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Heatwatch

Extreme heat in Roma

The average number of days over 35 and 40 degrees in Roma has increased annually since the early 1990s. CSIRO and Bureau of Meteorology projections estimate that, without climate action, days over 40 degrees could rise from five days per year to 58 days in 2070 and as many as 84 days by 2090. Half of summer nights are projected to remain above 25 degrees by 2070, a level considered dangerous to human health. Increasing extreme heat will have profound effects on people, industries and ecosystems.

Mark Ogge
Travis Hughes
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Level 1, Endeavour House, 1 Franklin St
Canberra, ACT 2601
Tel: (02) 61300530
Email: mail@tai.org.au
Website: www.tai.org.au

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.

The number of days over 35 degrees per year in Roma has nearly doubled from an average of 42 days per year from 1992–1997 to 68.5 days per year over the last five years. The amount of these extreme heat days could more than quadruple to a projected 185 days over 35 by 2090.

Days over 40 degrees are also projected to increase from a current average of four to five days per year to as high as 84 days annually by 2090.

Alarmingly, CSIRO and Bureau of Meteorology (BoM) projections also demonstrate an increase in the frequency of hot nights. Unless emissions are decisively reduced, CSIRO and BoM project about half of summer nights could be over 25 degrees by 2070 in Roma.

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]

Increased hot days would reduce productivity in important Queensland industries such as agriculture, construction and tourism. Roma specifically would see its large employment sectors of livestock and wheat crops greatly damaged.

Fortunately, CSIRO projections show that if emissions are reduced, the rises in extreme temperature days will be far lower. For instance, with a decisive reduction in emissions the rise in 40 degree days could be kept to around one third of the rise that could be expected otherwise.

[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 extreme temperature days is increasing. While Roma is known for its warm weather and hot days, the average number of over 35 and over 40 degree days has increased considerably in recent years and is forecast to increase drastically unless emissions are reduced.

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.[4]

A future that combines such extreme heat days with an increase in the frequency of nights over 25 degrees represents a serious threat to the wellbeing of Roma and 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.[5] Hot weather affects patterns in domestic violence,[6] interrupts sleep patterns and reduces capacity and willingness to exercise. All carry broad ramifications, such as increased accident

[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/

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

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

risk, sedentary life style induced diabetes and cardio vascular disease.[7,8] 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 very hot areas such as the Roma region.

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

[8] 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 Roma

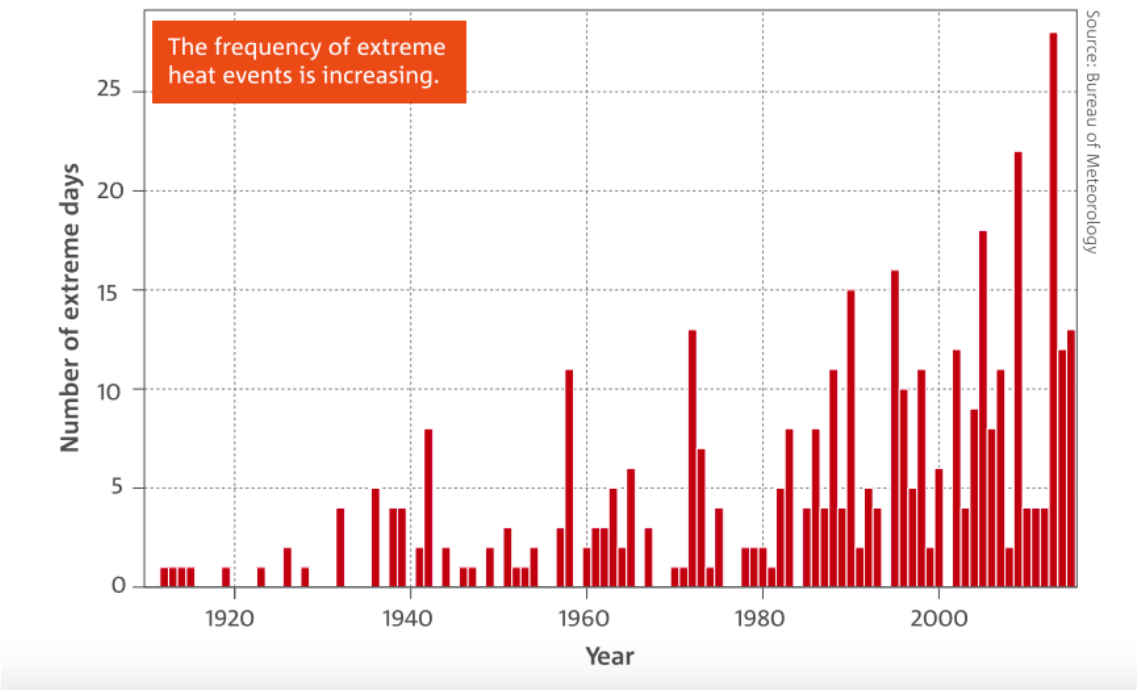
In Australia and globally there has been a clear trend of increasing temperatures and extreme heat events that are attributable to global warming.

The increase in extreme heat events across Australia as a whole is shown in Figure 1 below. This Bureau of Meteorology graph shows the annual number of days exceeding the 99th percentile of each month from 1910–2015.

The Bureau of Meteorology clearly attributes this trend to global warming.

> As the global climate system has warmed, changes have occurred to both the frequency and severity of extreme weather. In Australia, the most obvious change has been an increase in the occurrence of record-breaking heat.[9]

Figure 1: Frequency of extreme heat days, Australia.



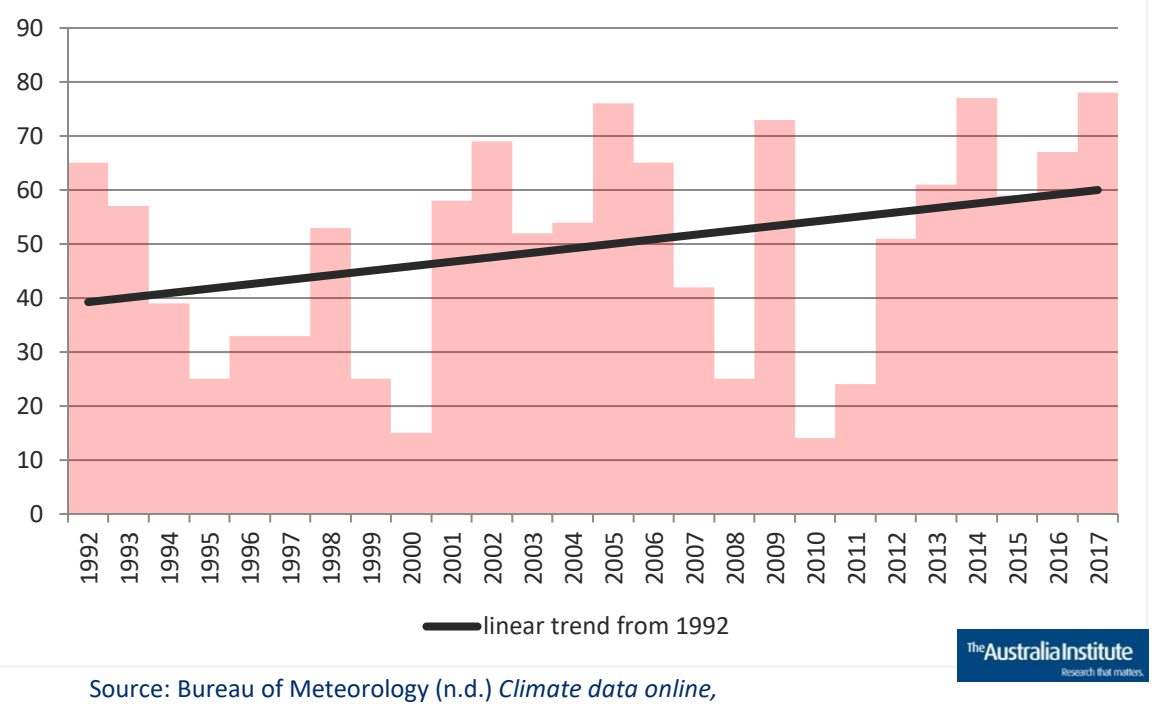
Source: BoM (2016) *State of the Climate*

The Bureau of Meteorology has temperature records from Roma Airport starting in 1992. The number of days over 35 degrees in each year is shown in Figure 2 below.

[9] BoM (2016) *State of the Climate,* http://www.bom.gov.au/state-of-the-climate/State-of-the-Climate-2016.pdf

While the relatively short timeframe of these records mean that trends should be viewed with caution, they echo the overall trend of increasing extreme heat events in Australia and globally.

Figure 2: Annual number of days over 35 degrees Roma, 1992–2017



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

Table 1 below, demonstrates the five yearly average temperatures recorded at the Roma Airport weather station from 1992.

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

Years	Average days over 35 degrees
1992–1997	42.0
1998–2002	44.0
2003–2007	57.8
2008–2012	37.5
2013–2017	68.5

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

Projected increases in days over 35 degrees

The number of days over 35 degrees days in Roma is expected to increase dramatically in the coming decades if global emissions continue to rise according to CSIRO and BoM climate modelling.

The CSIRO use eight climate models to project temperature extremes into the future. All climate models use different methods for understanding the complex climate system, and as such provide a range of projections. The models used by the CSIRO are selected on the basis of how well they simulate the current climate.[10]

Our analyses in Figures 3, 5 and 6 use all eight climate models selected by the CSIRO, and present the full range of their projected increases in days over the various temperature thresholds according to two different emissions scenarios. These Figures also mark the average of the projections, as well as the highest and lowest ones.

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

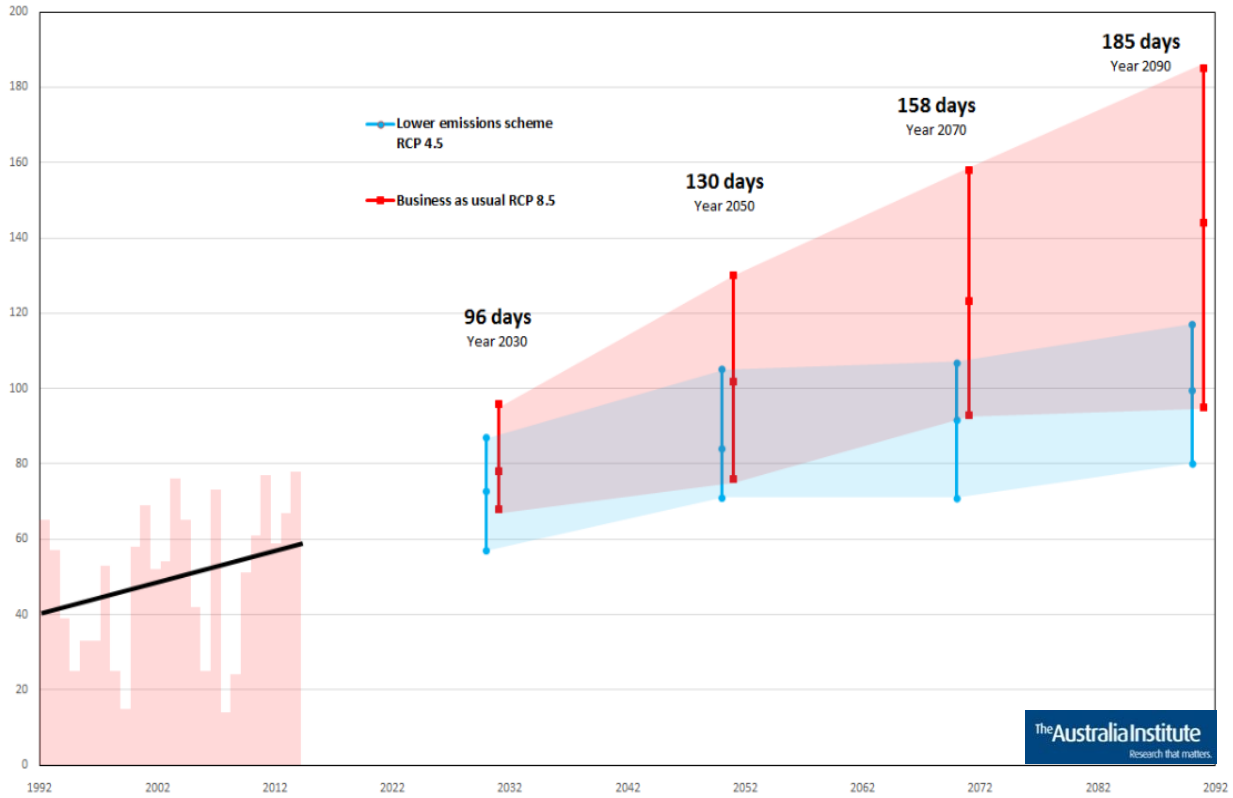
The historical data used to make projections by the CSIRO–BoM models is not that of Roma Airport shown in Figure 2, but is instead a time-series from the Australian Water Availability Project (AWAP) where the average temperature was compiled in 5x5km spatial grids between 1981–2010.[11] These models, and the projections built off them, observed 53 days a year over 35 degrees historically which is consistent with the average at Roma Airport station since 1992.

Figure 3 below lays out the CSIRO predictions to 2090 of the two scenarios:

[10] CSIRO (n.d.) *Modelling choices and methodology,* Climate Change in Australia, https://www.climatechangeinaustralia.gov.au/en/climate-projections/about/modelling-choices-and-methodology/

[11] 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.

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



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 3 displays the 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 business as usual (BAU) scenario, which most closely resembles the current global trajectory as emissions still continue to increase and no action is taken.[12]

Under the BAU scenario of greenhouse emissions, the CSIRO projects that Roma could experience as many as 96 days over 35 degrees per year in 2030, and 185 days per year by 2090. This would be a greater than fourfold increase from the BoM average of 42 days from 1992–1997. The range of the eight climate model projections under BAU is shaded in red.

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 pathways require decisive reduction in emissions. If this is achieved, the average of the CSIRO climate models expects the number of days over 35 degrees per year to be lower than in a BAU trajectory – with 73 days over 35 degrees per year in 2030, 84 days per year in 2040,

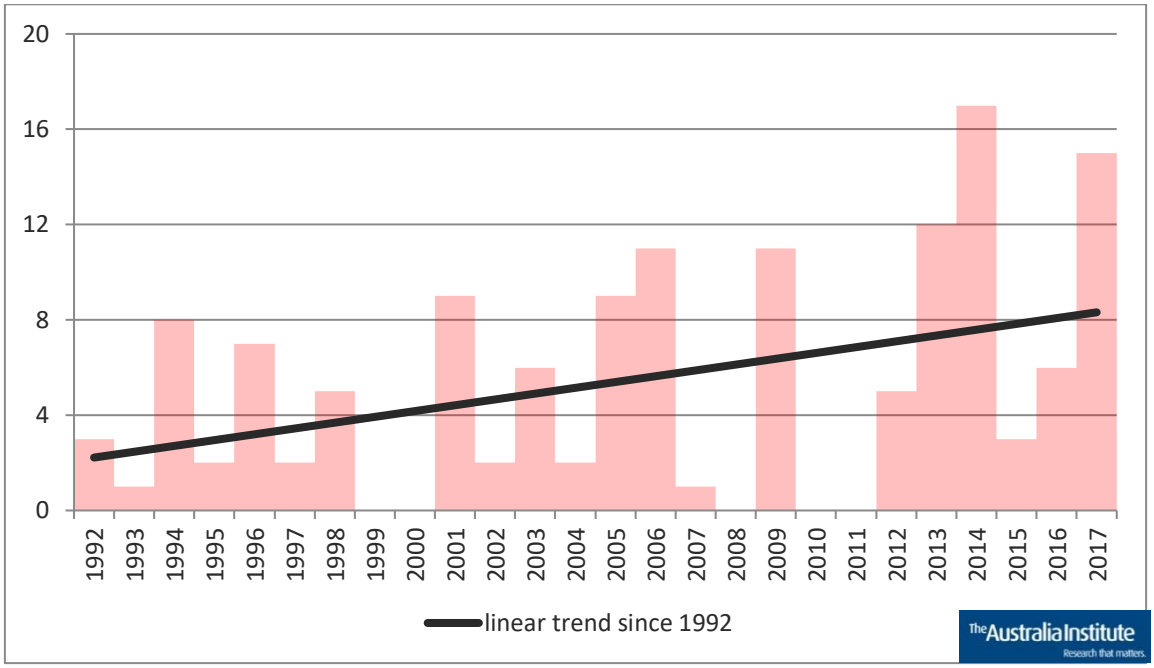
[12] Le Quere et al (2017) *Global carbon budget 2017,* Earth Syst Sci Data 8.

92 days per year in 2070, and 99 days per year in 2090. While these figures carry significant inherent risk, substantial additional harm could be avoided. The range of the eight climate model projections that assume a substantial reduction in emissions is shaded in blue.

Projected increases in days over 40 degrees

Even more concerning for Roma is the historical and projected increase in days over 40 degrees during the same timeframe. Figure 4 below shows the annual days over 40 degrees has increased significantly since 1992.

Figure 4: Annual number of days over 40 degrees Roma, 1992–2017

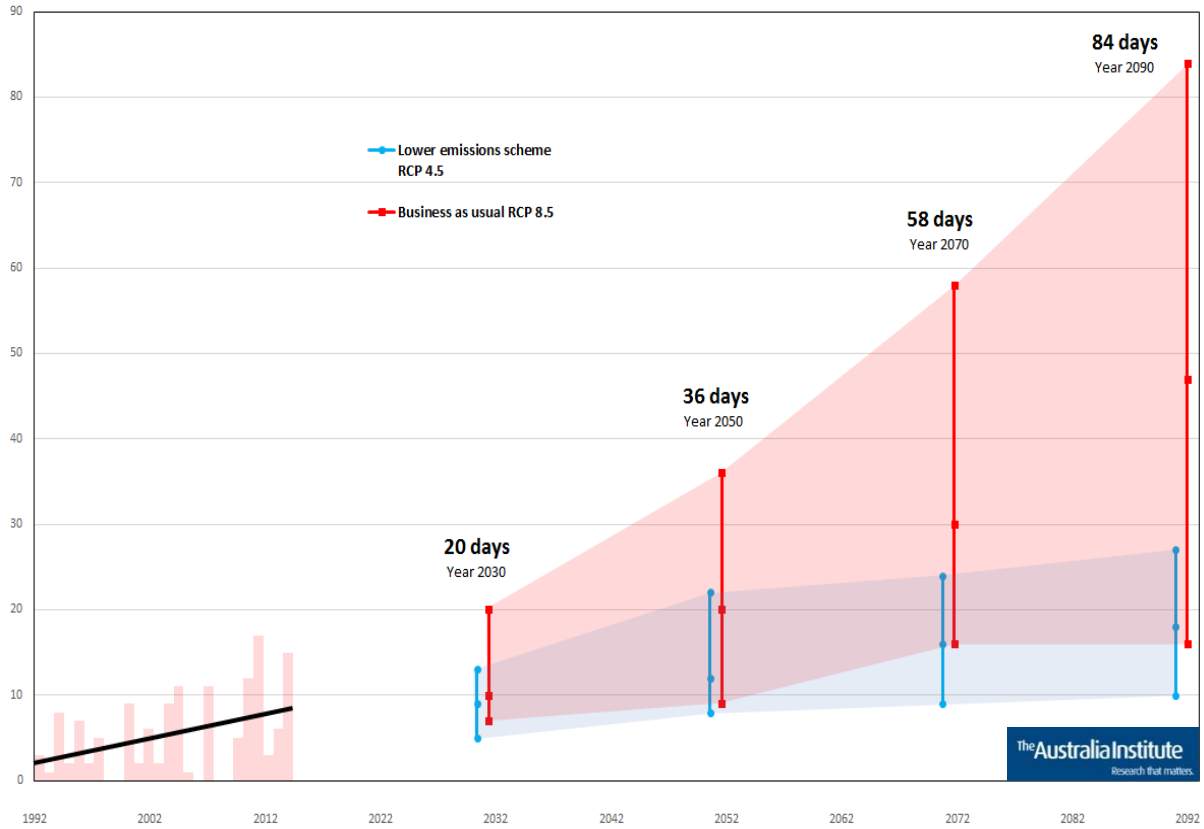


Source: Bureau of Meteorology (n.d.) *Climate data online,* http://www.bom.gov.au/climate/data/index.shtml

The number of days over 40 degrees days 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 5 below lays out the CSIRO predictions out to 2090 under the BAU and the RCP 4.5 scenario that includes a significant reduction in emissions.

Figure 5: Forecast annual number of days over 40 degrees Roma



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

Like Figure 3, Figure 5 displays the range of the eight climate model projections under BAU shaded in red. The range of the eight climate model projections with significant reduction taken is shaded in blue.

In the RCP 4.5 scenario, the average of the CSIRO climate models expects the number of days over 40 degrees per year to be significantly lower than in the BAU trajectory – with nine days over 35 degrees per year in 2030, twelve days per year in 2040, sixteen days per year in 2070, and eighteen days per year in 2090. While that many extreme heat days still carries significant inherent risk, they represent a situation of much reduced harm compared to the BAU scenario with many more extreme heat days.

These models, and the projections built off it, observed five days a year over 40 degrees historically which is consistent with the average at Roma Airport station since 1992.

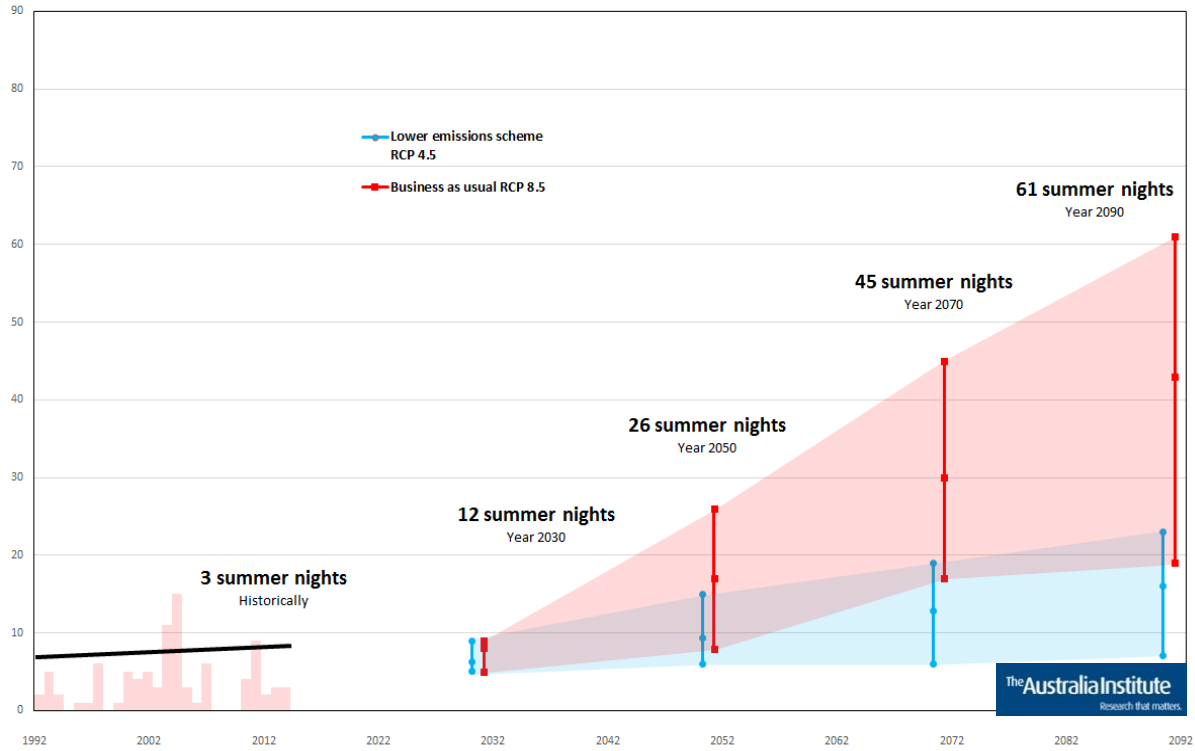
Projected extreme heat over summer nights

Though the number of extreme heat days is projected to increase in Roma, this is accompanied by an even greater increase in the frequency of extreme summer nights. Part of this more rapid warming at night is innate to the climate system, as night-time temperatures are inherently more sensitive to climate forcing (sunlight insolation).[13]

The BoM classifies nights with extreme heat as those with a minimum temperature of 25 degrees. A further indication of the projected distribution of extreme heat nights into the future can 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 Roma the historical average is 3 per cent of nights with a minimum temperature of 25 degrees between 1981–2010, or roughly one in thirty days as shown in Figure 6:

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

Figure 6: CSIRO–BoM projections of frequency of summer nights over 25 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 6 demonstrates the dramatic projected increase in the frequency of extreme heat nights in summer. Under a BAU scenario on greenhouse emissions, the CSIRO and BoM estimate that Roma could experience an average as high as one in three summer nights over 25 degrees in 2050, one in two by 2070 and 68% – over two thirds – of summer nights in extreme heat by 2090.

The high incidence of extreme summer nights combined with the significant increase in projected extreme heat days make for a climate very dangerous to human health and wellbeing.

Health and productivity impacts of extreme heat

The impact of extreme heat on human health, particularly over extended periods of time, is severe. Although people living in hot areas acclimatise to help cope with extreme temperatures, there are limits.[14] A large increase in days over 40 and nights over 25 degrees will push past those limits.

Symptoms can include both direct heat illnesses such as heat exhaustion and indirect illnesses such as heart failure and even death. As climate change worsens this can be expected to put more vulnerable people at increasingly greater risk.

As we operate during the day we produce heat that needs to be released from our bodies. Sweating exchanges heat from the body to the atmosphere, but this heat exchange process diminishes significantly beyond 35 degrees and body temperature rises.

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 not treatment is delayed.[15]

Those demographics that are most vulnerable 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.[16]

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 carries over and the body has

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

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

[16] 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

no opportunity to cool down and recover. Studies show that there is an association between the mortality of stroke patients and high night temperatures.[17,18]

Extreme heat nights also cause increased insomnia and lack of rest. As sleep is vital for healthy human functioning, a lack of it means more susceptibility to disease, obesity, chronic illness and harm to our psychological and cognitive functioning.[19]

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 to workplaces.[20]

[17] Murage et al. (2017) *Effect of night-time temperatures on cause and age-specific mortality in London,* Environmental Epidemiology 1.
[18] Roye (2017) *The effects of hot nights on mortality in Barcelona, Spain,* International Journal of Biometeorology 61.
[19] Obradovich et al. (2017) *Nighttime temperature and human sleep loss in a changing climate,* Science Advances 3.
[20] Climate Council (2014) *Heatwaves: Hotter, Longer, More Often,* https://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf

Extreme heat impacts on 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 to the increases in days of extreme heat. The effects that this will have on Roma's current economy are complex, but overwhelmingly negative – and will worsen as climate change progresses.

Table 2 below is a breakdown of the composition of Roma's workforce:

Table 2: Roma Region industry of employment – proportion of employed persons

Industry	2016 proportion of employed persons (%)
Agriculture, Forestry and Fishing	37.4
Other industries	16.4
Health care and social assistance	7.5
Public administration and safety	7.0
Construction	6.6
Education and training	6.3
Retail trade	5.4
Manufacturing	3.6
Mining	3.3
Electricity, Gas, Water & Waste Services	1.4

Source: ABS (2016) *Roma Region,* http://stat.abs.gov.au/itt/r.jsp?RegionSummary&region=307011177&dataset=ABS_REGIONAL_ASGS2016&geoconcept=ASGS_2016&measure=MEASURE&datasetASGS=ABS_REGIONAL_ASGS2016&datasetLGA=ABS_REGIONAL_LGA2017&regionLGA=LGA_2017&regionASGS=ASGS_2016

Agriculture, comprised mainly of cattle livestock and wheat, is the largest employer in Roma as of 2016 and comprises 37.4 per cent of the workforce. As a result, the effects of climate change on these industries is important in detailing how Roma will cope with rising temperatures.

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 in that environment.[21]

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.[22] 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, vital to Roma, is worth more than $5 billion per year nation-wide and is Australia's most valuable crop.

However, 'potential' wheat yields have slowed down in Australia between 1990 and 2015 by a dramatic 27 per cent.[23] Researchers attribute this decline to reduced rainfall and to the rising temperatures associated with climate change.[24] High temperatures can also damage crop reproduction and indirectly increase plant water stress.[25]

The CSIRO also 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.[26]

[21] 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
[22] Coventry and Phillips (2000) *Heat Stress in Cattle,* https://dpir.nt.gov.au/__data/assets/pdf_file/0015/233070/788.pdf
[23] The Conversation, *Changing climate has stalled Australian wheat yields: study,* https://theconversation.com/changing-climate-has-stalled-australian-wheat-yields-study-71411
[24] 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
[25] Climate Council (2014) *Heatwaves: Hotter, Longer, More Often,* https://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf
[26] CSIRO, *Crops ready for a different future climate,* https://research.csiro.au/climate/themes/agriculture/crops-ready-different-future-climate/

Extreme heat impacts on infrastructure

The effects of extreme heat on infrastructure essential to Roma is also projected to be significant:

- Power and transmission infrastructure around the Maranoa area, including Roma, would be affected by higher sustained temperatures. Levels of peak demand during heat would also rise, affecting the ability of generation to meet demand. The incidence of blackouts would also increase due to load shedding.
- General water demand would rise while supply would fall, leading to water stress.
- Medical facilities would be under increased strain because of the rise of detrimental health effects.
- Transport infrastructure would more frequently be damaged by intense levels of heat. Bridges, roads, concrete structures and rail lines would all be susceptible to damage from cracking and buckling under stress.
- Homes, businesses, power generators, and public infrastructure would all be under the increased threat of bushfires caused by drier and hotter conditions.[27]

The financial losses and economic cost that result from the effects of these failures and disruptions would affect all the people of Roma.

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

Conclusion

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

Given the vulnerability of Roma 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 implement and benefit from strong climate and energy emissions reduction policies. Queensland is blessed with an abundant solar resource. This presents it with the opportunity to make large reductions in power sector emissions and a particular opportunity for solar rich areas like the Roma region to benefit from the regional development and employment opportunities of renewable energy.

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.[28]

Australia is one of the highest per capita emitters in the world. Queensland's large and expanding coal and gas export activities are internationally significant, and are throwing fuel on the fire that is driving the increase in extreme temperatures that will have such a devastating impact on the Roma region.

There is an urgent need for adaptation measures to cope with increasing extreme heat in many parts of Australia, including the Roma region. However, unless ultimately there is strong global action on climate change, temperature increases will have a detrimental impact on the region. As a major emitter, it is important that Queensland and Australia as a whole play our part in achieving these emissions reductions.

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