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Heatwatch

Extreme heat in Rockhampton

The average number of days over 35 degrees in Rockhampton each year has increased dramatically since the 1980s, now averaging 31 days per year. CSIRO and Bureau of Meteorology projections estimate that without climate action this could rise to 37 days in 2050 and as many as 70 days by 2070. Half of summer days are projected to be over 35 degrees by 2070. Extreme heat will have profound effects on human health, industries and ecosystems.

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Summary

At temperatures above 35 degrees the human body's ability to cool itself reduces, making it a common benchmark temperature for occupational health and safety experts, academic and government researchers. Combined with 70% humidity, conditions over 35 degrees are considered 'extremely dangerous' by government agencies such as the US Government National Oceanic and Atmospheric Administration.

The number of days over 35 degrees per year in Rockhampton has nearly doubled from an average of 18.1 days per year in the mid-20th century to 31.6 days per year in the last five. Mid-20th century levels will more than triple to a projected 70 days over 35 by 2070. Combined with the humidity of Rockhampton's summer, more days are seeing dangerous heat levels.

Alarmingly, CSIRO and Bureau of Meteorology (BoM) projections demonstrate an increase in the frequency of hot days in summer. Without decisive climate action, CSIRO and BoM project about half of summer days will be over 35 degrees by 2070 in Rockhampton.

The impacts of more extreme heat are already being seen globally, with Europe, Russia, India and Pakistan all experiencing heat waves resulting in thousands of deaths.[1,2]

The implications of such temperature increases need to be considered and a part of the case for climate action. These includes increased severe health impacts and heat-related deaths. Increased hot days would reduce productivity in important Queensland industries such as agriculture, construction and tourism.

Increased intensity of extreme rainfall events is expected to bring more major flooding of the Fitzroy River and with it more climate risk to the Rockhampton community.

[1] Wang, Horten (2015) *Tackling climate change: the greatest opportunity for health The Lancet Climate Change and Human Health Commission*, The Lancet, https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60854-6/fulltext

[2] Hass, et al. (2016) *Heat and Humidity in the City: Neighbourhood Heat Index Variability in a Mid-Sized City in the Southeastern United States,* International Journal of Environmental Research and Public Health.

Introduction

As the climate warms, the number of extremely hot days is increasing. While Rockhampton is known for the consistency of its warm summer weather, the number of extremely hot days – days over 35 degrees – 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.

Extreme heat is dangerous for human health, for ecosystems 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 and body temperature rises. This creates discomfort and a range of health impacts, from mild to severe, and can ultimately be fatal without intervention. [3]

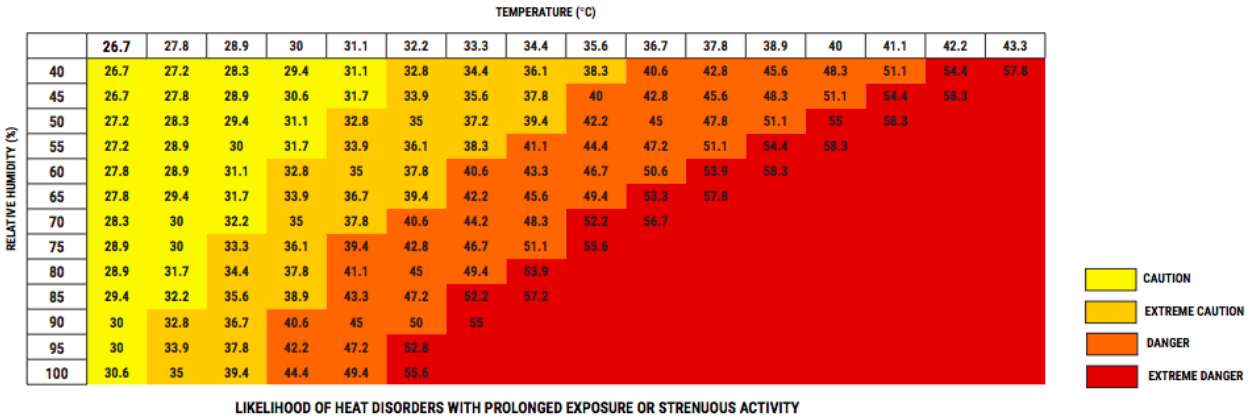
Because of this, many regulators and researchers use 35 degrees as an important threshold for safety, work and climatic conditions. 35 degrees is seen as the "Limit of high temperature tolerance" by the Occupational Health and Safety Representatives of the Victorian Trades Hall Council; academic researchers have pointed to this as a point where substantial productivity is lost. The CSIRO and Bureau of Meteorology publish 35 degree threshold predictions, presumably for this reason.[4]

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

[3] 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

[4] 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: http://www.nws.noaa.gov/os/heat/heat_index.shtml

NOAA's heat stress index rises to "Extreme Danger" at temperatures over 35 degrees with 70% humidity. Rockhampton's climate already sees relative humidity levels exceed 70%. From August 2017 to August 2018 there were 24 days, concentrated in summer, with a relative humidity of 70% or above at 3pm in Rockhampton.[5]

A future that combines such high humidity levels with an increase in the frequency of days over 35 degrees represents a serious threat to the wellbeing of Rockhampton's and Australia's wider population. Irritability and psychological stress increases with heat.[6] Hot weather affects patterns in domestic violence,[7] interrupts sleep patterns and reduces capacity and willingness to exercise. Both carry broad ramifications, such as increased accident risk and sedentary life style induced diabetes and cardio vascular disease.[8,9] Tracking and minimising the way climate change is affecting the number of hot days is of direct interest to the wellbeing of local communities and the broader Australian public.

[5] BoM (2018) *Daily Weather Observations*, http://www.bom.gov.au/climate/dwo/201708/html/IDCJDW4102.201708.shtml

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

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

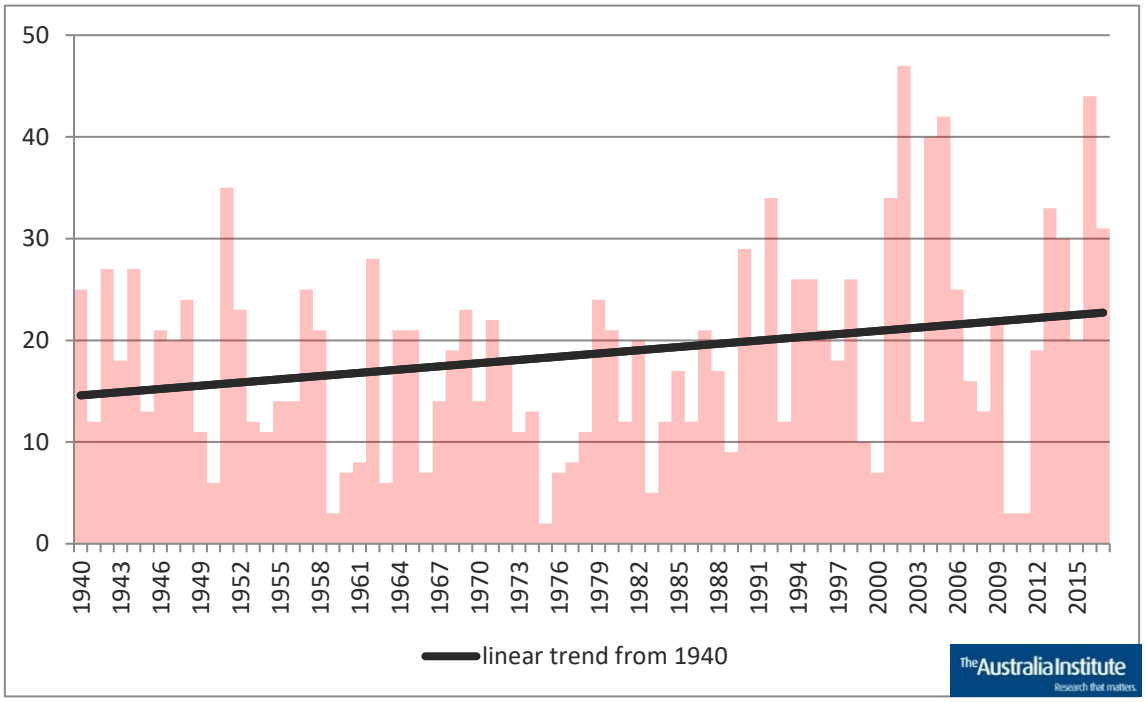
[8] Kjellstrom T et al (2009) *The Direct Impact of Climate Change on Regional Labor Productivity.* Archives of Environmental & Occupational Health 64 (4).

[9] 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

Hot days in Rockhampton

The Bureau of Meteorology has temperature records for Rockhampton from 1940. The number of days over 35 degrees in each year is shown in Figure 2 below:

Figure 2: Annual number of days over 35 degrees Rockhampton, 1940-2017



Source: Bureau of Meteorology (n.d.) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml

Figure 2 shows that the trend of over 35 degree days in Rockhampton has increased significantly over the last 75 years. While the 1940s had a large number of hot, with six years having over 20 days above 35 degrees, no decade reached this number until the 1990s, quickly repeated in the 2000s and likely to be repeated again in the 2010s.

Figure 2 shows two recent years, 2010 and 2011, with only three days above 35 degrees. This was likely due to the record-breaking La Niña event that took place over this time.[10] Despite this there is a clear increase in numbers of extreme heat days over the recorded period as summarised in Table 1 below:

[10] BoM (2012) *Record-breaking La Niña events: An analysis of the La Niña life cycle and the impacts and significance of the 2010-11 and 2011-12 La Niña events in Australia,* http://www.bom.gov.au/climate/enso/history/La-Nina-2010-12.pdf

Table 1: Average number of days per year above 35 degrees Rockhampton

Year	Average days over 35 degrees
1940-1959	18.1
1960-1979	14.2
1980-1999	18.4
2000-2017	24.5
2013-2017	31.6

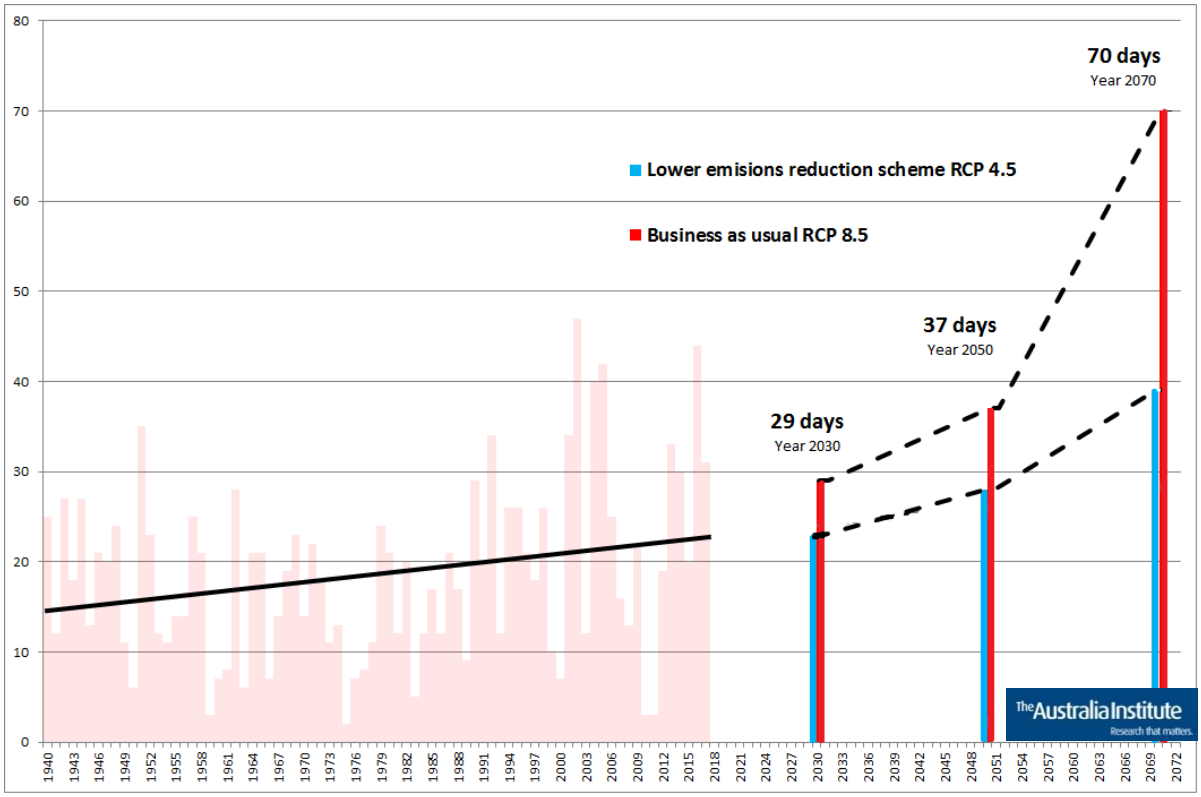
Source: Bureau of Meteorology (n.d.) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml

As shown in Table 1 above, the last five years have averaged 31.6 days over 35 degrees. This represents a near doubling since the middle of the 20th century. More worrying still, the following decades are likely to exacerbate these challenges.

Projected increases in days over 35 degrees

The number of days over 35 degrees days in Rockhampton is expected to increase in the coming decades according to CSIRO and BoM climate modelling. Under a business-as-usual (BAU) scenario on greenhouse emissions, the CSIRO estimates Rockhampton could experience 29 days over 35 degrees per year in 2030, 37 days per year by 2050 and 70 days per year in 2070. This would be more than a tripling from the BoM mid-20th century average of 18.1 days per year. Figure 3 below lays out the CSIRO predictions out to 2070 under this business-as-usual scenario and another scenario that includes greater action on climate change:

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



Source: CSIRO and Bureau of Meteorology (2015*) Climate projections: Climate threshold calculator*, https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/threshold-calculator/

These projections are based on the United Nations Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathways (RCPs), which are scenarios of various levels of concentrations of greenhouse gases in the atmosphere.

Figure 3 uses as the business-as-usual scenario 'RCP 8.5', which is the highest of the four scenarios of global emissions outlined by the IPCC in their 2014 Fifth Assessment. It reflects the BAU scenario, which most closely resembles the current global trajectory as emissions still continue to increase.[11]

Figure 3 also shows the projected number of days over 35 degrees under the RCP 4.5 scenario where strong emission reduction is achieved. The RCP 4.5 pathway requires decisive reduction in emissions. If this is achieved, the CSIRO expects number of days over 35 degrees per year for Rockhampton to be significantly lower than in BAU trajectory, with 23 days over 35 degrees per year in 2030, 28 days per year in 2040 and 39 days per year in 2070. While these figures carry significant inherent risk, substantial additional harm could be avoided.

An obvious problem arises when the projections in Figure 3 are compared to the historic data in Figure 2 – the lower projections have already been exceeded. It is possible that this could be explained by methodological differences - the historic data used by the CSIRO-BoM model is not the same as that shown in Figure 2, but is a time-series from the Australian Water Availability Project (AWAP) where the average temperature was compiled in 5x5km spatial grids between 1981-2010.[12] This model, and the projections built off it, observed only 14 days a year over 35 degrees in this period compared to the 24.5 days per year average at Rockhampton station over the last twenty years.

Whatever the reason for the discrepancy between the two historical averages, Figure 3 shows that the CSIRO projection of 29 days a year over 35 degrees by 2030 is close to being reached prematurely according to the Bureau of Meteorology.

This raises further the potential that the projection of 70 days a year over 35 degrees by 2070 is low and that CSIRO and BoM's most pessimistic projections from 2015 have been possibly too optimistic.

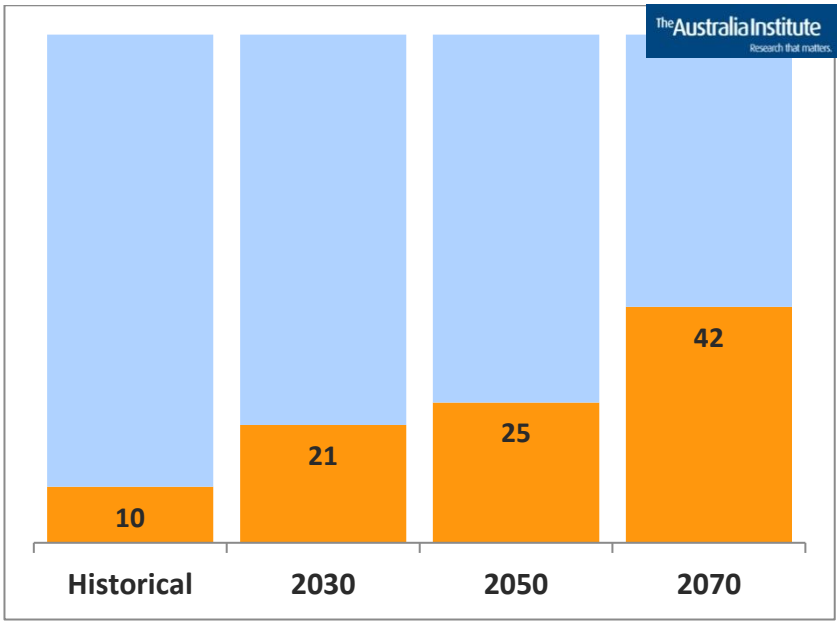
[11] Le Quere et al (2017) *Global carbon budget 2017*. Earth Syst Sci Data 8.

[12] CSIRO and Bureau of Meteorology (2015) *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*, CSIRO and Bureau of Meteorology.

Projected extreme heat days in summer

An indication of the projected distribution of extreme heat days throughout the year can also be gained from examining the CSIRO and BoM datasets. The CSIRO AWAP summer projections are based off December-February having 90.25 days - and for Rockhampton the historical average of 10 days over 35 degrees between 1981-2010, or roughly one in nine days as shown in Figure 4:

Figure 4: CSIRO-BoM projections of frequency of summer days over 35 degrees



Source: CSIRO and Bureau of Meteorology (2015) *Climate projections: Climate threshold calculator*, https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/threshold-calculator/

Figure 4 demonstrates the dramatic increase in the frequency of extreme heat days in summer. Under a BAU scenario on greenhouse emissions, the CSIRO and BoM estimate that Rockhampton could experience an average of one in four summer days over 35 degrees in 2030, one in 3.5 by 2050 and 47% – nearly half – of summer days in extreme heat by 2070.

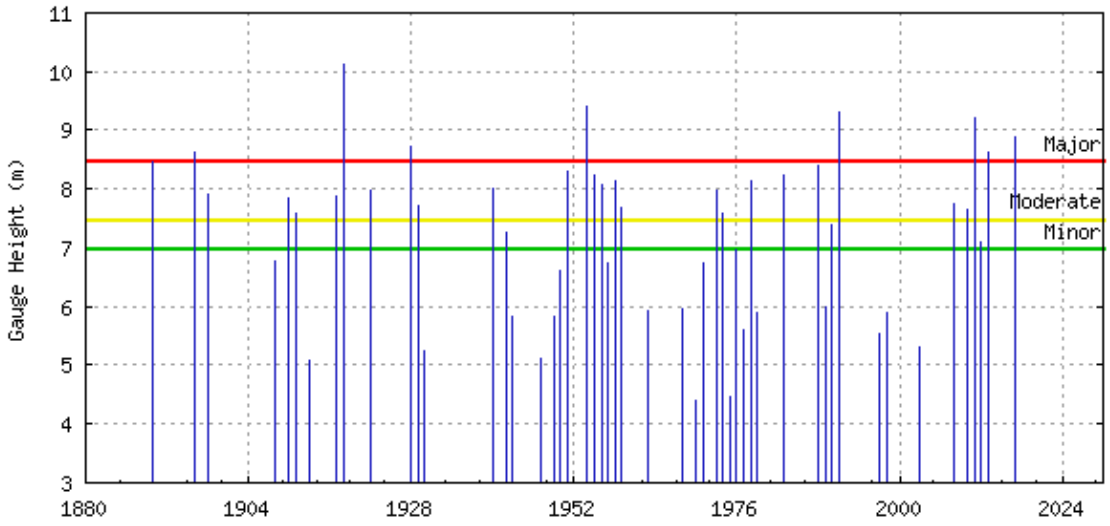
The high humidity of summer combined with the significant increase in projected extreme heat days make this period extremely dangerous to human health and wellbeing.

Floods on the Fitzroy River

Climate change brings other challenges for Rockhampton beside the increase in days of extreme heat. The city lies on the banks of the Fitzroy River which because of its size and fan shape, the BoM considers its catchment system 'capable of producing severe flooding following heavy rainfall events.'[13]

The BoM's Fitzroy River flood level classification defines major flood events as those with a gauge height exceeding 8.5m. These events cause extensive rural and urban inundation, flooding above the floor level causing home and property damage, and evacuation of affected areas. Figure 5 below displays the flooding records:

Figure 5: Fitzroy River at Rockhampton, highest flood peaks



Source: Bureau of Meteorology (2017) *Flood warning system for the Fitzroy River,* http://www.bom.gov.au/qld/flood/brochures/fitzroy/fitzroy.shtml

Figure 5 shows that three of the eight major flooding events over the last 150 years have occurred within the last six summers in 2011, 2013 and 2017.

Rockhampton and the Fitzroy River catchment system lie within what the CSIRO considers the North East Coast natural resource management (NRM) sub-cluster.

[13] Bureau of Meteorology, *Flood warning system for the Fitzroy River,* http://www.bom.gov.au/qld/flood/brochures/fitzroy/fitzroy.shtml

These clusters are developed by considering past climatic conditions, biophysical factors and expected broad patterns of climate change.[14]

Though the CSIRO-BoM are unsure of the overall rainfall trends – particularly in the next 20 years – it is highly confident about its projection of increased intensity in the region's extreme rainfall events:

> Understanding of the physical processes that cause extreme rainfall, coupled with modelled projections, indicate with high confidence a future increase in the intensity of extreme rainfall events, although the magnitude of the increases cannot be confidently projected.[15]

The further increase in these extreme weather events due to climate change is expected to be dramatic. Like previous major Fitzroy River floods these escalating conditions will continue to impact on the local community and mean significant damage to the state and national economy.[16]

[14] CSIRO and Bureau of Meteorology (2015) *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*, CSIRO and Bureau of Meteorology.

[15] Ibid, https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=ECNC&tooltip=true&popup=true

[16] Rockhampton Regional Council, (n.d) *Floods, https://www.rockhamptonregion.qld.gov.au/CouncilServices/Disaster-Management/Floods*

Conclusion

An increase in days of temperature and humidity extremes over 35 degrees will have severe impacts on human health, including increased rates of heat-related deaths.

Given the vulnerability of Rockhampton and the rest of the Queensland to climate change, strong emissions reduction policies are in the state's interests.

Fortunately Queensland is in a strong position to reduce, implement, and benefit from strong climate and energy emissions reduction policies. The current Queensland Government's renewable energy target will drive renewable energy development to reduce emissions, create jobs and bring other economic benefits.

Increasing gas and coal exports is incompatible with Australia's carbon budget and commitments under the Paris agreement to limit warming to less than 2 degrees. It has been calculated that two thirds of existing fossil fuel reserves need to remain in the ground in order to have even a 50% chance to avoid 2 degrees of warming.[17]

Strong action on climate change by reducing Australia's emissions and fossil fuel use production, as well as calling for global action, are in Rockhampton's and Australia's best interests.

[17] McGlade and Ekins (2015) *The geographical distribution of fossil fuels unused when limiting global warming to 2 °C*, https://www.nature.com/articles/nature14016