assessment for the electorate of Capricornia

The electorate of Capricornia stands to be heavily impacted by climate change. Increasing natural disasters, drought and heatwaves will impact the community's health, infrastructure and vital industries, particularly agriculture and mining unless decisive action is taken to tackle climate change

Report

Mark Ogge

April 2019

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Summary

The electoral profile of Capricornia describes the local industries as:

> Primary production, grains, beef cattle, grazing, fishing, coal mining, meat works, dairy products and tourism.[1]

All of these industries will suffer serious impacts from climate change. Primary production including grain, grazing and dairy and will all be severely impacted by flood, drought, reduced rainfall, increasing evaporation and extreme temperatures.

The health and safety of mining, agricultural and other outdoor workers as well as those required to work in non-airconditioned spaces will be put at risk as a result of a dramatic increase in heatwaves.

Tourism will be severely impacted by irreversible changes to the regions unique natural environment on land and at sea. Even ordinary recreational activities like sport will become hard to safely manage.

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

- These impacts would result in highly disruptive and costly impacts on the community and economy of the electorate, including:
    - Reduced agricultural yields
    - Reduced workforce productivity
    - Increasing heat related illnesses and deaths

Most of these impacts can be avoided if the globally agreed Paris climate target of 1.5 degrees is achieved.

1 AEC (2018) Profile of the electoral division of Capricornia (Qld), https://www.aec.gov.au/profiles/qld/capricornia.htm

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Introduction

The electorate of Capricornia includes Isaac Regional Council, Livingstone Shire Council, part of the Mackay Regional Council, part of the Rockhampton Regional Council, and part of the Whitsunday Regional Council.

This paper examines the projected impact of climate change in these regions on:

- Rainfall
- Evaporation
- Extreme temperature
- Heatwaves

This assessment draws on projections from the Queensland Government's *Future Climate Dashboard*.[2] The Dashboard has been developed by the Queensland Department of Environment and Sciences (DES), providing a comprehensive set of high resolution climate change projections for the state to assist the community and industries of Queensland to understand the changes and to support climate adaptation plans.

The assessment also draws on CSIRO/ BOM *Climate Change in Australia* projections which were primarily developed to support the planning needs of Australia's natural resource management sector, and to provide information to assist climate adaptation processes. These projections use up to 40 global climate models and are the most comprehensive analysis of Australia's future climate ever undertaken.[3]

2 Queensland Government (2018) Future Climate Dashboard, https://app.longpaddock.qld.gov.au/dashboard/#responseTab1

3 CSIRO/BOM, Climate Change in Australia: Projections for Australia's NRM regions, https://www.climatechangeinaustralia.gov.au/en/

PROJECTED CHANGES TO CAPRICORNIA'S CLIMATE

Decreasing rainfall and increasing evaporation in Capricornia

Water availability in the regions making up the Capricornia electorate is dependent on a number of factors including rainfall, the rate of evaporation and the distribution of rainfall throughout the individual years and over extended periods.

Rainfall projections as a result of climate change are uncertain, ranging from a small increase in average annual rainfall, to a large decrease (up to 50 percent in some areas by 2070).

Evaporation is projected to increase substantially, up to in excess of 30 percent by 2070 in some areas.

Rainfall is also projected to be more concentrated into large flooding events, with floods and droughts expected to become more frequent.

Evaporation

Increasing evaporation can exacerbate drought[4] and reduce soil moisture,[5] reduce water levels in dams and reservoirs[6] and dry out vegetation increasing bushfire risk.[7]

Evaporation rates in the Capricornia electorate are expected to increase substantially. Projections range from around 5 percent increase to over 30 percent by 2070. For instance, as shown in Figure 1 below the projections for Rockhampton range from 8 percent to 32 percent in 2070, with an average of all models being a rise of 21 percent.

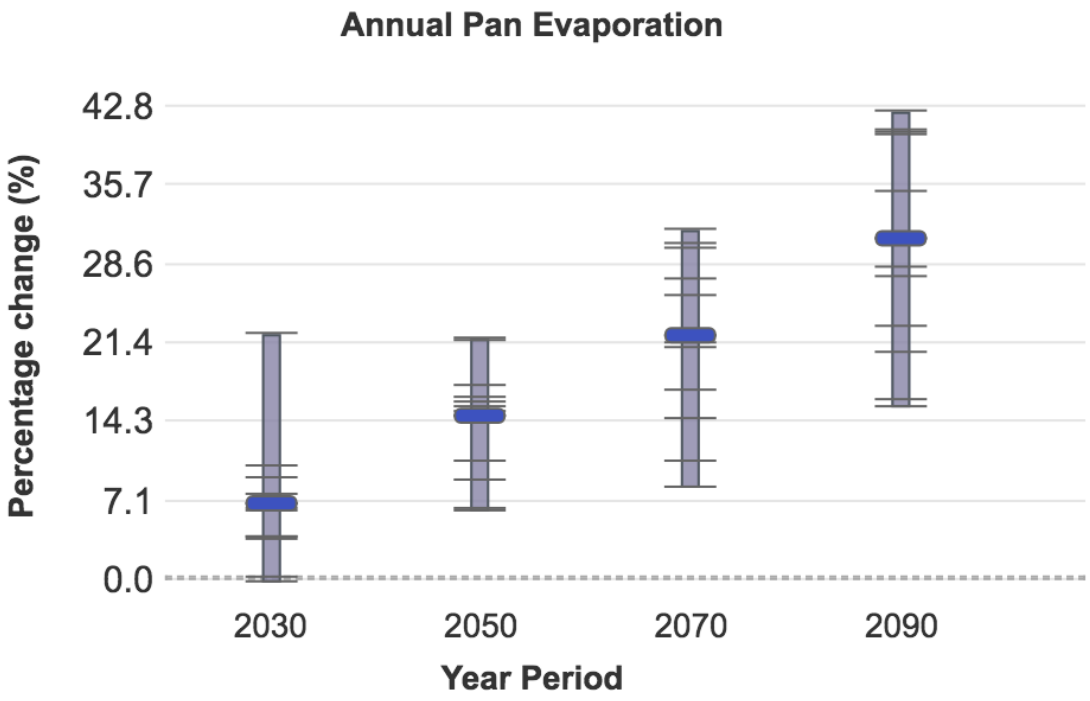
4 Hannan (2018), Record evaporation rates across eastern Australia exacerbate drought, https://www.smh.com.au/environment/weather/record-evaporation-rates-across-eastern-australia-exacerbate-drought-20180821-p4zys3.html

5 Steffen et al (2018) Deluge and drought: Australia's water security in a changing climate, https://www.climatecouncil.org.au/wp-content/uploads/2018/11/Climate-Council-Water-Security-Report.pdf

6 Helfer et al (2012) Impacts of climate change on temperature and evaporation from a large reservoir in Australia, https://www.sciencedirect.com/science/article/pii/S0022169412008827

7 Hughes et al (2018) Escalating Queensland Bushfire Threat: Interim Conclusions, https://www.climatecouncil.org.au/wp-content/uploads/2018/11/Queensland-Bushfires-and-Climate-Change_Interim-Conclusions.pdf

Figure 1: Projected change in annual pan evaporation in Rockhampton LGA



Source: QLD Government (2018) Future Climate Dashboard

Table 1 below shows the range of projected changes in rainfall for each of the local government areas within the Capricornia electorate.

Table 1: Projected change in annual pan evaporation in local government areas in the Capricornia election.

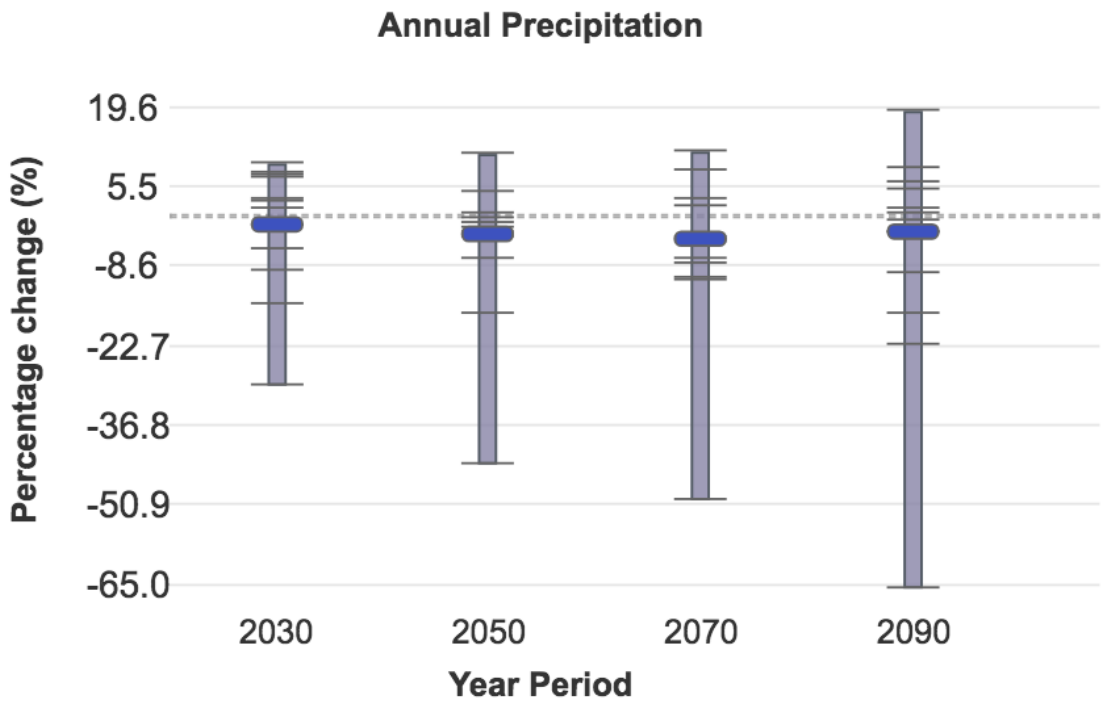
	2030	2050	2070	2090
Rockhampton	0-22% increase	6-22% increase	8-32% increase	16-43% increase
Isaac	1% decrease - 21% increase	2-22% increase	6-32% increase	12-46% increase
Livingston	1-18% increase	3-19% increase	7-26% increase	12-37% increase
Whitsundays	1% decrease - 18% increase	4-21% increase	5-27% increase	9-42% increase
Mackay	1% decrease - 14% increase	4-19% increase	7-24% increase	10-38% increase

Source: QLD Government (2018) Future Climate Dashboard

Rainfall

Rainfall projections for Capricornia electorate are uncertain. The average projections of all climate models are a relatively small fall in average rainfall (under 5 percent), however the overall range is from a small increase, to large decrease. For instance, as shown in Figure 2 below the projections for Rockhampton range from a 12 percent increase in rainfall by 2070 to a 50 percent decrease.

Figure 2: Projected change in annual precipitation Rockhampton LGA.



Source: QLD Government (2018) Future Climate Dashboard

Table 2 below shows the range of projections for each of the local government regions in the Capricornia electorate over the coming decades.

Table 2: : Projected change in annual precipitation of Local Government areas within the electorate of Capricornia.

	2030	2050	2070	2090
Rockhampton	10% increase-29% decrease	11% increase-44% decrease	12% increase-50%decrease	19% increase-65% decrease
Isaac	9% increase-29% decrease	4.5% increase-41% decrease	15% increase-46% decrease	15% increase-63 %decrease
Livingston	10% increase-24% decrease	15% increase-44% decrease	14% increase-50% decrease	24% increase-72% decrease
Whitsundays	9% increase-29% decrease	8% increase-46% decrease	11% increase-51% decrease	10% increase-24% decrease
Mackay	10% increase-27% decrease	8% increase-48% decrease	9% increase-52% decrease	20% increase-75% decrease

Source: QLD Government (2018) Future Climate Dashboard

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Increasing drought and floods

BOM modelling has found climate change has already increased the risk of major disruptions to Pacific weather (which includes eastern Australia), and that the risk will continue to rise as global warming increases. These major disruptions include drought and extreme rainfall.

The BOM modelling found there has already been a 30 percent increase in the frequency of these "rainfall disruptions" which is projected to increase 90 percent in the early part of this century, and 130 percent increase as century progresses.[8]

Increasing extreme heat in Capricornia

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.[9] The World Bank considers 4 degree "devastating" with "extremely severe risks for vital human support systems."[10]

8 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

9 BOM, 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

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

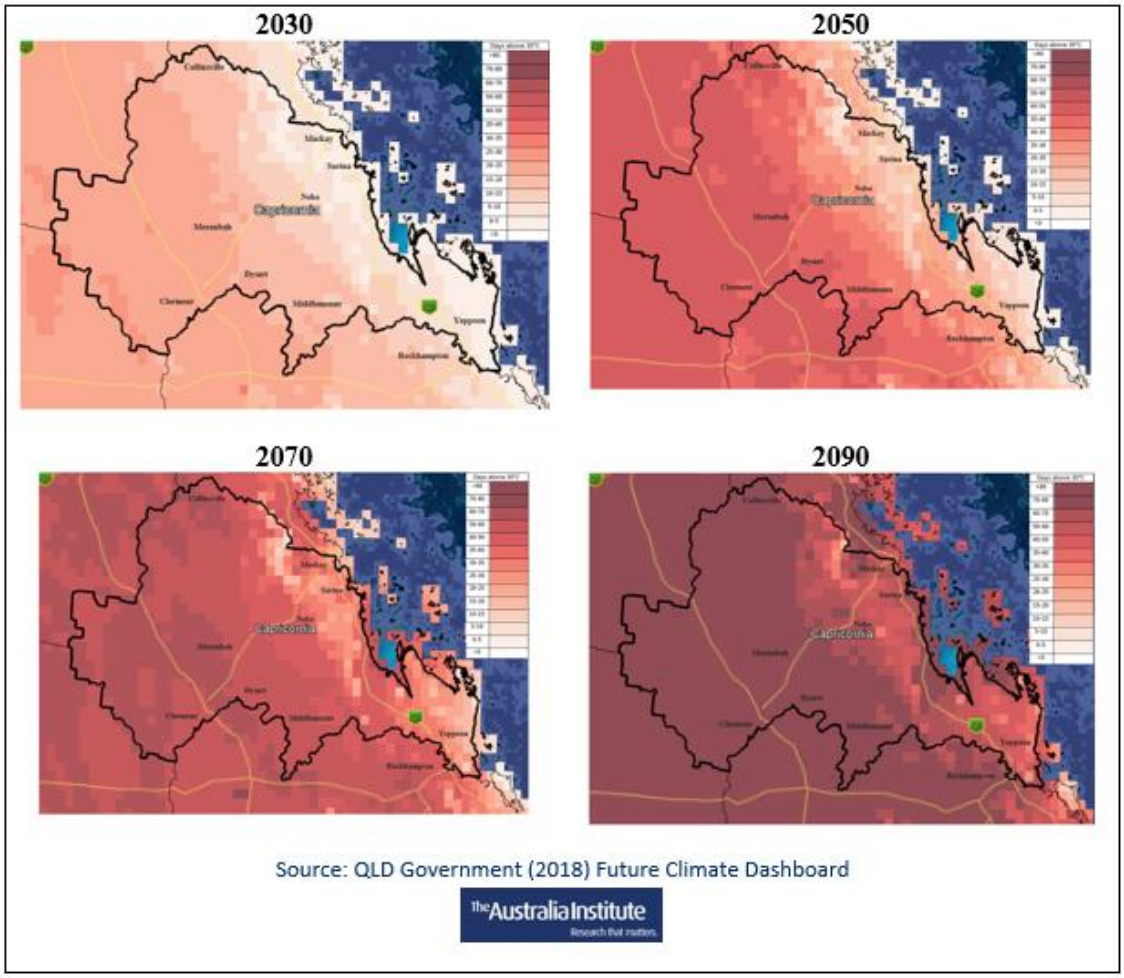
QLD Government projections show an increase in the annual mean temperature for QLD as a whole of up to 5.5 degrees by 2090.[11] The projections for the Capricornia regions follow a similar trajectory, with slight variations between the regions. For example, the annual mean temperature is projected to rise by up to 4.8 degrees by 2090 in the Rockhampton region, by up to 5.1 degrees in Isaac and by up to 4.5 degree in the Livingston Shire.

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 Table 3 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.

11 Queensland Government (1018) Future Climate Dashboard, Mean Temperature QLD, https://app.longpaddock.qld.gov.au/dashboard/#responseTab1

Table 3: Increases in number of days over 35 degrees in the electorate of Capricornia.



The CSIRO and BOM provide a separate set of projections, for the number of extreme heat days over various thresholds for particular locations. These projections are broadly consistent with the QLD Government projections but allow us to examine the projections for particular locations, and also enable a comparison between a business as usual emissions scenario, and a scenario consistent with emissions reductions required to meet the 1.5 degree Paris target.

Figures 4-7 below show the historic and projected increase in hot days (over 35 degrees) projected for some of the main regional centers in the electorate. The 35 degree threshold has been used because it is widely by regulators and health experts as an important threshold for safety, work and climatic conditions.

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.[12]

In the figures below the red line shows actual recorded historic annual number of days over 35 degrees, with the dotted line showing the trend.

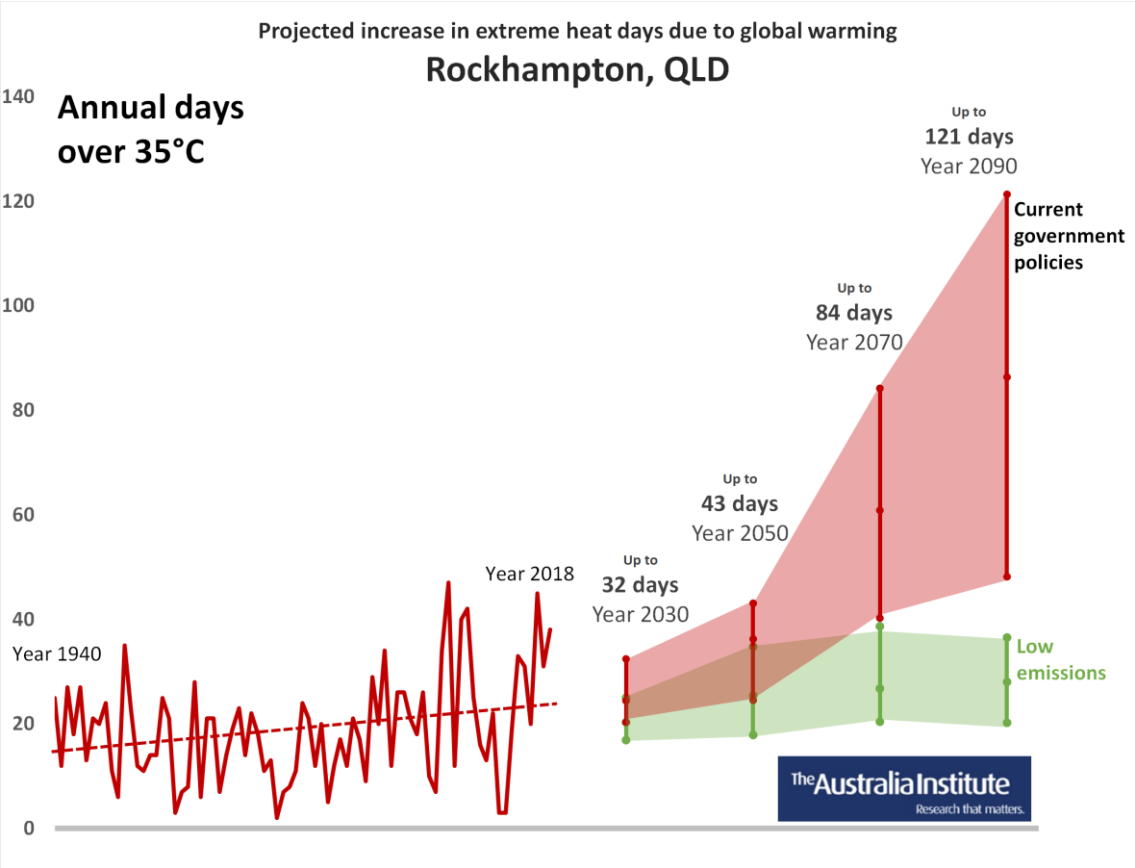
The red shaded area shows the range of projections from various climate models used by the CSIRO and BOM over coming decades if emissions continue to increase on current trajectories.

The Green shaded areas show the range of projected days over 35 if the world achieves a reduction in greenhouse gas emissions consistent with the 1.5-degree target agreed to by Australia and almost all other nations under the Paris Climate Agreement.

In all cases, a reduction of emissions in line with the globally agreed target of 1.5 degrees avoids the vast majority of the projected increase in extreme temperatures, leading to a decline beginning around mid-century.

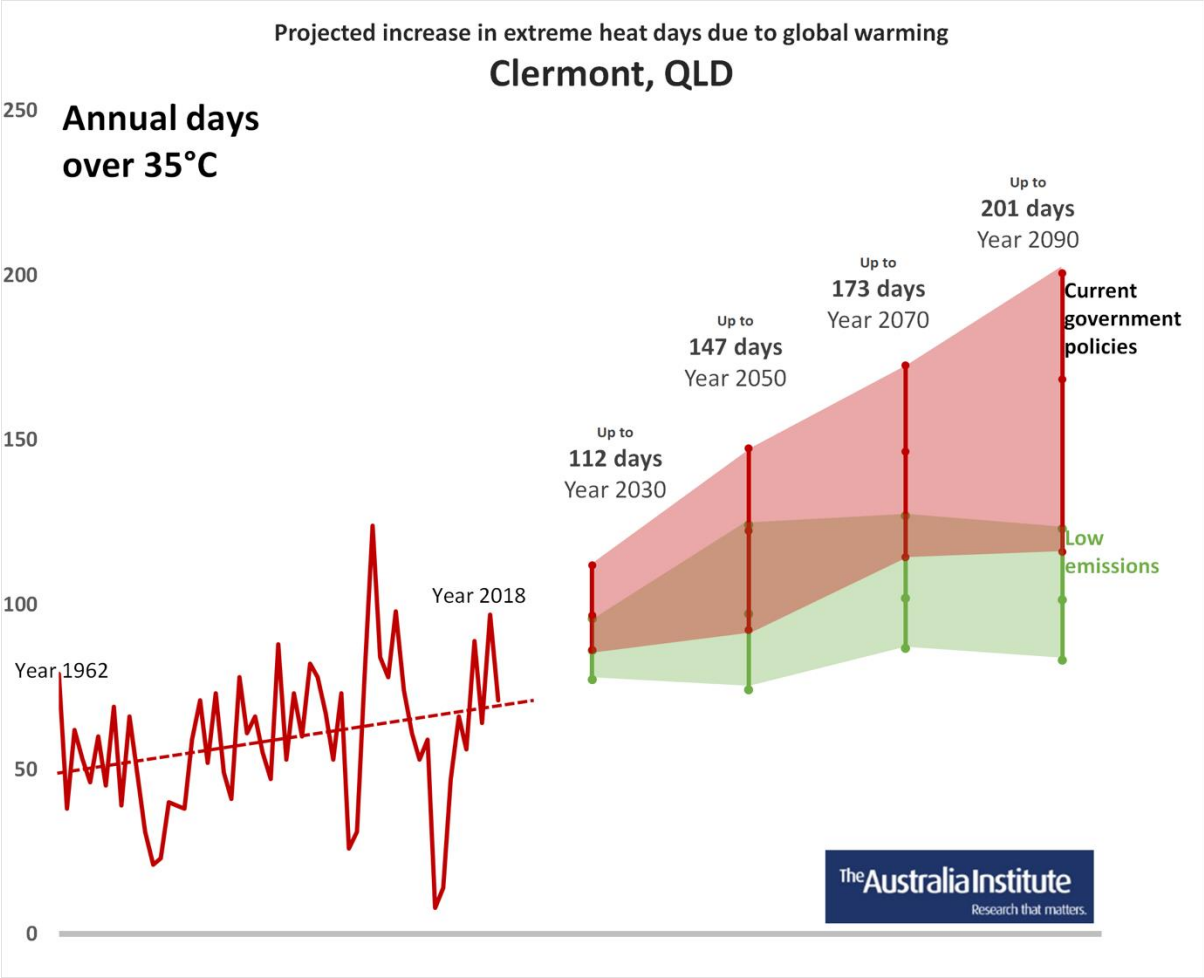
12 Hanna and Tait (2015) Limitations to thermoregulation and acclimatisation challenges human adaptation to global warming, Int J Environ Res Public Health, https://academic.oup.com/heapro/article/30/2/239/561863

Table 4: Forecast annual number of days over 35 degrees Rockhampton.



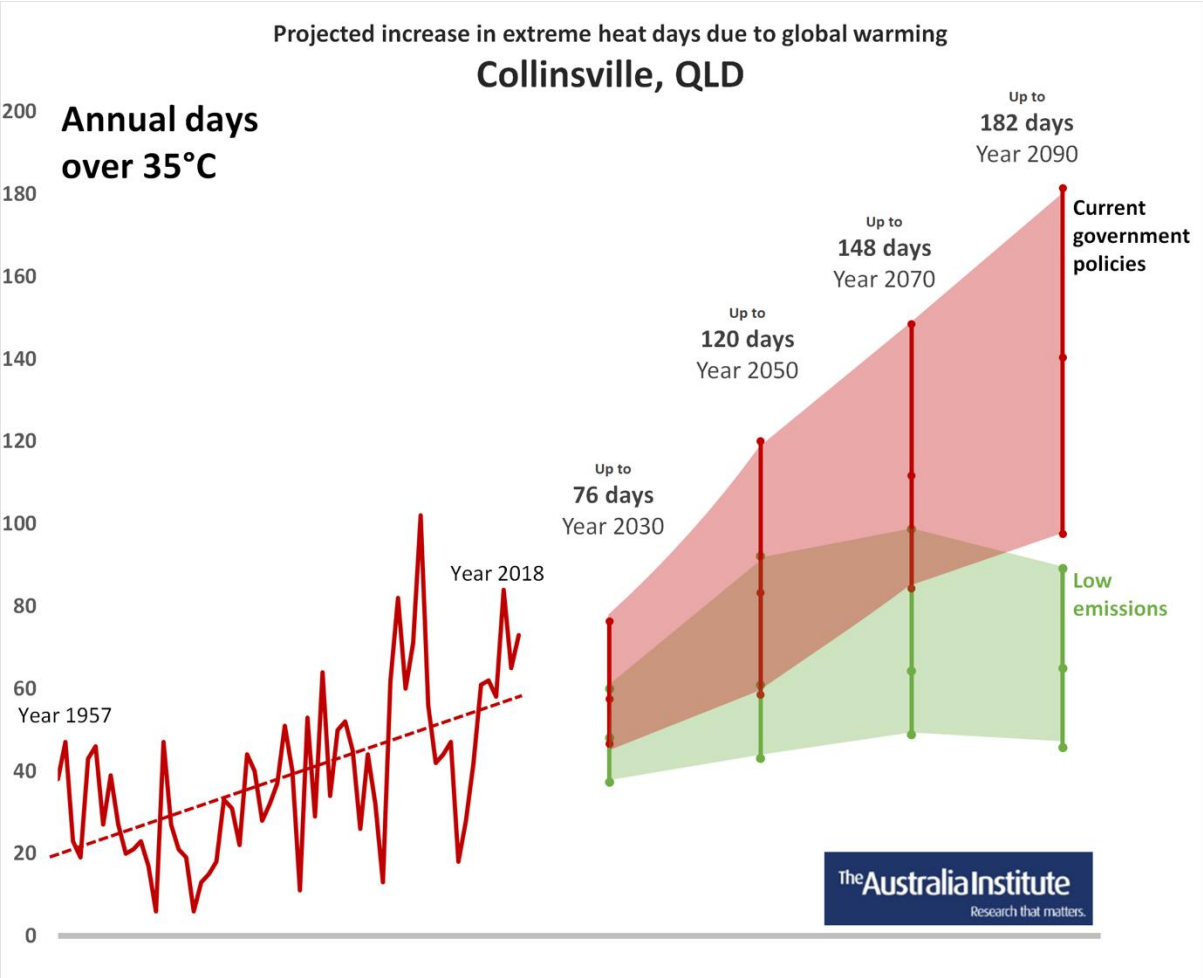
Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and Bureau of Meteorology (2018) *Climate projections,* provided on request

Figure 3: Forecast annual number of days over 35 degrees Clermont



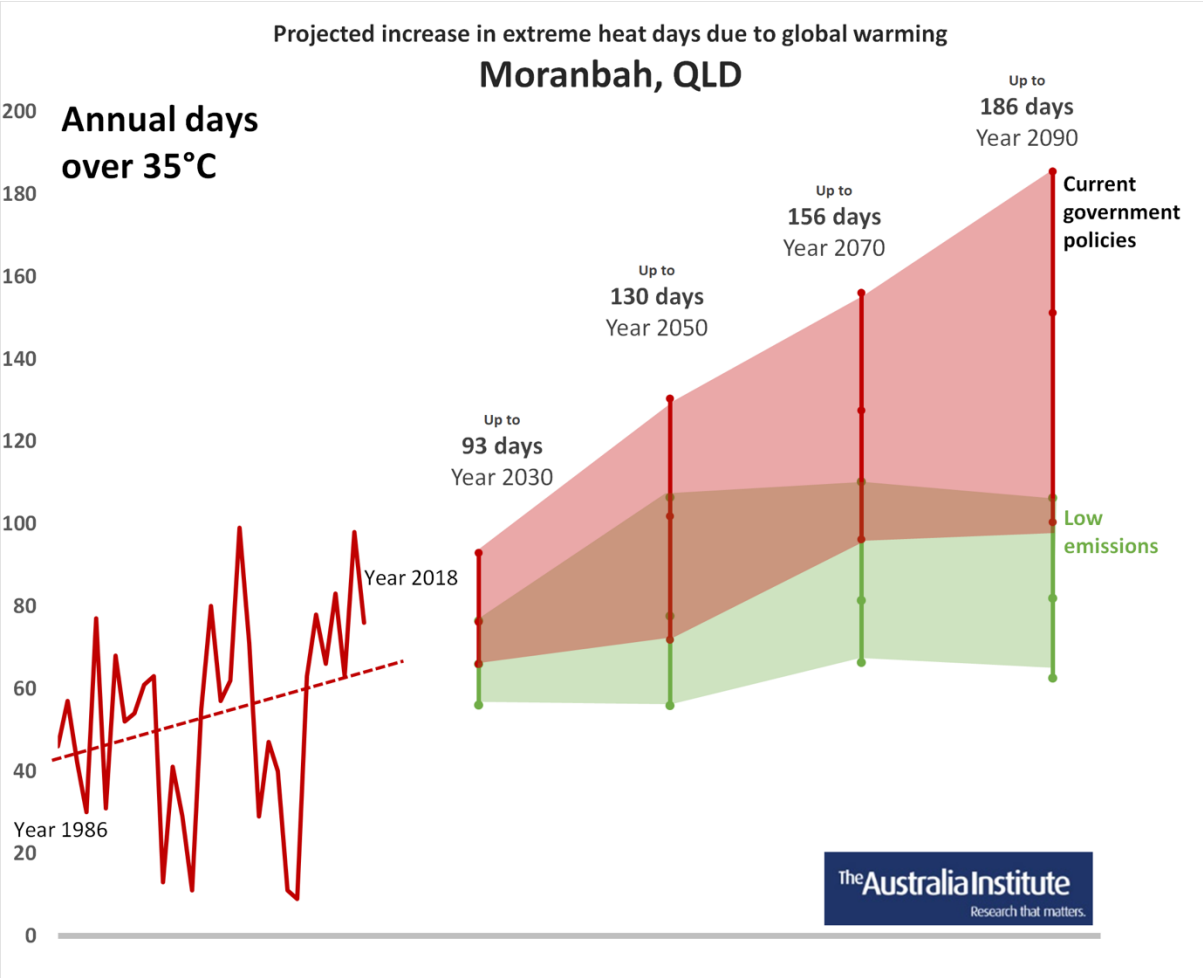
Source: Bureau of Meteorology (2019) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml; CSIRO and Bureau of Meteorology (2018) *Climate projections,* provided on request

Figure 4: Forecast annual number of days over 35 degrees Clermont



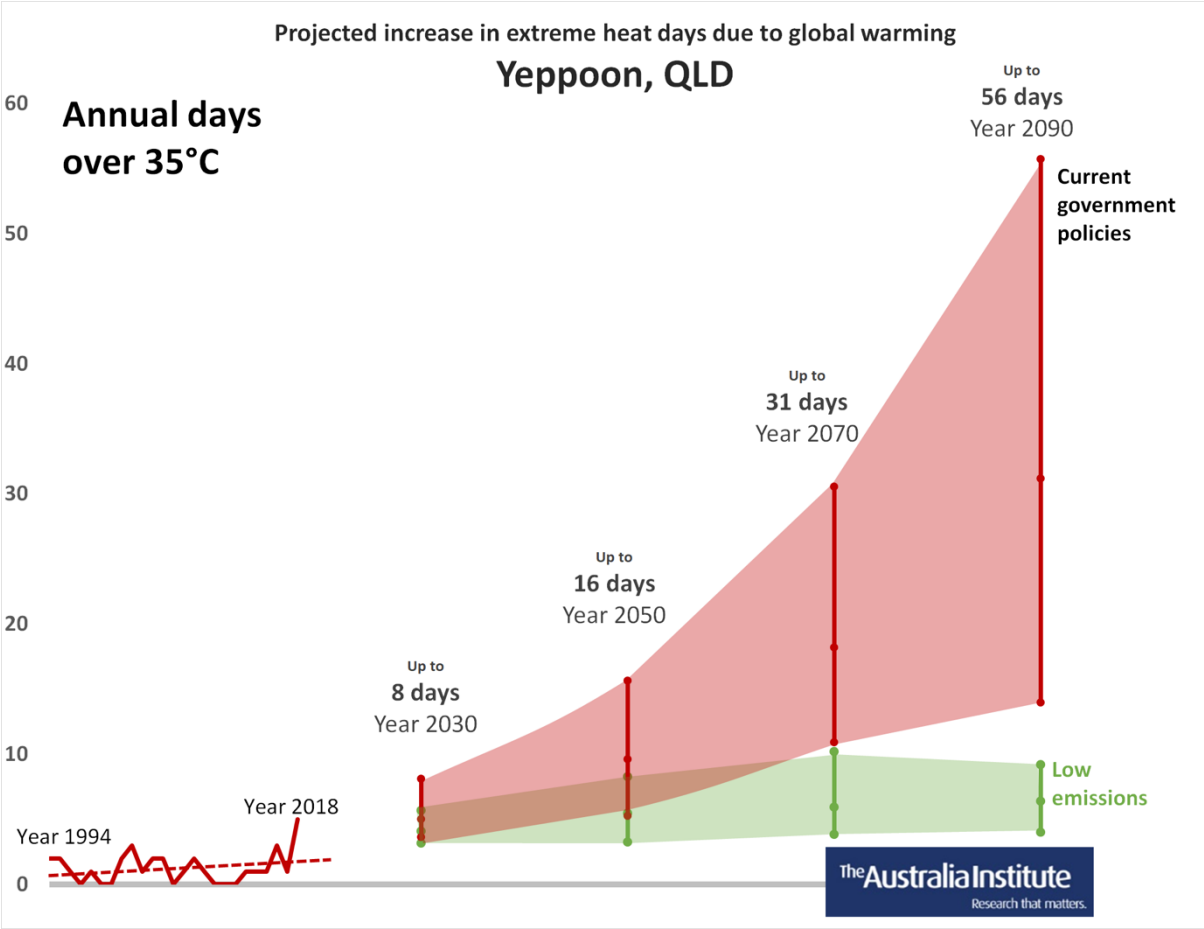
Source: Bureau of Meteorology (2019) Climate data online, http://www.bom.gov.au/climate/data/index.shtml; CSIRO and Bureau of Meteorology (2018) Climate projections, provided on request

Figure 5: Forecast annual number of days over 35 degrees Moranbah



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

Figure 6: Forecast annual number of days over 35 degrees Yeppoon



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

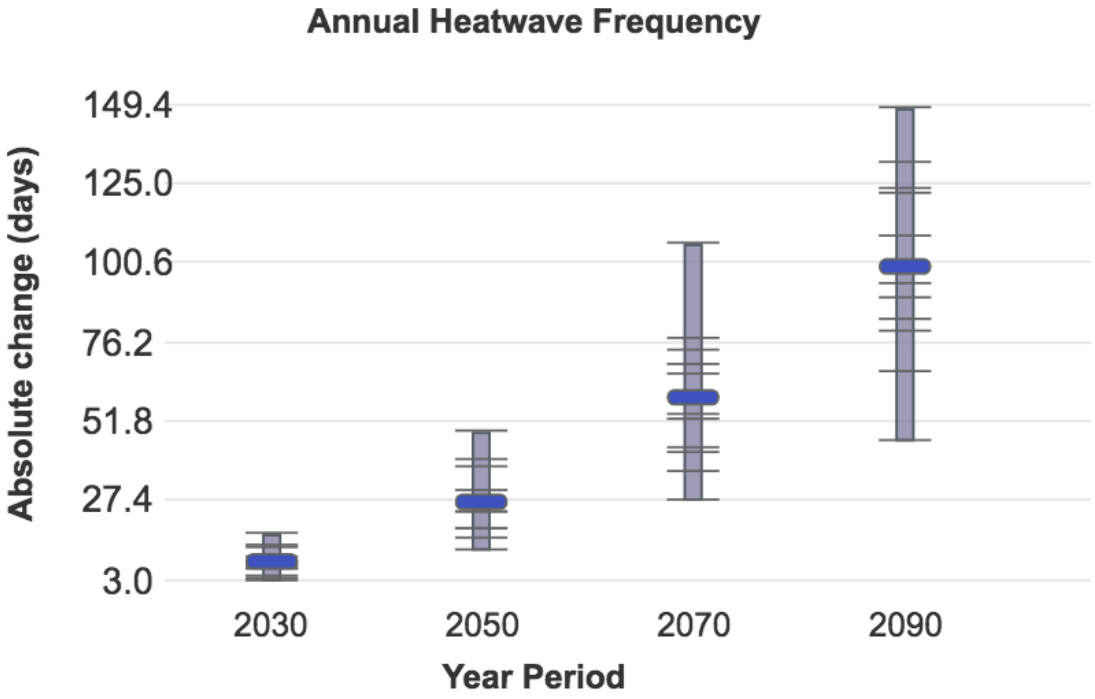
Increasing Heatwaves in Capricornia

Heatwaves occur when three consecutive days of extreme heat occur. Heatwaves have more serious consequences than hot days on their own, as people (and animals) have less opportunity to recover from extreme temperatures which can, in itself lead to illness and death. Heatwaves are serious health risk and have killed more people in Australia than all other natural disasters combined.[13]

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

Heatwaves in the region are projected to get hotter and longer. In the Rockhampton region for example, as shown in Figure 8 below, the annual number of heatwave days is projected to increase by up to over 100 percent by 2070.[14]

Figure 7: Projected increase in annual heatwave days Rockhampton LGA.



Source: QLD Government (2018) Future Climate Dashboard

Figure 9 below shows the range of the projected in heatwave days per year in each of the local government areas in Capricornia.

Figure 8: Projected increase in annual heatwave days of Local Government Areas within the electorate of Capricornia.

	2030	2050	2070	2090
Rockhampton	3-17%	12-49%	27-107%	46-149%
Isaac	3-19%	15-56%	35-114%	60-153%
Livingston	3-18%	14-57%	38-120%	60-158%
Whitsundays	3-19%	13-61%	35-132%	64-170%
Mackay	3-25%	17-71%	5-138%	85-171%

Source: QLD Government (2018) Future Climate Dashboard

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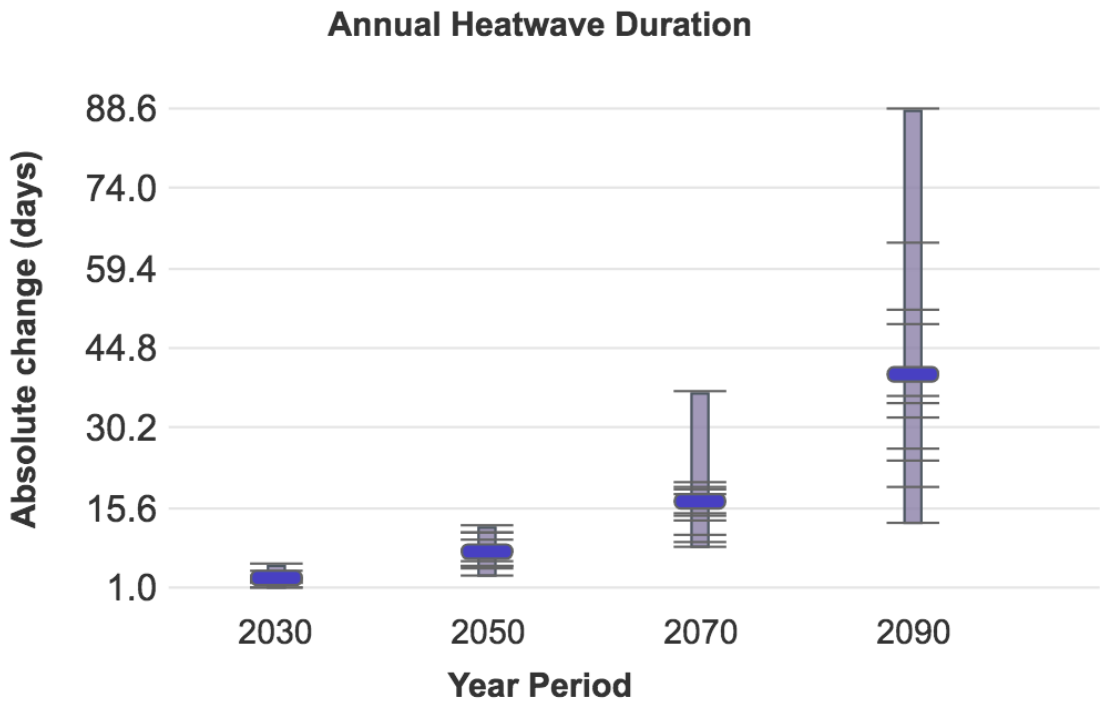
14 Queensland Government (2018), Queensland Future Climate Dashboard, https://app.longpaddock.qld.gov.au/dashboard/#responseTab2

As well as becoming more frequent, heatwaves in the region are projected to become hotter and longer. Heatwave amplitude (the hottest heatwave day per season) in the Rockhampton region is projected to increase by up to almost 4.5 degrees by 2090. Currently heatwaves typically last a few for a few days. The duration of heatwaves is projected to rise dramatically over coming decades. A single heatwave in the Rockhampton region 2070 is projected to last up to 37 days and up to 88 days per year by 2090, as shown in Figure 9 below .[15]

Figure 9: Projected increase in annual heatwave duration Rockhampton LGA.



15 Queensland Government (2018), Queensland Future Climate Dashboard, https://app.longpaddock.qld.gov.au/dashboard/#responseTab2

The economic costs of climate change impacts in Capricornia

NATURAL DISASTERS

The cost of natural disasters in Australia has been estimated by Deloitte Access Economics, in a report for the Australian Business Roundtable, at 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 disasters costs as it does not include projected climate change impacts.[16]

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.[17]

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.[18] 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.[19] 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

16 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

17 Deloitte Access Economics (2017) Ibid.

18 Deloitte Access Economic (2017) Ibid.

19 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.[20]

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 percent as a result of climate change and are projected to increase by 90 percent by mid-century and 130 percent by 2100.[21]

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.[22]

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.

Climate change also has many impacts that are not classified as natural disasters, but have very significant costs, nonetheless.

HEALTH

The impact of extreme heat on human health, particularly over extended periods, is severe. Although people living in hot areas do acclimatise to higher temperatures, there are limits.[23] A large increase in days above extreme heat thresholds as detailed above 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.[24]

WorkSafe Queensland lists a range of illnesses arising from extreme temperatures from cramps, rashes, and dehydration to severe injuries such as heat stroke,

20 Fernyhough (April 2019) Insurers slam budget's 'short-sighted' climate measureshttps://www.afr.com/news/politics/national/insurers-slam-budget-s-short-sighted-climate-measures-20190403-p51a93

21 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

22 BOM (2019) State of the Climate 2018 http://www.bom.gov.au/state-of-the-climate/

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

24 NSW Government (2017) Heat-related illness including heat stroke, https://www.health.nsw.gov.au/environment/factsheets/Pages/heat-related-illness.aspx

exhaustion and even death if treatment is delayed.[25] As climate change worsens this can be expected to put people that are more vulnerable at increasingly greater risk.

The groups most vulnerable to heat impacts include the elderly, the very young, and those with pre-existing health conditions. Illnesses such as angina, kidney disease, and diabetes are at higher risk of being triggered or exacerbated when people are unable to maintain a safe body temperature.[26] 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 mortality of and high night temperatures, particularly in stroke patients.[27] The 'synergistic effect' of night humidity, increased temperatures and UHI has been estimated in some studies to double general mortality risk by the end of the century under RCP 8.5.[28] Heatwaves have been dubbed the 'silent killer', causing more deaths in the last century in Australia than all natural disasters put together.[29]

Hot nights also increase insomnia and lack of rest. This can be exacerbated by high humidity. As sleep is vital for health, a deficit means more susceptibility to disease, obesity, chronic illness and harm to our psychological and cognitive functioning.[30]

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.[31]

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

26 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

27 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

28 Zhao et al (2018) Interactions between urban heat islands and heat waves, Environmental Research Letters 13

29 Hanna et al (2016) The silent killer: Climate Change and the Health Impacts of Extreme Heat, The Climate Council

30 Obradovich et al (2017) Nighttime temperature and human sleep loss in a changing climate, Science Advances 3

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

WORKFORCE PRODUCTIVITY

A significant proportion of the workforce in the electorate of Capricornia is exposed to the heat. Construction, agriculture, manufacturing and mining are all significant employers in the region and their workers are exposed to increasing temperatures.

These occupations almost always require strenuous activities and for workers to wear heavy protective clothing for health and safety reasons. Strenuous activity increases the risk of heat related illness, and heavy clothing reduces air circulation essential to cooling the body. Heavy equipment which adds to the level of exertion.

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.[32] The US Army Research Institute of Environmental Medicine advises that all outdoor work with physical exertion be cancelled when the WGTB temperature exceeds 32 degrees.[33]

There is no temperature threshold for halting heavy outdoor work in Queensland.

The cost of lost productivity because of extreme heat in Australia has been estimated at almost $7 billon in 2013-14 alone.[34]

Mining workers

Mining is currently a significant employer in the Isaac region. 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

32 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 (November 2017) WA miners urged to guard against heat stress, https://www.miningreview.com.au/wa-miners-urged-guard-heat-stress/

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

34 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

> 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.[35]

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.[36]

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.

Despite Worksafe Queensland warnings that working in extreme heat can lead to serious injury and death,[37] there is no temperature level threshold for halting heavy outdoor work in Queensland. The death of a coal seam gas worker near Roma in Queensland as a result of heat in 2016 prompted the Coroner to recommend temperature thresholds being adopted.[38]

Increasing extreme temperatures may also hasten the current trend of increasing automisation of mining operations in the region, leading to fewer mining jobs in the region.

AGRICULTURE

Agriculture is a vital industry in the Capricornia electorate. As noted above, beef grazing, grains and dairy are all important local industries.

Agriculture is on the frontline of global warming impacts in many ways. Increasing temperatures and falling precipitation can reduce cropping and livestock yields, the

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

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

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

38 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

extreme case being drought. Increasing temperatures can also reduce soil moisture and increase erosion. Extreme heat can damage crops, stress livestock and make farm work far more difficult, ultimately having health impacts on farm workers. Floods can demolish crops, kill livestock and damage farm infrastructure including buildings, roads, machinery and fencing.

Impacts on cropping

A recent ABARE report found that changes in the climate since 2000 have significantly reduced farm productivity and crop yield:

> The recent changes in climate have had a significant negative effect on the productivity of Australian cropping farms, particularly in south-western Australia and south–eastern Australia (Figure 2). In Western Australia, climate conditions between 2000–01 and 2014–15 lowered TFP by an average of 7.7 per cent—relative to what would have been seen under long-run average conditions (1914–15 to 2014–15). In New South Wales climate conditions post 2000–01 lowered productivity by an average of 6.5 per cent.
>
> A similar pattern is observed for wheat yields, although the climate effects are larger. Climate conditions between 2000–01 and 2014–15 lowered national wheat yields by around 11.9 per cent relative to long-run conditions (16.3 per cent in Western Australia and 14.8 per cent in Victoria).[39]

A recent CSIRO research has found potential wheat yields in Australia have already declined by 27% from 1990 to 2015 below what they would otherwise have been due to climate impacts, mostly the fall in rainfall and increasing temperatures over this period.[40]

As would be expected, increasing global warming will continue to reduce agricultural productivity and yields.

The Garnaut review found that as a result of climate change and without mitigation the Murray Darling Basin would be likely to lose up to half its annual irrigated agricultural output by mid-century.[41]

39 ABARE (2017) Farm performance and climate Climate-adjusted productivity for broadacre cropping farms, http://data.daff.gov.au/data/warehouse/9aas/2017/FarmPerformanceClimate/FarmPerformanceClimate_v1.0.0.pdf

40 Hochman et al (2017) Climate trends account for stalled wheat yields in Australia since 1990, https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.13604

41 The Garnaut climate change review (2009) Chapter 6, Climate Change Impacts on Australia, http://www.garnautreview.org.au/chp6.htm

Impacts on grazing

A recent CSIRO report examined 25 locations in south eastern Australia and found that without adaptation meat production could be reduced by up to 92% by 2050 and wool production by up to 95% [42]

These studies examine the more gradual impact increasing annual average temperatures and decreasing annual average rainfall. However, the impact of individual extreme weather events on agriculture must also be considered. The most extreme of these events are referred to as natural disasters.

As previously discussed, the frequency of pacific rainfall disruptions including drought and flooding have already increased by 30 percent and are projected to increase by 90 percent in the early part of this century, and 130 percent increase as century progresses.[43] An AgForce survey in October 2018 found that about half of Queensland's farmers had lost more than half their annual income due to drought. [44]

The floods that followed in February 2019 in and around Townsville were the highest on record since records began in 1888, with rainfall records set as far west as Mt Isa.[45] Agforce has estimated Queensland graziers alone have lost up to 500,000 head of cattle with an estimated value of $500 million.[46]

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 increased use of air-conditioning

42 Gaharamani and Moore (2014) Systemic adaptations to climate change in southern Australian grasslands and livestock: Production, profitability, methane emission and ecosystem function, https://www.researchgate.net/publication/269106683_Systemic_adaptations_to_climate_change_in_southern_Australian_grasslands_and_livestock_Production_profitability_methane_emission_and_ecosystem_function

43 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

44 AgForce (October 2018) Media Release: Impact of drought laid bare in survey of Queensland farmers, https://agforceqld.org.au/index.php?tgtPage=news&id=view,763

45 Bureau of Meteorology (February 2019) Special Climate Statement 69—an extended period of heavy rainfall and flooding in tropical Queensland, http://www.bom.gov.au/climate/current/statements/scs69.pdf

46 Crockford (February 2019) Queensland floods damage bill estimates top $1 billion, https://www.brisbanetimes.com.au/national/queensland/queensland-floods-damage-bill-estimates-top-1-billion-20190216-p50ya1.html

during extreme heat conditions. Last year there were 56 breakdowns of coal and gas power stations, in Queensland, many of which are likely to be as a result of extreme heat.

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.[47]

An efficient transport system is fundamental to regional areas like Capricornia, and climate change impacts transport infrastructure in many ways. The Queensland floods are estimated to have had a total economic cost of $14.1 billion,[48] including an estimated $157 million on road reconstruction[49]. The floods also affected over 3000 km of rail track in some way.[50]

Extreme heat can also disrupt transport infrastructure. It can cause roads can melt[51] and rail can buckle,[52] and disruption to airlines.[53]

47 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

48 Deloitte (2013), The economic cost of the social impact of natural disasters, costshttp://australianbusinessroundtable.com.au/assets/documents/Report%20-%20Social%20costs/Report%20-%20The%20economic%20cost%20of%20the%20social%20impact%20of%20natural%20disasters.pdf

49 Creighton (2016) Queensland floods 2011: The floods by the numbers, https://www.brisbanetimes.com.au/national/queensland/queensland-floods-2011-the-floods-by-the-numbers-20160112-gm4czk.html

50 Queensland Floods Commission of Inquiry: Final Report (2013) Chapter 10, Essential Services p155, http://www.floodcommission.qld.gov.au/__data/assets/pdf_file/0014/11714/QFCI-Final-Report-Chapter-10-Essential-services.pdf

51 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

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

53 Coffell and Horton (August 2017) How hot weather – and climate change – affect airline flights, https://theconversation.com/how-hot-weather-and-climate-change-affect-airline-flights-80795

Conclusion

The electorate of Capricornia stands to be heavily impacted by climate change.

Increasing heatwaves and falling water availability will impact the community's health, infrastructure and vital industries particularly agriculture.

However, none of this is inevitable. Climate projections clearly show that if the world achieves the 1.5-degree target agreed to by virtually every nation on earth under the Paris agreement, most of these impacts can be avoided.

Fortunately, the measures we need to take to tackle climate change are consistent with a prosperous future and growing employment in the region. Renewable energy jobs doubled in Queensland in the last two years[54] and the electorate of Capricornia has an excellent solar resource providing opportunities for more renewable development and provide ongoing power sector jobs. As the cost of renewable energy is already lower than new coal or gas, the region also has a potential competitive advantage in developing new industries that can take advantage of this clean, low cost power generation.

There are also ample opportunities for land use sequestration that could provide additional income streams for farmers, as well as necessary adaptation measure to build resilience in our communities, farms, businesses and infrastructure to the changes already locked in. Besides avoiding costs from climate impacts, these measures will also provide jobs and flow on economic benefits to the region.

However, leadership will be required to grasp these opportunities. It requires leaders with an understanding of the issues and a willingness to rise to the challenge.

54 Australian Bureau of Statistics (2019) 4631.0 - Employment in Renewable Energy Activities, Australia, 2017-18

https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4631.0Main+Features12017-18?OpenDocument