Queensland Health

Climate change adaptation planning guidance

ALMANAC

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Queensland Government

Climate change adaptation planning guidance for Hospital and Health Services in Queensland: Almanac, 2nd Edition.

Cover image – Queensland Children's Hospital

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An electronic version of this document is available at https://www.health.qld.gov.au/system-governance/strategic-direction/plans/climate-change/climate-change-strategy-and-planning

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1 Introduction

This Guidance provides the information you need to develop a Climate Change Risk Management Plan for your Hospital and Health Services (HHS). It has three components, the Guidelines, the Templates and the Almanac.

1.1 Policy context and intended audience of this Guidance

The Guidelines, Template and Almanac have been developed to support Queensland Health to:

- manage the risks associated with a changing climate, and
- take advantage of opportunities that may emerge.

The Guidance builds on existing risk management practices including disaster management arrangements within Queensland Health as well as other relevant state government planning in Queensland. It is consistent with the Queensland Government's *Human Health and Wellbeing Climate Change Adaptation Plan for Queensland* (Armstrong et al. 2018).

The purpose of the Guidance is NOT to remove any existing risk or disaster management arrangements within Queensland Health. Rather it is to build the capacity of Queensland Health internal stakeholders to understand and plan for how climate change might impact the sustainability of operations, human resources and infrastructure. Its aim is to help Queensland Health employees and stakeholders to access, interpret and use climate change information to identify and manage relevant risks as a part of their day-to-day business. The risk frameworks used are consistent with State endorsed risk management approaches identified under the Queensland Emergency Risk Management Framework (QERMF) (QFES 2017).

This Guidance seeks to deliver an approach which, when implemented, will allow identified climate change-related risks to be incorporated into existing risk management approaches (e.g. risk registers) which have been developed under the risk management policies of Queensland Health.

1.2 About this Almanac

This Almanac provides a compendium of information to support the development of a Climate Change Risk Management Plan when using the Guidelines and Template. This is the second edition of the Almanac, an updated and extended version of the original 2019 Almanac. It includes information on:

- climate change and sea-level rise
- climate change impacts and opportunities
- regional climate change summaries
- impacts of climate change relevant to HHSs
- adaptation options
- how to sequence adaptation options
- case studies and examples.

For those who require further information, a list of resources is provided in Section 10.

2 Key definitions

Climate change hazard: In the context of climate change, hazard refers to any potential occurrence of a natural or human-induced physical event that may cause damage to property, infrastructure, livelihoods, human health, service provision, environmental resources etc.

Exposure: The degree to which a system such as an HHS is exposed to a given hazard (e.g. sea-level rise)

Sensitivity: In the context of a risk assessment, the term sensitivity refers to the degree to which a system is affected by, or responsive to, a hazard.

Adaptive capacity: The ability of systems, institutions, humans, and other organisms to adjust to change, to take advantage of opportunities, or to respond to consequences.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

> **Relationship between climate change hazard, exposure, sensitivity, adaptive capacity and vulnerability:** A system (e.g. a HHS, an asset component, a business operation) can be exposed to a climatic hazard (e.g. heatwave) and if that system is sensitive to the hazard (e.g. a component can malfunction under extreme heat, therefore it is sensitive to heatwave) or has less capacity to adapt to the hazard (e.g. a facility without an air conditioner has limited capacity to adapt during a heatwave), then the system can be considered as vulnerable to future heatwaves which are likely to increase in intensity and frequency as a result of climate change.

Resilience: The capacity of a system (social, economic, environmental, infrastructure) to cope with a hazardous event or trend or predictable change, responding or reorganising in ways that maintain its essential function, identity, and structure, while also maintaining the capacity for further adaptation, learning, and transformation.

Climate-related risk: The potential for consequences where something of value is at stake and where the outcome is uncertain. The risk to a system can be assessed qualitatively or quantitatively and, in the accompanying Guidelines, we explain how this can be done by combining consideration of the likelihood of a climate hazard, its consequence should it occur, and the vulnerability of the system to the hazard.

Climate-related impact: The effects on natural and human systems of climate events and of climate change. As an example, if higher average temperatures associated with climate change leads to more frequent and more intense heatwaves, such that a greater number of people suffer from heat stress for longer periods, this would be a climate-related impact.

Climate change adaptation: The process of adjustment to actual or expected climate and its effects. Adaptation in human systems such as HHSs seeks to moderate or avoid harm or exploit beneficial opportunities. An example of adaptation in the HHS would be to use heat reflective coatings on roofs to reduce heat transmission and air conditioning requirements or to develop sustainable energy options to offset increasing energy demands and provide long term savings.

> **Relationship between climate change impacts, risks and adaptation:** Climate change is expected to cause incremental changes in our climate as well as to increase the frequency and/or intensity of some extreme events (e.g. heatwaves, bushfires, extreme rainfall, drought). These changes create different ***risks*** for different regions in Queensland. Of relevance to the HHS, heatwaves may become more severe and more frequent, leading to the risk that admissions to hospitals may increase. Where the risk eventuates, i.e. admissions during heatwaves do increase due to increasingly severe conditions, then this becomes a region — or facility-specific ***impact***. The scale of these risks/impacts depends in part on how well ***adapted*** a service or system is, considering factors such as its exposure, the likely consequences of identified risks, and the HHS's capacity to manage the impacts.

Climate change mitigation: Mitigation is the reduction of greenhouse gas emission by society. It can include reducing or preventing emissions from sources (e.g. replacing coal fired energy with renewables) or by enhancing the uptake of greenhouse gases (e.g. planting trees, carbon farming).

> **Relationship between adaptation and mitigation:** Mitigation is to adaptation what prevention is to disease management – one is needed to support the success of the other. Wherever possible, adaptation and mitigation actions should have co-benefits and should be mutually reinforcing. For example, installing rooftop solar on hospital buildings can reduce emissions of greenhouse gases (mitigation) and build resilience to climate change through increased energy security at the facility level (adaptation).

Transition risk: Risks associated with the transition to a low-carbon economy. This can entail extensive policy, legal, technology and market changes to address mitigation and adaptation requirements related to climate change. This can increase operating costs and affect critical operations of the HHSs.

3 About climate change

Climate change is a change in the pattern of weather, and related changes in oceans, land surfaces and ice sheets, over timescales from decades to millions of years. Throughout the Earth's history, the climate has changed in response to solar variations, changes in the Earth's orbit around the Sun, volcanic eruptions, movement of the continents and natural variability such as El Niño and La Niña events. These processes still occur, but the climate is now changing far more rapidly in response to human activities.

In the Earth's atmosphere, greenhouse gases (including water vapour, carbon dioxide, methane, nitrous oxide and ozone) allow sunlight to pass through to the surface of the planet and warm our world. Some of the infrared radiation that is reflected back from the Earth is absorbed by these greenhouse gases, warming both the atmosphere and the Earth's surface. This is referred to as the *greenhouse effect* (Figure 1) and was identified more than a century ago. It keeps the Earth warm enough to be habitable.

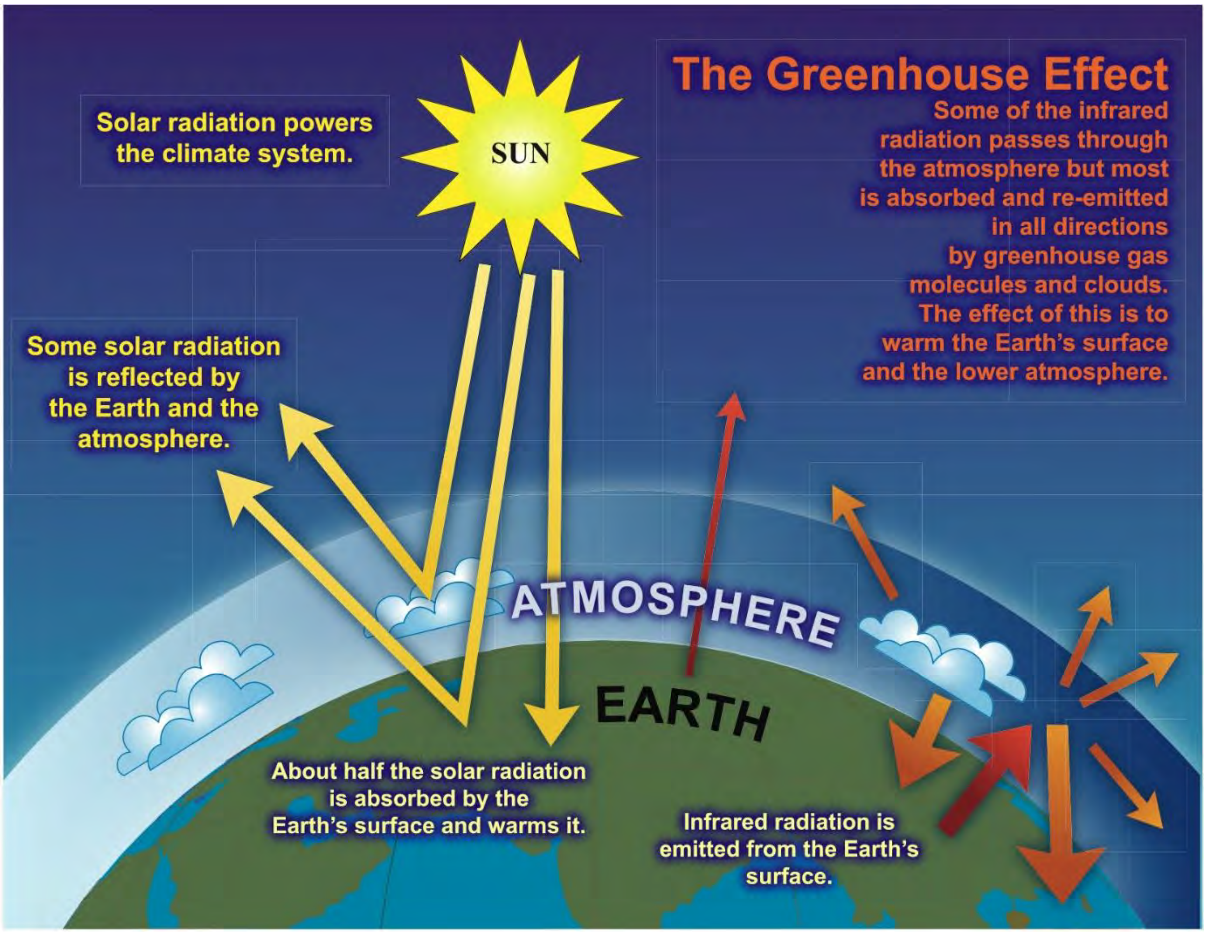


Figure 1: *An idealised model of the natural greenhouse effect. Source: IPCC*
https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/faq-1-3.html

Since the industrial revolution in the nineteenth century, human activities have increased atmospheric concentrations of key greenhouse gases, chiefly through burning fossil fuels in industrial processes and transport, and through deforestation and intensive livestock farming. This causes warming of the atmosphere and, because more energy is available, other effects on our climate such as changes in rainfall and storm intensity. Our oceans have absorbed much of the additional heat. As water warms it expands and the expansion of ocean water is leading to sea-level rise. Smaller contributions to sea-level rise are made by the melting of land-based glaciers and ice sheets, although we expect this contribution to rise in future as rates of melting increase. Over the past 100 years, temperature has increased over almost the entire globe, the rate of increase being largest in continental interiors. Sea levels have risen by around 25 cm since 1880.

3.2 Recent climate change in Australia

Average surface temperatures over the Australian continent have increased by around 1.5ºC since 1910. The eight years from 2013 to 2020 all rank among the 10 warmest years on record, leading to a pronounced increase in the number of hot days over time (Figure 2). Sea surface temperatures around Australia have increased by just over 1 °C since 1900. There has been an increase in the incidence of extreme heatwaves on land and in the ocean. There are differences across Australia, with some regions experiencing faster warming than others, and greater warming in summer than in other seasons. Rainfall has also changed in different regions with increases in northern Australia and seasonal declines in the southeast and southwest (Figure 3).

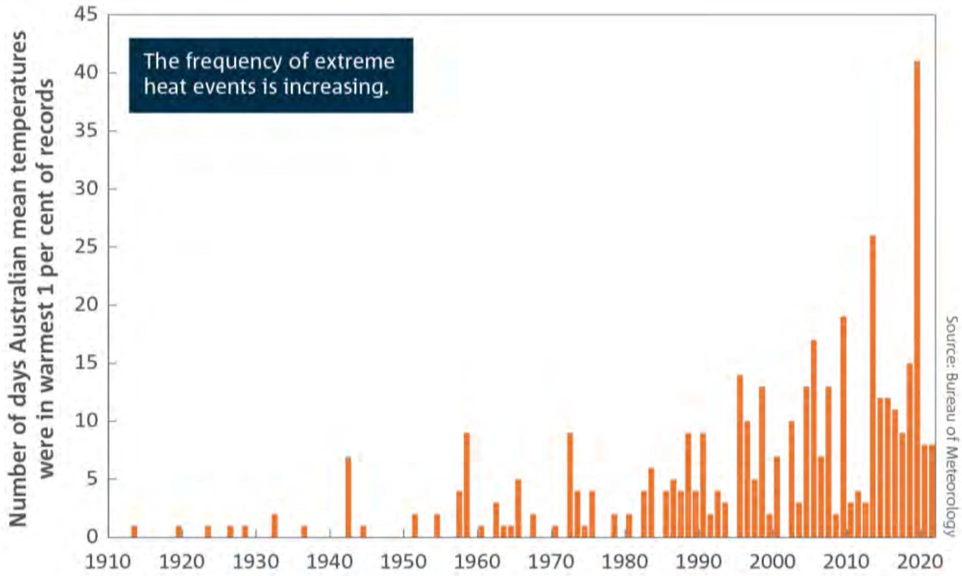


Figure 2*: Number of extremely warm days each year. Source: Bureau of Meteorology and CSIRO (2024).*

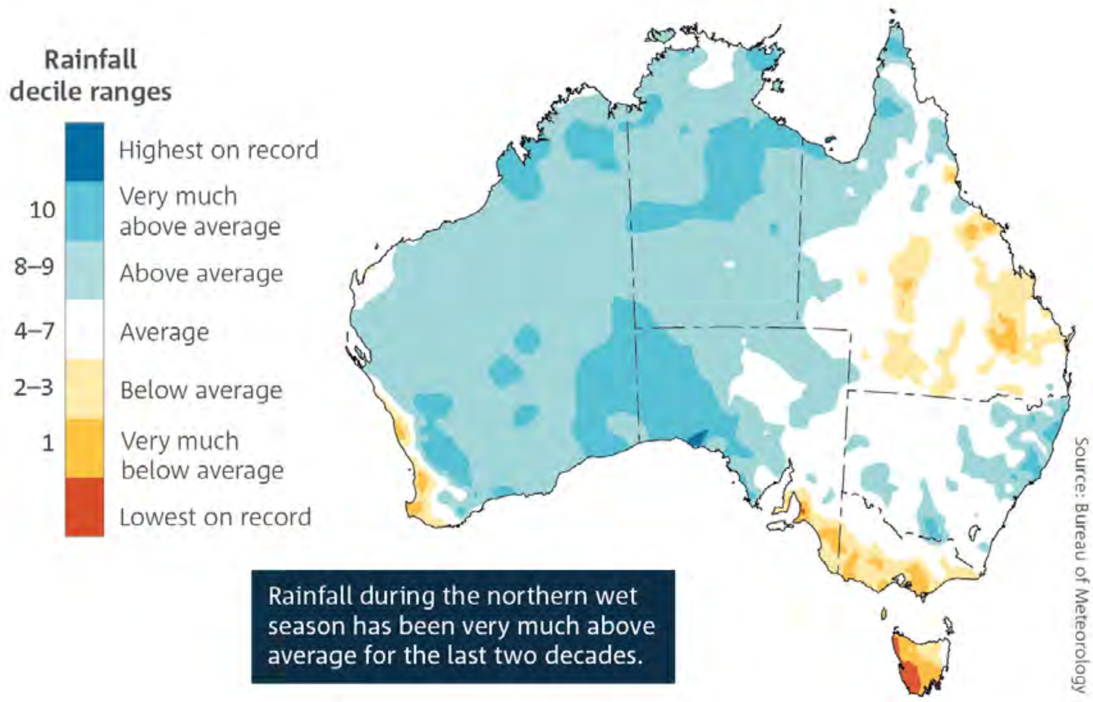


Figure 3: *Northern wet season (October–April) rainfall deciles for the past 22 years (2000–01 to 2021–22). A decile map shows where rainfall is above average, average or below average for the recent period, in comparison with the entire national rainfall record from 1900. Source: Bureau of Meteorology and CSIRO (2022).*

Queensland's climate is highly variable. Changes in the climate to date have reflected that variability with different regions experiencing different changes. Warming is already occurring, and far western Queensland is experiencing some of the fastest temperature increases in Australia. Some of the highest rates of sea level rise in Australia are found around the Gulf of Carpentaria, the western coast of Cape York and the Torres Strait islands. We expect the current trends to continue and changes in the climate to accelerate in future.

3.3 Future climate change in Queensland

This section summarises recent and projected climate change for Queensland. Much of the information comes from the website Climate Change in Australia (https://www.climatechangeinaustralia.gov.au/en/), which provides Australia-wide and regional climate projections.

In thinking about future climate change, we have to make some assumptions about how our emissions of greenhouse gases will evolve in the future. We call these assumptions 'scenarios'. Will emissions be strongly constrained through policy, regulation and technical breakthroughs? Or will emissions continue to grow in a largely unregulated manner? The former case is represented by a low emissions scenario (termed RCP2.6) and the latter by a high emissions scenario (RCP8.5) (see Section 3.4.1). A summary of the projections for RCP8.5 for four major regions of Australia is provided in Figure 4.

The extent of climatic changes we face in Queensland depends on the emissions scenario (high or low) and the timeframe being considered.

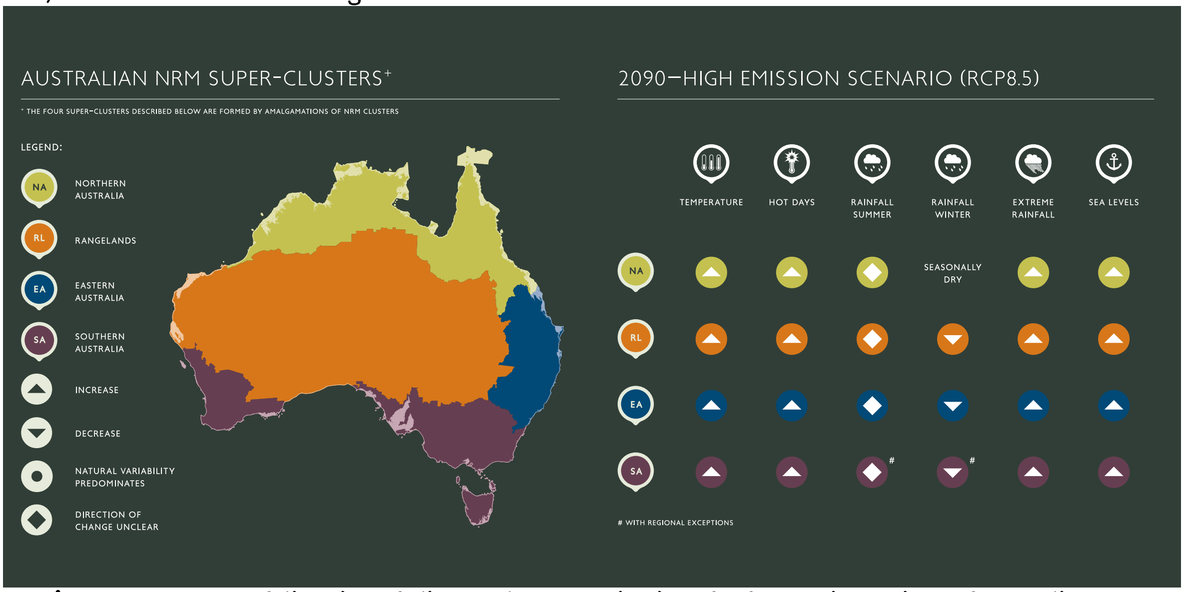


***Figure 4**: Summary of direction of climate change projections for four major regions of Australia. Source: https://www.climatechangeinaustralia.gov.au/en/*

Land areas in Queensland can expect higher average and extreme temperatures in the future. Marine areas will also experience warming and extreme heat events as well as more acidic waters. All of Queensland's coast will be impacted by rising sea levels, but the greatest rises are projected for Cape York and the adjoining islands. Saltwater intrusion into groundwater systems will impact coastal mangroves, floodplains and wetlands.

Periods of extreme heat are projected to become hotter and to last for longer. Although the projected trend in droughts is not clear, it is anticipated that southern Queensland will be likely to experience more droughts by the end of the century. Increased severe fire weather can also be expected to affect large areas of the state. Extreme rainfall is projected to bring more frequent, prolonged and widespread flooding. In all regions, changed flow and flood regimes will impact streams and wetlands. And finally, we may experience more intense and slow-moving cyclones that might track further south in the state although overall the number of cyclones is expected to decrease.

3.3.1 Air temperature

Queensland has a tropical to sub-tropical climate with warm to hot humid and wet summers and mild dry winters. Inland and northern parts regularly experience very hot conditions.

Heatwaves occur in most years. The Australian Bureau of Meteorology provides a formal definition of a heatwave as "three days or more of high maximum and minimum temperatures that are unusual for that location." Unusual temperatures in this context are often taken to be those in excess of the 95th percentile of the long-term temperature record for that location, i.e. heatwaves are defined relative to the climate of the place.

Throughout Australia, temperatures have been increasing over time. Over the past 50 years, Queensland air temperatures have increased, with south-western areas warming at the fastest rate in Australia. More heatwaves are occurring, and there has been a shift to more extremely warm days and fewer extremely cool nights.

How are air temperatures expected to change?

There is very high confidence that, if greenhouse gas emissions continue under a high emissions scenario (RCP8.5), projected changes will include the following:

- Australia's temperatures are projected to increase to 2.0–4.6 °C above the 1986-2005 average by the year 2100.
- Increases will occur in the mean, daily maximum and daily minimum temperatures, with inland areas experiencing greater increases than coastal areas.
- There will be fewer frosts.
- Very hot days will happen more frequently. For example, models project that Cairns might experience around 50 days over 35 °C in an average year by 2090, compared to around 4 days at present. Brisbane could experience around 55 days per year hotter than 35 °C.
- There will be increases in the duration, frequency, and intensity of heatwaves.

3.3.2 Rainfall, precipitation and runoff

Queensland's rainfall is highly variable on both an annual and decadal basis. The long-term (1900 to 2015) state-wide average annual rainfall is 628 mm. Rainfall is highly seasonal, with summer dominated rainfall across the state and a distinct wet season in the tropical north. Rainfall is influenced by several annual and interdecadal influences, including the Australian Monsoon and the El Niño-Southern Oscillation.

Since the mid-1990s, there have been substantial long-term changes in rainfall over Australia. In southern Queensland, there has been a trend towards lower rainfall throughout the year, particularly during the past decade. Since the 1970s, there has been increased rainfall across northern Australia, particularly in the period October – April.

How are rainfall, precipitation and runoff expected to change?

Whether rainfall will increase or decrease overall is uncertain for most of Australia. Natural variability is expected to dominate Queensland's rainfall patterns in the next two decades. Beyond that time, models are inconsistent, projecting both substantial increases and decreases. It is likely that rainfall will be less predictable, including seasonal patterns. The intensity of extreme rainfall events (wettest day of the year and wettest day in 20 years) is projected to increase and is likely to lead to more extensive and prolonged flooding. Drought will continue to be a feature of Queensland's climate, though it is not clear whether or how the intensity or frequency of drought will change.

3.3.3 Humidity and heat stress

When temperatures are high, this can affect human health through heat stress, which occurs when the body cannot get rid of excess heat. Our internal body temperature must be maintained at 37°C, and the way we maintain that temperature in hot conditions is by sweating. Heat stress is not a function of temperature alone – in humid conditions sweating becomes less efficient. Thus, heat stress is a function of both temperature and humidity. In terms of the impacts of climate change on human health, we must consider changes in both temperature and humidity to understand our heat stress risks from climate change.

Humidity is in part a function of temperature – the warmer the air, the more moisture it can hold. Humidity can be measured in different ways. *Relative humidity* tells us how much moisture there is in the air, compared to how much there could be at that temperature, and is expressed as a percentage. *Vapour pressure* is an absolute measure – the pressure exerted by the water molecules in a sample of air.

How is humidity expected to change?

Section 3.3.1 described the expected changes in temperature linked to global warming. What are the projected changes in humidity? Other things being equal we would expect humidity to increase in a warmer world since warmer air can hold more moisture. However, the projections from climate models do not support this. Across Queensland, projections suggest little change in relative humidity up to mid-century followed by a decrease later. This decrease, in the context of warming temperatures, suggests that the absolute moisture content of the atmosphere changes little if at all.

The relatively few studies of heat stress suggest that it will increases in future, especially over northern Australia. Figure 5 shows the change in heat stress (in days per year) by 2050. It is based on only one climate model, and so should be interpreted with caution, but suggests more than 80 additional extreme heat stress days per year by 2050 in northern Cape York. This must be related to increased temperatures, since the projected changes in humidity are small.

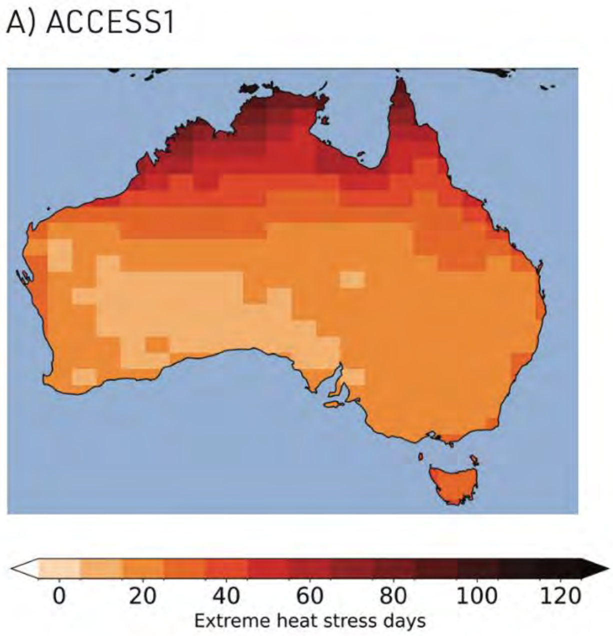


Figure 5: *The change in the number of extreme heat stress days in Australia under an intermediate emissions scenario (RCP4.5) for 2050 compared to present day. The map is for a single climate model (ACCESS1). Source: Pathmeswaran and Pitman (2023)*

3.3.4 Sea-level rise and coastal inundation

Globally-averaged sea levels have risen by around 25 cm since 1880. Some of the highest rates of sea level rise in Australia are found around the Gulf of Carpentaria, the western coast of Cape York and the Torres Strait islands. Along these coasts, rates are significantly higher than globally-averaged rates of sea-level rise.

How are sea level and coastal inundation expected to change?

There is very high confidence that Australian sea levels will continue to rise. The rate will be faster during the 21st century than experienced over the past four decades. Relative to the 1986-2005 average, the best estimate for sea level rise around the Australian coastline is around 16-36 cm by 2050 by 2050 and around 61-66 cm higher by 2090 (for RCP8.5). These figures from the IPCC Sixth Assessment (Lawrence et al. 2022) do not include some ice sheet processes in Antarctica. When these are included, the IPCC estimates for global sea level rise increase by around 10 cm. However, some global estimates which include additional potential contribution from major ice sheets in their calculations, suggest sea level rise as high as 2 m by 2100 (Bamber et al. 2019).

The Queensland Government has adopted a sea-level rise projection of 80 cm by 2100 for planning purposes (https://www.qld.gov.au/environment/coasts-waterways/plans/hazards/sea-level-mapping).

3.3.5 Ocean temperature and acidification

Australia's oceans have experienced substantial warming with sea surface temperatures warming by 1.05°C since 1910. Eight of the 10 warmest years on record have occurred since 2010.

Sea surface temperatures in the Coral Sea and around northern Australia are about 1°C warmer on average than 100 years ago. There have been five mass coral bleaching events along the Great Barrier Reef since 2016, caused largely by unusually warm sea surface temperatures in summer.

Since around 1885, the oceans have absorbed between a third and a half of the CO_2 emitted to the atmosphere. As a result, the average pH of surface waters around Australia and globally is estimated to have decreased by about 0.12, from 8.2 to 8.1, corresponding to about a 30% increase in acidity. (A pH value of 7 is neutral, values above 7 are alkaline and below are acidic). Between 1982 and 2020 the increase in acidity was 12-18%, indicating that the rate of increase is growing.

How is ocean temperature and acidification expected to change?

There is very high confidence that sea surface temperatures around Australia will rise, with near-coastal sea surface temperatures around Australia expected to rise by around 0.4-1.0 °C by 2030, and by 2-4 °C by 2090 under RCP8.5 compared to average temperatures across 1986–2005.

Australian oceans will become less alkaline with a projected increase in acidity of around 0.3 by 2090 for RCP8.5.

3.3.6 Increases in greenhouse gas emissions

Global average annual CO_2 concentrations in the atmosphere are steadily increasing and reached 421 parts per million (ppm) in 2023. Prior to the Industrial Revolution, concentrations were around 280 ppm.

How are greenhouse gas emissions expected to change?

Future levels of anthropogenic greenhouse gases and aerosols depend on trends that are hard to predict such as take up of renewable energy, technological developments and methods of transport, and particularly political will and social factors. In a high emissions scenario, it is projected that concentrations of CO_2 in the Earth's atmosphere might reach 800 ppm or higher by 2100. Taking all atmospheric greenhouse gases into consideration, the equivalent CO_2 concentration could exceed 1200 ppm by 2100.

3.3.7 Storms and cyclones

There is considerable year-to-year variability in the occurrence of cyclones. There is some observational evidence that the number of tropical cyclones each year has decreased between 1981 and 2013 (http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/history/climatology/). No trend in intensity can be discerned.

How are storms and cyclones expected to change?

Tropical cyclones are projected to become less frequent but those that do occur are more likely to be of high intensity (stronger winds and greater rainfall). There is some chance that more cyclones will track further south (e.g. to around 25ºS, about the latitude of Bundaberg).

3.3.8 Fire weather

There has been an increase in the occurrence of high (90th percentile) Forest Fire Danger Index (FFDI) days in recent decades across Australia (Figure 6), especially in southern and eastern Australia (including south-east Queensland), and the fire season has lengthened. Increasing temperatures and drying contributed to the observed upward trend in FFDI.

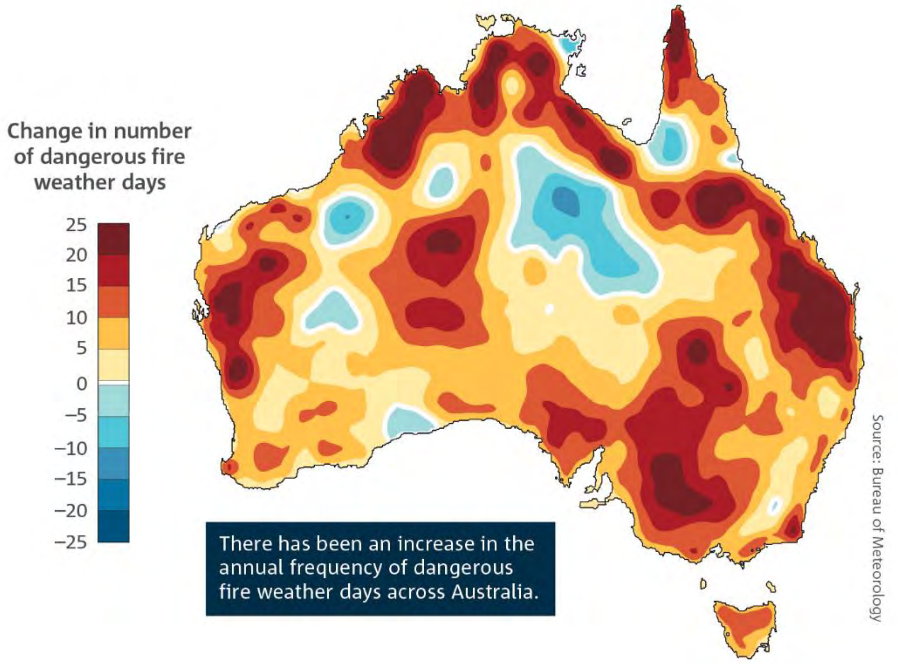


Figure 6: *Change in the annual (July to June) number of days that the Forest Fire Danger Index (FFDI) exceeds its 90th percentile between the two periods: July 1950 to June 1986 and July 1986 to June 2022. The FFDI is an indicator of dangerous fire weather conditions for a given location. Positive values, shown in yellow to red, indicate an increased length and intensity of the fire weather season. Source: Bureau of Meteorology and CSIRO (2022).*

How is fire weather expected to change?

For southern Queensland, it is expected that there will be more severe fire weather. While modelling suggests little change in the risk for tropical and monsoonal northern Australia, the length of the fire season has increased significantly in these areas. Confident projections about fire risk are difficult because of the important role of fuel loads, which are driven by rainfall, which has unclear future patterns.

3.3.9 Coincident events

When climate events coincide or closely follow one another, it can put strain on otherwise well-prepared systems. In 2009, Victoria experienced an extreme heatwave followed by catastrophic bushfires (the Black Saturday bushfires). The two events were extremely deadly and stretched emergency management responders to their limit. In the summer of 2010-2011, almost three-quarters of Queensland experienced intense rainfall and flooding following a monsoonal trough and a cyclone. In that case, the costs in terms of human lives, damage to property and infrastructure and business interruption were enormous.

How are coincident events expected to change?

While projections do not provide specific information about coincident events, it is reasonable to expect that the increase in frequency of events is likely to increase the probability of closely timed events or of recovery from events to overlap.

3.4 Understanding and using climate change scenarios

3.4.1 What are climate change scenarios?

A climate change scenario is a coherent, internally consistent, and plausible description of a possible future state of the climate. Most climate change scenarios are based on data from three-dimensional General Circulation Models, or GCMs. These models are computer-based simulations of the Earth-ocean-atmosphere system, which use fundamental thermodynamic equations to describe the behaviour of the system. They have been developed to help scientists understand the Earth-atmosphere-ocean system and how it might evolve when forced with increasing atmospheric concentrations of greenhouse gases.

Fine spatial and temporal information can be generated from these global models by nesting Regional Climate Models inside GCMs, to produce projections that are useful for considering local conditions. Some uncertainties remain, including around how human greenhouse gas emissions might grow or reduce in the future (the choice of emissions scenarios) and around precisely how the Earth-atmosphere-ocean system behaves, and the different components interact. As climate change scenarios will always be plausible representations of future climate, rather than forecasts or predictions, it is important to understand their limitations and the appropriate way to use them for making decisions (see Box 1).

Box 1: *Six tips for using climate models*

- Don't rely on a single model run – use an array of model runs as the basis to identify a 'best-guess' scenario or use a resource such as the Climate Change in Australia website (www.climatechangeinaustralia.gov.au) which has gone through this exercise for you.
- Make a reasoned choice of greenhouse gas scenario: perhaps RCP8.5 to be risk averse. Choosing a low emissions scenario such as RCP2.6 implies that we believe there will be a very substantial reduction in future emissions – the present-day evidence does not suggest that we will go down that pathway.
- Always keep in mind that models only provide a scenario – a likely or plausible future – and not a prediction. The reality maybe be better, worse, or just different.
- Use model output accordingly – as a basis to explore system sensitivities and vulnerabilities, and to identify appropriate low-regrets adaptation options and their timing.
- Keep in mind the things the models can't help you with – sudden shocks such as very rapid sea-level rise and the impact of events occurring simultaneously (for example, windstorm and catchment flooding). These could happen – would your system be able to cope?
- Finally, always remember, precision does not equal accuracy!

Source: CoastAdapt (NCCARF 2017)

Climate change is simulated in GCMs by gradually increasing the atmospheric concentrations of greenhouse gases and observing the effects on the model climate. To do this, some decisions must be made about how greenhouse gas concentrations will change in the future. Will we continue to burn fossil fuels at current rates, or will high emissions coal burning be substantially replaced by low-emissions renewable energy? These choices are captured by a set of four emissions trajectories called RCPs (Representative Concentration Pathways, Figure 7). The highest emissions scenario, RCP8.5, is often called "business as usual" as this is the future of emissions if we carry on much as before. It is likely to deliver warming of 4 °C or more by 2100. The lowest emissions scenario, RCP2.6, will only happen if aggressive efforts to reduce and capture emissions occur. The others are somewhere in-between. RCP2.6 is the emissions scenario most likely to deliver a global temperature change of less than 2 °C compared to pre-industrial temperatures (2 °C is recognised as the threshold at which climate change becomes 'dangerous').

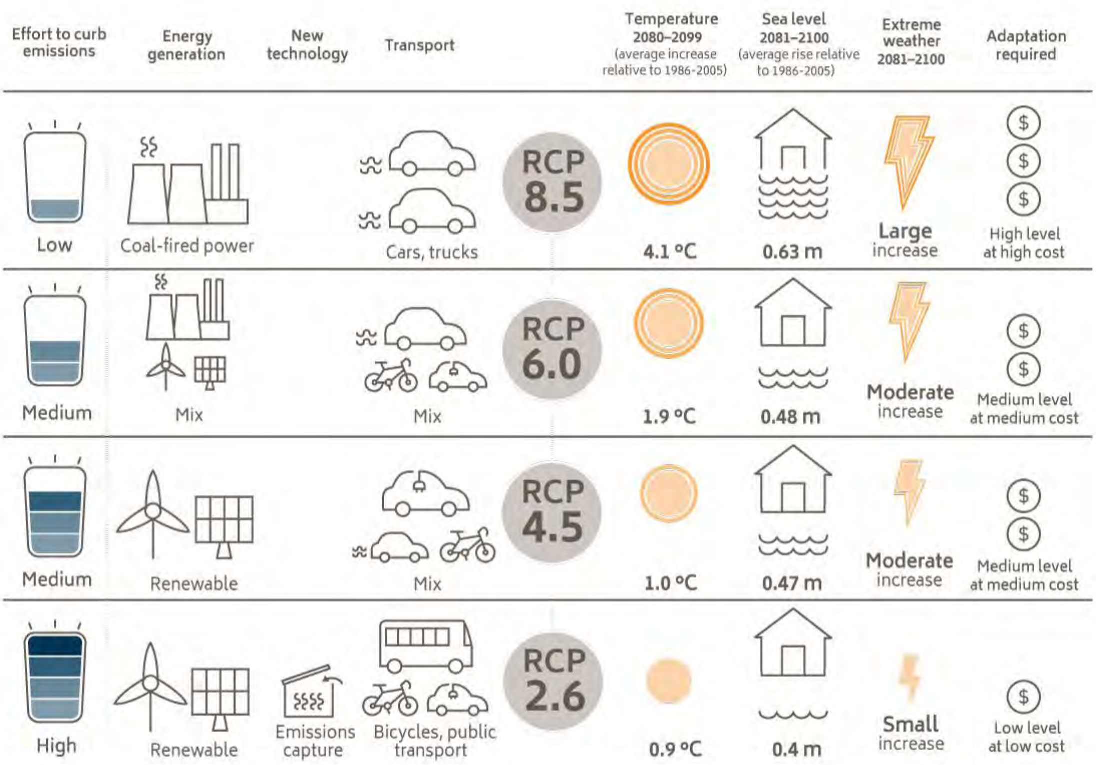


Figure 7: *Schematic to understand the different RCPs. Source: CoastAdapt (NCCARF 2017).*

3.4.2 How reliable are climate models?

The outputs of climate models are evaluated by measuring the level of agreement between model simulations and observations of the present climate. This assessment contributes to our confidence in the models. This testing can even consider the past influence of volcanic and solar activity (referred to as natural forcings) to understand their role in shaping our climate.

Over time, as computers have increased in power and in size, it has become possible to increase the spatial resolution of the model grid, and the model geography has therefore become more realistic. Using information from a single model gridpoint, or even a few gridpoints, will be misleading. The more model gridpoints we aggregate across, the better the model accuracy becomes. The Climate Change in Australia scenarios (https://www.climatechangeinaustralia.gov.au/en/) and the projections in the Queensland Climate Dashboard (https://www.longpaddock.qld.gov.au/qld-future-climate/dashboard/) are built on multiple models and gridpoints to achieve high model accuracy – as are all scenarios produced by major international scientific organisations (e.g. the National Oceanic and Atmospheric Administration in the US).

3.4.3 Understanding scenarios

Scenarios of climate change are constructed around a set of parameters and assumptions. These include:

- ***Time scales:*** Models are calculated using time steps and results can be created for a point in the future that is of interest.
- ***Emissions:*** Some decisions have to be made about how greenhouse gas concentrations will change in the future, and these are then translated into emissions scenarios which are plugged into the GCM. In the Almanac we use projections based on the 'RCP' emission scenarios.
- ***Level of aggregation:*** Climate variables are simulated by GCMs with different degrees of accuracy. Models are very good at simulating temperature. Their accuracy is much less for the simulation of rainfall and windstorm. However, the more we aggregate spatially across model gridpoints, and the more we average across time, the better the accuracy becomes.
- ***Baseline:*** Many climate variables are expressed as an anomaly from an averaging period (e.g. relative to 1961-1990 or change since 1910 etc.)

Most climate projections information is derived from a suite of multiple different models. This is because individual models will produce slightly different information based on different assumptions or calculations. When projections are provided to users, they are usually shown as a plausible range around a central point, usually the median or average of the model answers. The projections provided in this Almanac are the average from 11 models, along with the 10th to 90th percentile of the model outputs (Queensland Future Climate Dashboard, https://www.longpaddock.qld.gov.au/qld-future-climate/). Figure 8 illustrates the model output, average and 10th – 90th percentile range.

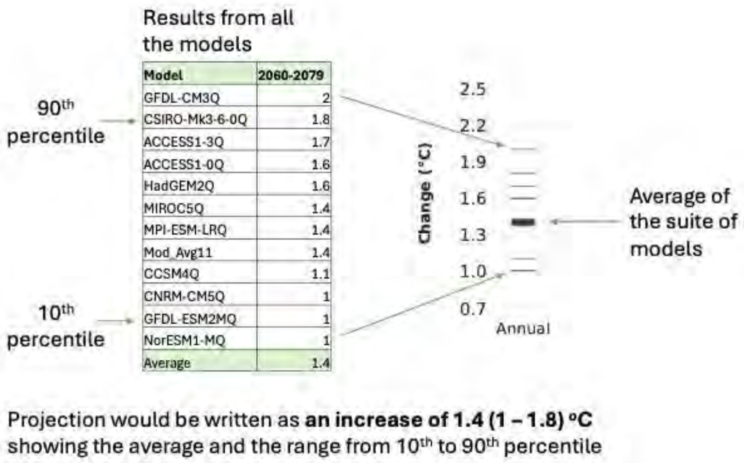


Figure 8: *An example of the results from the 11 models used in the Queensland Future Climate Dashboard. The table on the left shows the average annual change in temperature for Queensland for 2070 for the 11 models. The average of those values is 1.4 °C. The information used in this Almanac also includes the 10th percentile (meaning 10% of model results were less than that number) and 90th percentile (meaning 10% of the model results were greater than that number).*

3.4.4 Understanding what climate change scenarios tell us

Climate change scenarios provide information on the likely future climate for a specific location or region (Figure 9). We have more confidence in some climate projections (e.g. of average temperature) than others (e.g. of rainfall). This is simply because the models are better able to simulate some physical processes than others. To accommodate this, we express future changes in different ways. For changes in which we have more confidence, we can provide a range of values and a confidence measure (Example 1 below). Where there is less confidence, we may only provide broad statements of direction of change (Example 2 below). Note that, when scientists mention 'confidence', they are referring to the degree of confidence in being correct. When they talk about 'likelihood' they are referring to the probability of an event or outcome occurring.

- **Example 1:** By 2030, Australian annual average temperature is projected to increase by 0.6-1.3 °C above the climate of 1986–2005 under RCP4.5 with little difference between RCPs. Source: Climate Change in Australia.
- **Example 2:** Winter and spring rainfall is projected to decrease in southern Australia. Time in drought is projected to increase in southern parts of Australia. Elsewhere, the signal of rainfall change is too small relative to natural variability to be able to make any firm statements. Source: CoastAdapt.

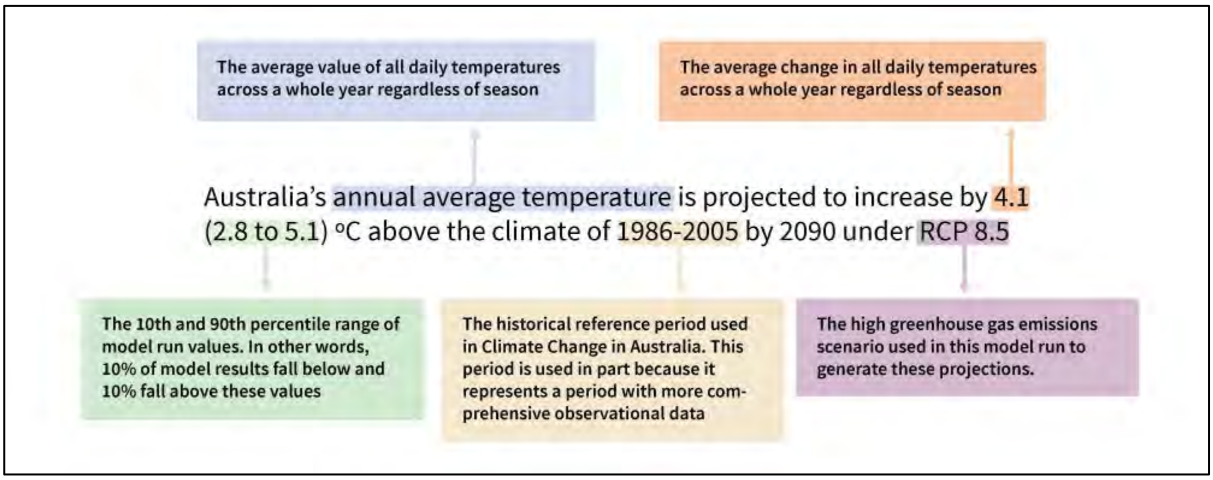


Figure 9: *An explanation of a typical statement about expected future temperatures. This statement is drawn from the [Climate Change in Australia](#) website. Always make sure you understand what these quite complex statements are telling you about future climate.*

3.4.5 What future climate changes might look like

Much of the information in climate change scenarios indicates seemingly small changes in averages. It is important to bear in mind that small changes in the average value can lead to disproportionate changes in extreme values. For example, a small increase in the average temperature will be accompanied by disproportionate changes in extremely hot and extremely cold weather (Figure 10).

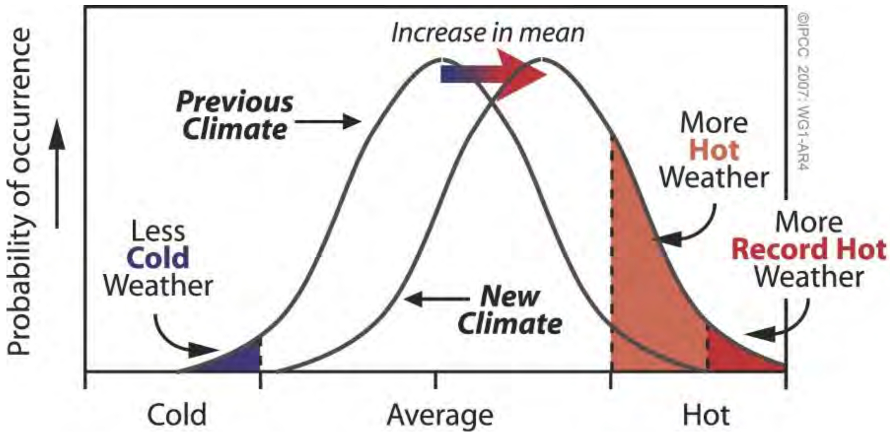


Figure 10: *A schematic illustrating the disproportionate change in occurrence of extremely hot and extremely cold weather that accompanies a small shift in average temperatures. Source: IPCC 2007.*

4. Climate change hazard summaries for each of the HHS regions

Regional climate summaries of select climate variables have been compiled for each of the HHS regions (shown in Figure 11). A guide to understanding the climate information in the summaries is provided in Box 2.

The regional summaries in this section have been compiled from the following sources:

- Department of Environment, Science and Innovation (Queensland) regional climate change summaries
- Queensland Climate Future Dashboard https://www.longpaddock.qld.gov.au/qld-future-climate/
- Climate Change in Australia www.climatechangeinAustralia.gov.au
- CoastAdapt https:coastadapt.com.au/
- Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report https://www.climatechangeinaustralia.gov.au/en/communication-resources/reports/

Information on other variables (e.g. wind speed, solar radiation, humidity) and more detailed information and seasonal projections on the climate variables presented here can be found in the above sources. The Queensland Climate Future Dashboard provides regional summaries for a wide variety of variables and should be your next port of call if looking for more detailed information.

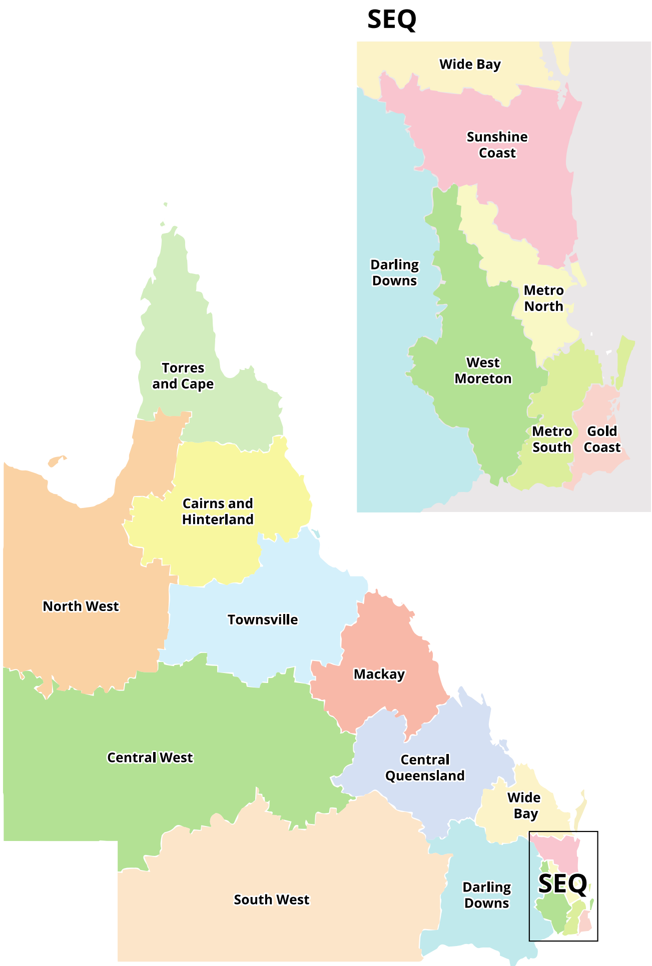


Figure 11: *Map of Queensland HHS regions. Source: https://www.health.qld.gov.au/maps*

***Box 2:** Understanding the data in the regional summaries.*

The HHS region summaries provide a snapshot of current climate change projections for each of the local government councils within the region. The projection information is presented for two emissions scenario:

Left column: Future scenario 1 assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in this column are based on RCP4.5.

Right column: Future scenario 2 assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in this column are based on RCP8.5.

Under each of the scenarios we provide projection information for a range of climate variables. For each climate variable we provide:

- a short phrase of key change
- a short description of key changes
- data tables that are described below.

Data tables include the average of 11 models plus the 10th to 90th percentile range (see Figure 8).

Air temperature

Here we summarise minimum (lowest night time) and maximum (highest day time) temperatures experienced in the past. Then, we provide information on how much temperatures may change at two points in the future, the years 2030 and 2070. The first value is the 'average' of the suite of models used. In the example below, Cairns Regional Council area might expect that by 2030 maximum temperatures will be 1.1 degree warmer on average than they were in 1986-2005, but that a range from 0.5 – 1.5 degrees is plausible. Note that when we say '2030', we are talking about two decades 2020-2039 around that year, and similarly '2070' refers to 2060-2079.

Extract of air temperature data table

Local government council	**Recent temperatures (1986-2006) °C**		**Mean projected increase in temperatures by 2030 °C**		**Mean projected increase in temperatures by 2070 °C**	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Cairns Regional	18.6	32.0	1.1 (0.5 – 1.5)	1.1 (0.1 – 1.8)	2.1 (1.3 – 3.0)	2.0 (0.7 – 2.9)

Hotter and more frequent hot days

We also provide information on extreme temperature changes. First, is information on the number of hot and very hot days as change in number of days over 35 °C and 40 °C. Again we provide average number of days over those two temperature thresholds experienced in the past (green column), then average projections for the years 2030 and 2070 with the 10th to 90th percentile in brackets to show the plausible range.

In the example below, Cairns Regional Council area might expect that by 2030 they will experience an extra 19 days over 35 degrees and an extra 17 days over 40 degrees than in recent history (147 over 35 degrees and 45 days over 40 degrees). By 2070 an extra 36 days more than recent history might be expected. Again, note that when we say 2030, we are talking about two decades 2020-2039 around that year, and similarly '2070' refers to 2060-2079.

***Box 2**. Continued*

Extract of hot and very hot days data table

Local government council	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35ºC	>40ºC	>35ºC	>40ºC	>35ºC	>40ºC
Cairns Regional	147.4	44.9	19.3 (-2.8 – 37.8)	17.3 (-0.7 – 32.9)	36.5 (11.6 – 56.2)	36.6 (7.7 – 59.4)

Heatwaves

Projections of heatwaves are reported by three measures:

- Peak temperature: *Maximum temperature (in ˚C) of the hottest day of the hottest heatwave in the year*
- Frequency: *Number of heatwave days relative to number of days in the year*
- Duration: *Average duration in days of all heatwave events in the year.*

In the example below, Cairns Regional Council area might expect that by 2030 that the hottest day of the hottest heatwave will increase by half a degree (e.g. go from 43.8 to 44.3 degrees), that the number of heatwave days as a proportion of the days in a year will increase by 2.1% (e.g. increase from 3% to 5.1 % of days in the year), and that the average number of days in each heatwave event will be almost half a day longer (e.g. heatwaves last 5.3 days on average an increase from 4.9 days).

Again, note that when we say 2030, we are talking about two decades 2020-2039 around that year, and similarly '2070' refers to 2060-2079.

Extract of heatwave measures data table

Local gov't council	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp ˚C	Freq. %	Duration Days	Peak temp ˚C	Freq. %	Duration Days	Peak temp ˚C	Freq. %	Duration Days
Cairns Regional	43.8	3.0	4.9	0.5 (0.1 – 1.3)	2.1 (0.4 – 4.0)	0.4 (-0.4 – 1.6)	1.2 (0.4 – 2.6)	6.3 (1.5 – 11.1)	1.5 (0.4 – 2.7)

Humidity

Projections of changes in humidity are shown as changes in relative humidity. In the example below, Cairns Regional Council area, the average of the models shows small decreases in humidity (-0.7% by 2030), although the range from 10th to 90th percentile of model outputs show the possibility of larger decreases or increases (-9.5-5.6% by 2030).

Extract of relative humidity data table

Local government council	**Relative humidity %** Historical annual average (1986-2005)	**Relative humidity %** Change in mean annual relative humidity 2030	**Relative humidity %** Change in mean annual relative humidity 2070
Cairns Regional	55.7	-0.7 (-9.5 – 5.6)	-0.5 (-10.9 – 6.5)

Fire weather

Fire weather is monitored using the Forest Fire Danger Index (FFDI). It is calculated using measures of daily temperature, wind speed, humidity and a drought factor (an indication of fuel load). Using model data, it is possible to calculate the number of days that might be under different fire conditions in each year and for each emissions scenario. An increase in the cumulative annual FFDI can indicate an increase in the potential incidence and/or severity of bushfire danger.

Box 2*. Continued*

Here we present number of days in a year that pose a:

- high fire risk (days with FFDI between 12 and 25)
- very high fire risk (days with FFDI between 25 and 50)
- severe fire risk (days with FFDI > 50).

In the example below, Cairns Regional Council area might expect that by 2030 they experience a small decrease in the number high fire risk days (2.2. days less) but a slight increase in the number of very high fire risk days (4.4 days more) and severe fire risk days (5.6 more days).

Extract of fire risk data

Local government council	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Cairns Regional	119.6	128.2	21.3	-2.2 (-11.4 – 14.0)	4.4 (-15.8 – 30.0)	5.6 (-2.7 – 15.9)	-6.9 (-22.2 – 7.4)	7.3 (-13.0 – 27.5)	10.7 (-2.0 – 26.6)

Rainfall

Rainfall projections present changes in average daily rainfall across the year. More detailed seasonal weather projections can be found on the Queensland Future Climate Dashboard. In the example below, Cairns Regional Council area might expect an extra 0.1mm per day by 2070, with the 10th to 90th percentile range from a decline (-0.2mm per day) to a small increase (0.2mm per day.

Extract of precipitation data

Local government council	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Cairns Regional	1.2	0.0 (-0.2 – 0.2)	0.1 (-0.2 – 0.2)

Sea-level rise

Sea-level rise information has been calculated for all the coastal local councils in Australia and is available from CoastAdapt (NCCARF 2017). Where applicable, we provide the sea-level rise information for each coastal council in each HHS. We present the mean increase in sea level for four time periods (2030, 2050, 2070 and 2090) for each emissions scenarios (RCP4.5 and RCP8.5). The increases are relative to actual sea level in the period 1986-2005. We also include a measure of an 'allowance'. This is the height defences would need to be raised to provide similar protection to current recent history.

In the example below, the Cairns Regional Council might expect sea level to rise by about 0.13m by 2030, and by 0.24m by 2050. In response, the council would need to raise any sea protections (e.g. sea wall) by 0.14m by 2030 to get similar protection from sea inundation to recent time (1986-2005).

Again, note that when we say 2030, we are talking about two decades 2020-2039 around that year, and similarly '2070' refers to 2060-2079.

Box 2*. Continued*

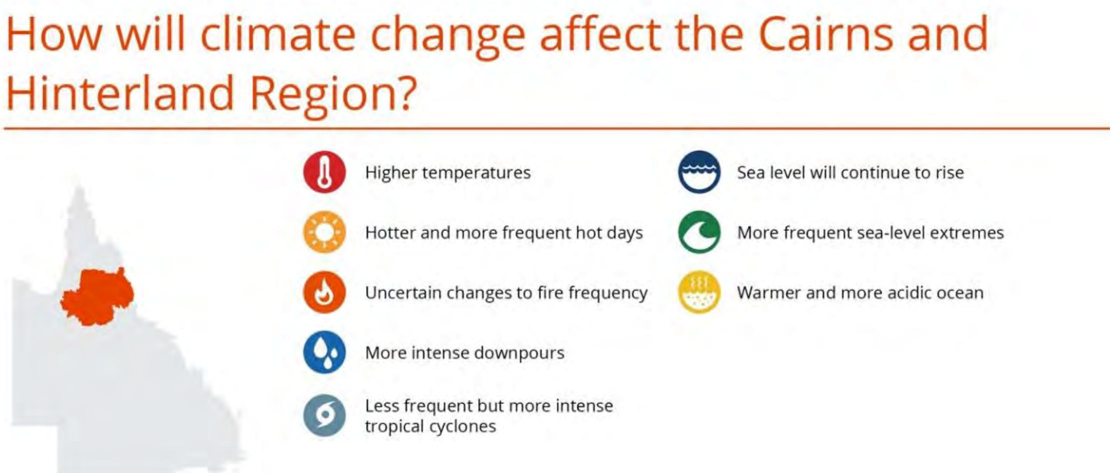
Extract of sea level rise data table

Date	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.13 (09-0.18)	0.14
2050 (m)	0.24 (0.16-0.32)	0.26

Sea-level rise
The *average* projected increase in sea level shown in metres. In brackets is the 66%confidence that the increase will fall within this range.

Allowance
The height (in metres) that coastal defences would need to be raised to provide the same level of protection they do today. It reflects the expected change in extreme events (storm surges) due to higher sea levels.

4.1 Cairns and Hinterland



Far North Queensland is centred on the coastal city of Cairns. The Cairns and Hinterland HHS region includes Cairns Regional, Cassowary Coast Regional, Croydon Shire, Douglas Shire, Etheridge Shire, Mareeba Shire, Tablelands Regional, Yarrabah Aboriginal Shire and Wujal Wujal Aboriginal Shire Councils.

4.1.1 Current climate

The Cairns and Hinterland HHS region has a diversity of climates based on distance from the coast and elevation. Closer to the coast, in the Wet Tropics region, it is hot and humid with a distinct wet season (December–March) and dry season (April–November). Further west to the Gulf region, in the wet-dry tropics (savanna) it is generally hot to very hot throughout the year.

The current average annual temperature is in the range 24-26 °C, with the warmer average for the more western parts of the region. The December to February average temperature is 27-30 °C; for July to August, the average is 20-22 °C.

Annual average rainfall is 1085 mm for the coast and Atherton Tablelands, reducing to 751 mm further west in the Etheridge and Croydon regions. Most rainfall occurs during a distinct hot and humid wet season (November-March), generated in moist onshore south-east trade winds, monsoonal lows and tropical cyclones. Annual and seasonal average rainfall is variable across the whole region, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño–Southern Oscillation.

Tropical cyclones occur from November to April, although the risk is greatest between January and March.

4.1.2 Climate projections

This section provides plausible scenarios of the future climate for the Cairns and Hinterland region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in this first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as “worst case”. In climate modelling terms, the changes outlined in this second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Temperature Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking. In the near future (2030), the annually averaged maximum temperature for the Cairns and Hinterland region is projected to increase as much as 2.0 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.4 °C warmer on average (Table 1). By 2070, the increase in average maximum daily temperatures above the recent climate (1986–2005) by at least 0.2 °C, and as much as 2.7 °C (Table 1). Nights are projected to also be at least 0.6 °C warmer and as much as 2.8 °C warmer.	**Temperature** Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for RCP4.5. Annual average maximum temperatures for the Cairns and Hinterland HHS region for this high emissions scenario are projected to increase by at least 0.1 °C, and as much as 2.8 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.5 – 2.3 °C warmer on average (Table 2). By 2070, there is considerable divergence between temperatures for the high and low emissions scenarios. For this high emissions scenario, the projected increase in average maximum daily temperatures across the region is at least 1.2 °C, with some models showing as much as 3.6 °C above the recent climate (1986–2005) (Table 2). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 1:** Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Cairns and Hinterland region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Cairns Regional	20.1	27.3	0.8 (0.5 – 1.1)	0.7 (0.5 – 1.1)	1.4 (1.0 – 2.0)	1.5 (1.0 – 2.1)
Cassowary Coast Regional	20.4	26.9	0.8 (0.5 – 1.2)	0.8 (0.5 – 1.1)	1.5 (1.0 – 2.1)	1.6 (1.0 – 2.1)
Croydon Shire	20.1	32.5	0.9 (0.5 – 1.4)	1.0 (0.2 – 2.0)	1.0 (1.1 – 2.4)	1.7 (0.7 – 2.7)
Douglas Shire*	21.0	26.9	0.7 (0.5 – 1.2)	1.0 (0 – 1.8)	2.0 (1.2 – 2.8)	1.9 (0.6 – 2.6)
Etheridge Shire	18.2	30.6	0.8 (0.5 – 1.3)	1.0 (0.3 – 1.9)	0.9 (0.6 – 1.3)	1.0 (0.2 – 1.8)
Mareeba Shire	19.4	30.9	0.8 (0.5 – 1.3)	1.0 (0.5 – 1.8)	1.6 (1.1 – 2.2)	1.7 (0.9 – 2.7)
Tablelands Regional	17.2	25.7	0.8 (0.5 – 1.2)	0.9 (0.6 – 1.4)	1.5 (1.0 – 2.1)	1.7 (1.0 – 2.5)
Yarrabah Aboriginal Shire	23.0	27.3	0.7 (0.5 – 1.1)	0.7 (0.4 – 1.1)	1.4 (1.0 – 1.9)	1.4 (0.9 – 1.9)

*Includes Wujal Wujal Aboriginal Shire

Hotter and more frequent hot days

There is likely to be a handful of extra days over 35 °C in coastal parts, while western areas in the region are likely to experience 46 to 70 days over 35 °C by 2070. Some parts will experience just a few additional days over 40 °C, while other parts can expect 1- 3 weeks extra of days over 40 °C (Table 3).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 2:** Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Cairns and Hinterland region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Cairns Regional	20.1	27.3	0.8 (0.5 – 1.1)	0.9 (0.5 – 1.1)	2.4 (1.8 – 3.1)	2.6 (2.0 – 3.2)
Cassowary Coast Regional	20.4	26.9	0.8 (0.5 – 1.1)	0.9 (0.5 – 1.2)	2.4 (1.9 – 3.2)	2.6 (2.0 – 3.3)
Croydon Shire	20.1	32.5	1.01 (0.5 – 1.4)	1.0 (0.1 – 1.8)	3.0 (2.1 – 3.8)	2.6 (1.2 – 3.5)
Douglas Shire*	21.0	26.9	0.8 (0.5 – 1.0)	0.9 (0.5 – 1.3)	2.3 (1.8 – 3.0)	2.5 (2.0 – 3.2)
Etheridge Shire	18.2	30.6	0.9 (0.6 – 1.3)	1.0 (0.2 – 1.8)	2.8 (2.1 – 3.6)	2.6 (1.4 – 3.5)
Mareeba Shire	19.4	30.9	0.9 (0.6 – 1.2)	1.0 (0.5 – 1.6)	2.7 (2.0 – 3.5)	2.6 (1.7 – 3.4)
Tablelands Regional	17.2	25.7	0.9 (0.6 – 1.1)	1.0 (0.5 – 1.6)	2.5 (2.0 – 3.3)	2.7 (1.9 – 3.5)
Yarrabah Aboriginal Shire	23.4	27.3	0.7 (0.5 – 1.1)	0.7 (0.4 – 1.9)	2.2 (1.7 – 2.9)	2.3 (1.8 – 3.0)

*Includes Wujal Wujal Aboriginal Shire

Many more hot days and an increase in very hot days.

There is likely to be anything from 12 to over 100 extra days over 35 °C by 2070. western parts of the region will be particularly impacted, with Croydon Shire likely to experience days over 35 °C for three quarters of the year by 2070. Some parts of the region will experience a few additional days over 40°C, while western parts such as might expect in the order of 16-39 extra days over 40 °C (Table 4).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 3**: Average number of projected additional days over 35 °C and 40 °C for Cairns and Hinterland region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		***Increase*** **in mean annual number of days for 2030**		***Increase*** **in mean annual number of days for 2070**	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Cairns Regional	2.2	0	3.8 (0.2 – 5.9)	0.1 (0– 0.3)	12.9 (3.8 – 25.4)	0.1 (0 – 0.2)
Cassowary Coast Regional	2.7	0	5.1 (0.8 – 8.8)	0.2 (0 – 0.5)	15.9 (4.4 – 29.7)	0.4 (0 – 0.6)
Croydon Shire	142.4	8.9	36.6 (2.6 – 71.3)	0.1 (0 – 0.4)	70.1 (26.2 – 129.4)	22.1 (6.6 – 42.4)
Douglas Shire*	0.8	0	1.5 (-0.2 – 2.7)	0 (0 – 0.1)	4.9 (0.6 – 9.8)	0 (0 – 0.1)
Etheridge Shire	84.4	3.3	26.3 (5.1 – 48.6)	3.9 (1.4 – 7.0)	50.1 (17.7 – 80)	10.1 (3.6 – 19.2)
Mareeba Shire	67.5	1.3	23.7 (9.6 – 43.6)	2.4 (0.9 – 4.8)	46.4 (17.8 – 75.8)	7.1 (2.5 – 14.9)
Tablelands Regional	2.9	0.1	2.5 (0.8 – 4.4)	0.1 (0 – 0.3)	2.8 (2.1 – 1.6)	0.4 (0.1 – 1.0)
Yarrabah	2.0	0	4.0 (0.3 – 6.7)	0.1 (0 – 0.3)	15.3 (4.3 – 28.4)	0.1 (0 – 0.2)

*Includes Wujal Wujal Aboriginal Shire

The region will experience an increase in length, peak temperatures and frequency of heatwaves

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with a doubling of the days in a year under heatwave conditions (Table 5). By 2070 the average hottest temperature in a heatwave is expected to increase by 10.5 - 1.6°C across the region. Individual heatwave events are likely to last 1.8 – 4.5 days longer. The total number of days in the year that are heatwave days could increase at least threefold, and more in some areas (Table 5).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 4**: Average number of projected additional days over 35 °C and 40 °C for Cairns and Hinterland region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		***Increase*** **in mean annual number of days for 2030**		***Increase*** **in mean annual number of days for 2070**	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Cairns Regional	2.2	0	4.7 (0.5 – 9.0)	0.1 (0 – 0.3)	12.9 (3.8 – 25.4)	0.1 (0 –0.2)
Cassowary Coast Regional	2.7	0	5.8 (0.2 – 11.5)	0.1 (-0.1 – 0.5)	43.9 (23.9 – 73.8)	2.4 (0.2 – 5.5)
Croydon Shire	142.4	8.9	37.3 (-0.7 – 67.7)	10.6 (4.6 – 19.1)	109.7 (4.7 – 23.9)	38.7 (14.5 – 66.8)
Douglas Shire*	0.8	0	1.7 (0 – 3.7)	0 (0 – 0)	18.2 (6.2 – 39.0)	0.2 (0 – 0.8)
Etheridge Shire	84.4	3.3	26.9 (3.2 – 45.0)	4.5 (2.2 – 7.8)	79.7 (43.9 – 123.1)	20.3 (7.7 – 33.6)
Mareeba Shire	67.5	1.3	24.6 (9.1 – 40.3)	2.9 (1.0 – 4.9)	79.7 (46.5 – 121.8)	16.0 (6.9 – 25.6)
Tablelands Regional	2.9	0.1	2.8 (0.9 –5.3)	0.2 (0 – 0.5)	14.2 (6 – 28.8)	1.6 (0.3 –3.6)
Yarrabah	2.0	0	4.7 (1.0 – 9.0)	0 (0 – 0.2)	51.6 (26.7 – 89.2)	0.6 (0 –2.0)

*Includes Wujal Wujal Aboriginal Shire

The region will experience an increase in length, peak temperatures and frequency of heatwaves

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with a doubling of the days in a year that are under heatwave conditions (Table 5). By 2070 the average hottest temperatures in a heatwave may have increased by 1.1 - 2.2 °C. Heatwave events are likely to last 5 to 20 days longer. The total number of days in the year that are heatwave days could increase by at least four times as long, and longer in some areas.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 6**: Average change in peak temperature, frequency and duration of heatwaves for the Cairns and Hinterland region under a moderate emissions scenario. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt. area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days
Cairns Regional	35.2	1.8	4.4	0.2 (-0.7 – 0.9)	2.0 (0.7 – 3.1)	0.7 (-1.0 – 1.4)	0.7 (-0.7 – 1.2)	9.6 (2.1 – 19.8)	2.7 (0.9 – 5.4)
Cassowary Coast	35.5	1.8	4.4	0.4 (-0.5 – 1.4)	2.3 (0.9 – 3.7)	0.9 (0 – 1.8)	0.8 (-0.6 – 1.5)	9.1 (2.2 – 17.7)	3.2 (0.9 – 5.5)
Croydon Shire	40.8	2.4	4.7	0.4 (-0.1 – 1.0)	2.3 (0.5 – 4.1)	0.7 (0.2 – 1.4)	1.0 (0.4 – 1.7)	6.8 (2.2 – 13.8)	2.8 (1.4 – 6.0)
Douglas Shire**	35.7	2.4	4.5	0.7 (0.1 – 2.4)	2.1 (0.8 – 5.1)	0.7 (0.2 – 2.1)	1.6 (0.7 – 2.8)	6.4 (2.2 – 10.5)	2.0 (0.8 – 3.3)
Etheridge Shire	39.3	2.0	4.3	0.3 (-0.3 – 0.9)	2.0 (0.4 – 3.6)	0.5 (0.2 – 1.5)	1.0 (0.1 – 1.8)	6.5 (2.1 – 13.3)	2.0 (1.2 – 3.8)
Mareeba Shire	38.4	1.8	4.3	0.3 (-0.3 – 1.0)	12.0 (0.5 – 4.0)	0.6 (0 – 1.7)	1.0 (-0.4 – 1.9)	6.4 (2.0 – 12.0)	1.8 (0.6 – 2.8)
Tablelands Regional	35.0	1.8	4.2	0.3 (-0.5 – 1.0)	1.7 (0.5 – 2.8)	0.5 (-0.1 – 1.3)	1.0 (-0.4 – 1.9)	6.4 (2.0 – 12.0)	1.8 (0.6 – 2.8)
Yarrabah	35.2	1.8	4.6	0 (-1.0 – 1.0)	2.8 (0.7 – 4.4)	0.8 (0 – 2.2)	0.5 (-0.9 – 1.1)	12.1 (2.3 – 23.1)	4.5 (1.3 – 9.7)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year
**Includes Wujal Wujal Aboriginal Shire

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 6**: Average change in peak temperature, frequency and duration of heatwaves for the Cairns and Hinterland region under a high emissions scenario. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days
Cairns Regional	35.2	1.8	4.4	0 (-0.5 – 0.4)	2.0 (0.7 – 3.1)	0.7 (-0.1 – 1.4)	1.4 (0.1 – 2.6)	28.9 (17 – 44)	12.8 (3.1 – 29.4)
Cassowary Coast	35.5	1.8	4.4	0.2 (-0.8 – 0.8)	2.7 (0.8 – 5.8)	0.9 (0.1 – 1.8)	1.7 (0.3 – 2.5)	26.4 (15.7 – 40.3)	12.4 (3.6 – 23.5)
Croydon Shire	40.8	2.4	4.7	0.4 (0 – 0.8)	2.8 (1.0 – 4.5)	1.1 (0.3 – 1.8)	1.8 (1.1– 2.8)	15.9 (6.2 – 25.5)	6.0 (3.4 – 10.7)
Douglas Shire**	35.7	2.4	4.5	0.6 (-0.3 – 1.5)	2.3 (0.6 – 4.1)	0.8 (-0.2 – 1.8)	1.1 (0 – 2.6)	30.7 (17.5 – 47.6)	14.7 (3.3 – 37.9)
Etheridge Shire	39.3	2.0	4.3	0.4 (-0.2 – 1.0)	2.3 (0.7 – 3.7)	0.8 (0.2 – 1.6)	1.9 (0.9 – 3.2)	18.4 (6.7 – 34.3)	5.5 (3.2 – 11.4)
Mareeba Shire	38.4	1.8	4.3	0.5 (0 – 1.0)	2.6 (0.9 – 4.4)	1.0 (0.3– 2.4)	1.8 (0.8 – 3.4)	21.5 (8.4 – 41.2)	6.9 (3.6 – 15.8)
Tablelands Regional	35.0	1.8	4.2	0.5 (-0.4 – 0.9)	2.3 (0.6 – 4.7)	0.8 (-0 – 1.8)	2.2 (0.7 – 4.2)	21.0 (9.8 – 36.2)	6.8 (2.5 – 15.5)
Yarrabah	35.2	1.8	4.6	-0.2 (-1.0 – 0.32)	3.3 (1.07 –5.8)	0.9 (0– 2.4)	1.4 (-0.5 – 2.2)	32.3 (20.4 – 46.6)	19.5 (5.6 – 42.4)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year
**Includes Wujal Wujal Aboriginal Shire

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Humidity

The Cairns and Hinterland region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 7).

***Table 7**: Average change in humidity for the summer months in Cairns and Hinterland under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Cairns Regional	92	-0.3 (-1.1 – 0.2)	-0.2 (-1.1 – 0.2)
Cassowary Coast Regional	91.9	-0.2 (-1.0 – 0.2)	-0.3 (-1.3 – 0.1)
Croydon Shire	79.3	-1.1 (-9.0 – 1.9)	-0.7 (-8.4 – 1.9)
Douglas Shire*	91.9	-0.4 (-1.9 – 0.4)	-0.3 (-1.7 – 0.5)
Etheridge Shire	79.9	-1.2 (-8.0 – 1.6)	-0.8 (-6.0 – 1.3)
Mareeba Shire	83.6	-1.1 (-6.6 – 1.0)	-1.1 (-7.7 – 1.4)
Tablelands Regional	88.7	-1.1 (-4.1 – 0.6)	-1.2 (-6.2 – 0.6)
Yarrabah Aboriginal Shire	87.3	-0.1 (-0.9 – 0.3)	0 (-0.9 – 0.4)

*Includes Wujal Wujal Aboriginal Shire

Fire weather

Uncertain changes to fire frequency

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Humidity

The Cairns and Hinterland region can expect a slight decrease in humidity for the year as a whole.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 8).

***Table 8**: Average change in humidity for the summer months in Cairns and Hinterland under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Cairns Regional	92	-0.2 (-0.8 – 0.5)	-0.4 (-1.5 – 0.1)
Cassowary Coast Regional	91.9	-0.2 (-0.9 – 0.4)	-0.4 (-1.6 – 0.1)
Croydon Shire	79.3	-0.7 (-6.1 – 1.4)	-0.3 (-6.4 – 3.0)
Douglas Shire*	91.9	-0.3 (-1.3 – 0.4)	-0.5 (-1.7 – 0.2)
Etheridge Shire	79.9	-0.9 (-8.5 – 1.5)	-0.5 (-6.0 – 2.4)
Mareeba Shire	83.6	-0.5 (-7.9 – 4.1)	0.6 (-8.6 – 7.7)
Tablelands Regional	88.7	-1.1 (-4.28 – 0.9)	-1.4 (-5.4 – 0.4)
Yarrabah Aboriginal Shire	87.3	-0.2 (-1.2 – 0.6)	-0.2 (-1.4 – 1.2)

*Includes Wujal Wujal Aboriginal Shire

Fire weather

Uncertain changes to fire frequency

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

The primary driver of bushfires in the region is fuel availability, which varies mainly with rainfall and management. Rainfall projections for the region are uncertain, meaning there is no clear trend in projections of changes in fire weather at this stage. However, when and where fire does occur, its behaviour is likely to be more extreme (Table 9).

Table 9*: Average change in seasonal count of days in each level of fire risk in Cairns and Hinterland region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt. area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Cairns Regional	0	0	0	0 (-0.1 – 0.1)	0 (0 – 0)	0 (0 – 0)	0 (-0.1 – 0)	0 (0 – 0)	0 (0 – 0)
Cassowary Coast Regional	0	0	0	0 (-0.1 – 0.2)	0 (0 – 0)	0 (0 – 0)	0 (0 – 0.2)	0 (0 – 0)	0 (0 – 0)
Croydon Shire	118.1	76.2	2.6	0.6 (-7.0 – 12.1)	8.1 (-1.0 – 32.4)	0.9 (-0.2 – 3.1)	0.4 (-2.5 – 14.0)	11.8 (-3.1 – 39.4)	1.7 (-0.4 – 4.1)
Douglas Shire*	0.1	0	0	0.1 (-0.1 – 0.5)	0 (0 – 0)	0 (0 – 0)	0.5 (-0.1 – 0.2)	0 (0 – 0)	0 (0 – 0)
Etheridge Shire	101.2	55	1.6	3.9 (-6.2 – 15.8)	7.6 (-0.8– 26.6)	0.5 (-0.2 – 1.7)	4.1 (-5.8 – 16.4)	11.4 (-2.0 – 37.9)	1.5 (-0.2 – 3.9)
Mareeba Shire	88.9	38.9	0.6	5.8 (-0.1 – 16.8)	5.7 (-1.0 – 20.2)	0.3 (-0.2 – 0.9)	-5.1 (-15.1 – 11.2)	13.1 (-8.2 – 37.5)	5.3 (-1.2 – 12.6)
Tablelands Regional	17.7	2.6	0	3.4 (-0.3 – 12.2)	1.0 (-0.5 – 3.9)	0 (0 – 0.1)	5.1 (-0.4 – 20)	1.7 (-0.5 – 5.2)	0 (0 – 0.2)
Yarrabah Aboriginal Shire	0	0	0	0 (0 – 0)	0 (0 – 0)	0 (0 – 0)	0 (-0.1 – 0)	0 (0 – 0)	0 (0 – 0)

*Includes Wujal Wujal Aboriginal Shire

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

The primary driver of bushfires in the region is fuel availability, which varies mainly with rainfall and management. Rainfall projections for the region are uncertain, meaning there is no clear trend in projections of changes in fire weather at this stage. However, when and where fire does occur, its behaviour is likely to be more extreme (Table 10).

Table 10*: Average change in seasonal count of days in each level of fire risk in Cairns and Hinterland region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt. area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Cairns Regional	0	0	0	0 (-0.1 – 0.2)	0 (0 – 0)	0 (0 – 0)	0 (-0.1 – 0)	0 (0 – 0)	0 (0 – 0)
Cassowary Coast Regional	0	0	0	0 (-0.1 – 0.2)	0 (0 – 0)	0 (0 – 0)	0 (-0.1 – 0.1)	0 (0 – 0)	0 (0 – 0)
Croydon Shire	118.1	76.2	2.6	-0.9 (-17.9 – 20)	5.3 (-1.5 – 25)	0.7 (-0.3 – 2.7)	-2.4 (-17.9 – 20.1)	13.1 (-5.1 – 37.5)	2.0 (-0.2 – 5.2)
Douglas Shire*	0.1	0	0	0.1 (-0.1 – 0.5)	0 (0 – 0)	0 (0 – 0)	0.1 (-0.1 – 0.3)	0 (0 – 0)	0 (0 – 0)
Etheridge Shire	101.2	55	1.6	2.1 (-11.9 – 13.5)	4.6 (-0.5 - 19.8)	0.6 (-0.2 – 2.5)	4.8 (-11.9 – 13.5)	11.1 (-5.0 – 30.9)	1.7 (-0.1 – 4.8)
Mareeba Shire	88.9	38.9	0.6	3.8 (-3.4 – 14.9)	4.5 (-0.1 – 16.5)	0.2 (-0.1 – 0.6)	7.9 (-2.5 – 16.2)	9.2 (-2.7 – 21.5)	0.7 (-0.1 – 2.3)
Tablelands Regional	17.7	2.6	0	3.0 (-0.8 – 12.2)	0.9 (-0.5 – 3.0)	0 (0 – 0.1)	6.4 (-0.6 – 12.8)	2.5 (-0.5 – 5.2)	0.1 (0 – 0.2)
Yarrabah Aboriginal Shire	0	0	0	0 (-0.1 – 0.2)	0 (0 – 0)	0 (0 – 0)	0 (0 – 0)	0 (0 – 0)	0 (0 – 0)

*Includes Wujal Wujal Aboriginal Shire

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Rainfall

More intense downpours

Natural variability (e.g. due to El Niño and La Niña) is likely to remain the major factor influencing rainfall changes in the next few decades. Projections of rainfall change for 2070 continue to show a large amount of variability, but there may be slight declines in winter (western parts of the region only) and spring (whole region) rainfall by the end of the century. The intensity of heavy rainfall events is likely to increase in the Wet Tropics region.

***Table 11**: Average change in precipitation for Cairns and Hinterland under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Cairns Regional	10.5	-0.4 (-1.5 – 0.9)	-0.42 (-1.7 – 0.4)
Cassowary Coast Regional	10.6	-0.4 (-1.3 – 0.5)	-0.4 (-1.9 – 0.3)
Croydon Shire	2.6	0 (-0.5 – 0.4)	0.1 (-0.4 – 0.3)
Douglas Shire*	7.7	-0.5 (-1.5 – 0.5)	-0.4 (-1.3 – 0.3)
Etheridge Shire	2.4	0 (-0.5 – 0.3)	0 (-0.3 – 0.3)
Mareeba Shire	3.2	-0.1 (-0.5 – 0.2)	-0.1 (-0.6 – 0.2)
Tablelands Regional	6.8	-0.3 (-3.1 – 1.2)	0.1 (-3.4 – 1.2)
Yarrabah Aboriginal Shire	1.6	0.1 (-0.3 – 0.4)	0.1 (-0.2 – 0.3)

*Includes Wujal Wujal Aboriginal Shire

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Rainfall

More intense downpours

Natural variability (e.g. due to El Niño and La Niña) is likely to remain the major factor influencing rainfall changes in the next few decades. Projections of rainfall change for 2070 continue to show a large amount of variability, but there may be slight declines in winter (western parts of the region only) and spring (whole region) rainfall by the end of the century. The intensity of heavy rainfall events is likely to increase in the Wet Tropics region.

Table 12: Average change in precipitation *for Cairns and Hinterland under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Cairns Regional	10.5	-0.3 (-1.3 – 0.5)	-0.5 (-0.2 – 0.9)
Cassowary Coast Regional	10.6	-0.3 (-1.5 – 0.3)	-0.5 (-1.9 – 0.8)
Croydon Shire	2.6	0 (-0.4 – 0.3)	0.2 (-0.2 – 0.8)
Douglas Shire*	7.7	-0.4 (-1.1 – 0.1)	-0.4 (-1.4 – 0.3)
Etheridge Shire	2.4	0 (-0.4 – 0.4)	0.2 (-0.2 – 0.7)
Mareeba Shire	3.2	-0.1 (-0.4 – 0.1)	0 (-0.4 – 0.4)
Tablelands Regional	6.8	-0.4 (-2.7 – 0.5)	0.1 (-3.0 – 2.2)
Yarrabah Aboriginal Shire	1.6	0.1 (-0.3 – 0.4)	0.1 (-0.2 – 0.3)

*Includes Wujal Wujal Aboriginal Shire

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Tropical cyclones **Less frequent but more intense tropical cyclones** Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.	**Tropical cyclones** **Less frequent but more intense tropical cyclones** Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.
Sea level **Sea level will continue to rise** Sea level is projected to rise by as much as 0.66m above present-day levels by 2100. **More frequent sea-level extremes** Higher sea levels will increase the risks of coastal hazards such as storm tide inundation. **Warmer and more acidic ocean** Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide from the atmosphere, with acidification proportional to emissions growth.	**Sea level** **Sea level will continue to rise** Sea level is projected to rise by as much as 0.88m above present-day levels by 2100. **More frequent sea-level extremes** Higher sea levels will increase the risks of coastal hazards such as storm tide inundation. **Warmer and more acidic ocean** Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide from the atmosphere, with acidification proportional to emissions growth.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 13: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for a moderate emissions scenario RCP4.5 for the Cairns and Hinterland region. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised to provide the same level of protection as is experienced today.*

Year	**Cairns***	
	Sea-level rise (relative to average 1986-2005)	Allowance
2030 (m)	0.13 (09-0.18)	0.14
2050 (m)	0.24 (0.16-0.32)	0.26
2070 (m)	0.35 (0.24-0.48)	0.40
2090 (m)	0.48 (0.31-0.66)	0.57
Rate of change by 2100 (mm/year)	6.0 (3.2-8.8)	N/A

* Changes in sea levels projected for Cassowary Coast Regional and Douglas Shire are almost identical to those for Cairns Regional.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 14: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for a moderate emissions scenario RCP8.5 for the Cairns and Hinterland region. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised to provide the same level of protection as is experienced today.*

Year	**Cairns***	
	Sea-level rise (relative to average 1986-2005)	Allowance
2030 (m)	0.14 (09-0.18)	0.14
2050 (m)	0.27 (0.19-0.35)	0.29
2070 (m)	0.44 (0.31-0.58)	0.49
2090 (m)	0.65 (0.45-0.88)	0.79
Rate of change by 2100 (mm/year)	11.5 (7.4-16.3)	N/A

* Changes in sea levels projected for Cassowary Coast Regional and Douglas Shire are almost identical to those for Cairns Regional.

4.2 Central Queensland

How will climate change affect the Central Queensland Region?

- Higher temperatures
- Hotter and more frequent hot days
- Fewer frosts
- Harsher fire weather
- More intense downpours
- Changes to drought are less clear
- Sea level will continue to rise
- More frequent sea-level extremes
- Warmer and more acidic ocean

The Central Queensland HHS region extends from the coast to the central highland regions and includes the local government councils of Banana Shire, Central Highlands Regional, Gladstone Regional, Livingstone Shire, Rockhampton Regional and Woorabinda Aboriginal Shire.

4.2.1 Current climate

The Central Queensland HHS region has a sub-tropical climate with hot, moist summers and warm, dry winters, with occasional frost in the south.

The average daily maximum temperature in summer (Dec – Feb) range from 29.8 °C in Livingstone Shire to 31.3 °C in the Central Highlands region with winter daytime maximums averaging 21.9 to 22.8 °C. Overnight average minimum temperature in summer range from 20 °C in the Banana Shire to 22.2 °C in Livingstone Shire, with winter minimums falling to 10.5 to 14.3 °C.

Annual and seasonal average rainfall is variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño–Southern Oscillation. Annual average rainfall is 277 mm, with the greatest falls in summer.

4.2.2 Climate projections

This section provides plausible scenarios of the future climate for the Central Queensland region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Temperature Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking. In the near future (2030), the annually averaged maximum temperature for the Central Queensland region is projected to increase by at least 0.4 °C, and as much as 2.0 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.4 °C warmer on average (Table 15). By 2070, the increase in average maximum daily temperatures above the recent climate (1986–2005) by at least 1.0 °C, and as much as 3.4 °C (Table 15). Nights are projected to also be at least 1.1 °C warmer and as much as 2.5 °C warmer.	**Temperature** Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for RCP4.5. In the near future (2030), annual average maximum temperatures for the Central Queensland region for this high emissions scenario are projected to increase by at least 0.2 °C, and as much as 2.0 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.5 – 1.4 °C warmer on average (Table 16). By 2070, there is considerable divergence between temperatures for the high and low emissions scenarios. For this high emissions scenario, the projected increase in average maximum daily temperatures across the region is at least 1.6 °C, with some models showing as much as 4.2 °C above the recent climate (1986–2005) (Table 16). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 15: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Central Queensland region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Banana Shire	15.3	27.3	0.9 (0.5 – 1.3)	1.1 (0.5 – 1.8)	1.8 (1.2 – 2.4)	2.1 (1.0 – 3.4)
Central Highlands Regional	15.9	27.9	0.9 (0.6 – 1.4)	1.1 (0.5 – 2.0)	1.8 (1.2 – 2.5)	2.1 (0.8 – 3.2)
Gladstone Regional	17.1	26.3	0.9 (0.5 – 1.2)	0.9 (0.5 – 1.7)	1.7 (1.1– 2.3)	1.8 (1.1 – 3.0)
Livingstone Regional	18.3	26.7	0.9 (0.5 – 1.3)	0.91 (0.4 – 1.7)	1.67 (1.1 – 2.3)	1.73 (1.0 – 2.6)
Rockhampton Regional	17.1	27.2	0.9 (0.6 – 1.3)	1.0 (0.4 – 1.9)	1.7 (1.2 – 2.4)	1.9 (1.0 – 3.0)
Woorabinda Aboriginal Shire	16.3	28.0	0.9 (0.5 – 1.3)	1.1 (0.4 – 2.0)	1.8 (1.2 – 2.5)	2.0 (0.8 – 3.4)

Hotter and more frequent hot days

There is likely to be doubling of the number of days over 35 °C across the region by 2070. Days over 40 °C show a doubling by 2030 with 3 times as many days over 40 °C by 2070 (Table 17).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 16: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Central Queensland region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Banana Shire	15.3	27.3	1.0 (0.6 – 1.3)	1.0 (0.4 – 1.9)	3.0 (2.2 – 3.9)	3.1 (1.7 – 4.2)
Central Highlands Regional	15.9	27.9	1.0 (0.6 – 1.4)	1.1 (0.2 – 2.0)	3.1 (2.2 – 4.0)	3.0 (1.6 – 4.1)
Gladstone Regional	17.1	26.3	0.9 (0.6 – 1.3)	0.9 (0.5 – 1.8)	2.8 (2.1 – 3.7)	2.8 (1.9 – 3.7)
Livingstone Regional	18.3	26.7	0.9 (0.5 – 1.3)	0.9 (0.4 – 1.6)	2.8 (2.1 – 3.6)	2.7 (1.8 – 3.6)
Rockhampton Regional	17.1	27.2	1.0 (0.6 – 1.3)	0.9 (0.3 – 2.0)	2.9 (2.1 – 3.8)	2.9 (1.8 – 3.8)
Woorabinda Aboriginal Shire	16.3	28.0	1.0 (0.6 – 1.3)	1.0 (0.2 – 2.0)	3.1 (2.2 – 4.0)	3.0 (1.6 – 4.2)

Many more hot days and an increase in very hot days.

For this high emissions scenario, by 2070 there is likely to be about more than double the number of days over 35 °C. There will a greater increase in days over 40 °C by 2070 with projections showing 5-9 times as many extremely hot days (Table 18).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 17**: Average number of projected additional days over 35 °C and 40 °C for the Central Queensland region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		***Increase*** in mean annual number of days for 2030		***Increase*** in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Banana Shire	29	1.0	13.9 (3.5 – 32.7)	1.1 (-0.6 – 2.6)	31.1 (8.5 – 59.0)	3.8 (0.7 – 10.3)
Central Highlands Regional	46.1	2.4	17.9 (5.5 – 41.7)	2.3 (-0.1 – 5.7)	36.6 (7.9 – 62.6)	7.2 (2.3 – 14.6)
Gladstone Regional	2.1	0.1	2.2 (0.1 – 5.6)	0.1 (0 – 0.4)	5.8 (2.2 – 11.7)	0.3 (0 – 0.8)
Livingstone Regional	5.7	0.1	5.6 (2.2 – 13.6)	0.4 (0 – 1.4)	13.9 (4.7 – 24.9)	1.1 (0.3 – 3.9)
Rockhampton Regional	16.6	0.5	9.7 (1.9 – 25.1)	0.8 (-0.2 – 2.2)	22.1 (7.9 – 39.8)	2.1 (0.4 – 4.3)
Woorabinda Aboriginal Shire	42.5	1.7	17.3 (4.4 – 43.5)	1.6 (-0.3 – 4.6)	36.2 (8.3 – 65.7)	5.3 (1.2 – 12.0)

The Central Queensland region will experience an increase in length, peak temperatures and frequency of heatwaves.

Increasing temperatures will result in more frequent, warmer and longer heatwave conditions (Table 19).

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with a doubling of the days in a year under heatwave conditions.

By 2070 the average hottest temperature in a heatwave is expected to increase by 1.5 - 1.6°C across the region. Individual heatwave events are likely to last 1.3 – 2 days longer. The total number of days in the year that are heatwave days could increase fourfold.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 18**: Average number of projected additional days over 35 °C and 40 °C for the Central Queensland region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		***Increase*** in mean annual number of days for 2030		***Increase*** in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Banana Shire	29	1.0	14.3 (4.8 – 31.1)	1.1 (0.1 – 2.8)	48.4 (18.8 – 73.3)	8.9 (2.3 –19.5)
Central Highlands Regional	46.1	2.4	18.5 (4.6 – 39.3)	2.5 (0.8 – 5.3)	54.7 (20.7 – 79.2)	16.0 (5.0 – 30.1)
Gladstone Regional	2.1	0.1	1.9 (0.6 – 4.6)	0.1 (0 – 0.2)	13.8 (4.7 – 23.9)	0.6 (0 – 1.9)
Livingstone Regional	5.7	0.1	5.2 (1.1 – 10.8)	0.3 (0 – 0.7)	30 (13.5 – 45.9)	3.8 (0.7 – 9.7)
Rockhampton Regional	16.6	0.5	9.0 (1.9 – 23.1)	0.6 (-0.1 – 1.5)	38.8 (16.3 – 56.5)	5.4 (1.5 – 12.1)
Woorabinda Aboriginal Shire	42.5	1.7	17.4 (4.0 – 41.4)	1.7 (0.3 – 3.6)	55.1 (21.2 – 83.2)	13.1 (4.4 – 26.5)

The Central Queensland region will experience an increase in length, peak temperatures and frequency of heatwaves.

Heatwaves are expected to reach higher temperatures, last longer and happen more frequently (Table 20).

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with a doubling of the days in a year that are under heatwave conditions.

By 2070 the average hottest temperatures in a heatwave may have increased by 2.3°C. Heatwave events are likely to last 3 days longer. The total number of days in the year that are heatwave days could increase sevenfold.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 19**: Average change in peak temperature, frequency and duration of heatwaves for the Central Queensland region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days
Banana Shire	38.5	2.6	4.8	0.4 (-0.8 – 1.9)	2.0 (0.3 – 4.1)	0.5 (-0.1 – 1.4)	1.4 (0.4 – 3.1)	6.0 (1.6 – 11.5)	1.3 (-0.1 – 2.5)
Central Highlands Regional	39.7	2.7	4.7	0.4 (-0.7 – 1.7)	2.3 (0.4 – 4.5)	0.5 (-0.1 – 1.3)	1.4 (0.3 – 2.9)	6.5 (1.2 – 11.9)	1.6 (0.5 – 2.8)
Gladstone Regional	34.2	2.2	4.6	0.3 (-0.6 – 1.8)	1.9 (0.2 – 4.4)	0.8 (-0.1 – 2.1)	1.0 (0.3 – 2.1)	5.9 (2.5 – 10.6)	1.8 (0.7 – 3.7)
Livingstone Regional	35.7	2.4	4.5	0.7 (0.1 – 2.4)	2.1 (0.8 – 5.1)	0.7 (0.2 – 2.1)	1.6 (0.7 – 2.8)	6.4 (2.2 – 10.5)	2.0 (0.8 – 3.3)
Rockhampton Regional	37.6	2.5	4.6	0.5 (-0.4 – 3.1)	1.8 (0.5 – 4.8)	0.5 (0 – 1.7)	1.6 (0.3 – 3.3)	5.5 (1.9 – 9.8)	1.4 (0.7 – 2.8)
Woorabinda Aboriginal Shire	39.6	2.7	4.7	0.3 (-0.7 – 2.0)	2.1 (0.4 – 4.4)	0.6 (0.1 – 1.5)	1.6 (0.5 – 3.0)	6.1 (1.6 – 11.5)	1.5 (0.5 – 2.9)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.

$^{\alpha}$Number of heatwave days relative to number of days in year

$^{\phi}$Average duration in days of all heatwave events in year

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 20**: Average change in peak temperature, frequency and duration of heatwaves for the Central Queensland region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days
Banana Shire	38.5	2.6	4.8	0.4 (-0.4 – 1.3)	2.1 (0.5 – 3.9)	0.4 (-1.0 – 1.3)	2.4 (0.9 – 4.0)	14.7 (7.1 – 26.1)	3.4 (1.5 – 6.6)
Central Highlands Regional	39.7	2.7	4.7	0.5 (-0.6 – 1.6)	2.5 (0.2 – 4.7)	0.6 (-0.6 – 1.4)	2.4 (0.5 – 3.9)	15.5 (7.3 – 26.2)	3.8 (1.7 – 7.2)
Gladstone Regional	34.2	2.2	4.6	0.4 (-0.3 – 0.9)	2.1 (0.6 – 4.2)	0.7 (-0.2 – 2.1)	1.9 (1.0– 3.0)	17.6 (7.2 – 30.3)	5.8 (2.1 – 12.2)
Livingstone Regional	35.7	2.4	4.5	0.6 (-0.3 – 1.5)	2.3 (0.6 – 4.1)	0.8 (-0.2 – 1.8)	2.8 (1.6 – 4.7)	18.9 (9.7 – 32.5)	7.0 (3.8 – 14.8)
Rockhampton Regional	37.6	2.5	4.6	0.6 (-0.6 – 1.9)	1.9 (0.3 – 4.7)	0.6 (-0.3 – 1.7)	2.9 (1.2 – 5.1)	15.9 (6.7 – 29.0)	4.3 (1.9 – 8.9)
Woorabinda Aboriginal Shire	39.6	2.7	4.7	0.5 (-0.5 – 1.6)	2.3 (0.5 – 4.6)	0.6 (-0.6 – 1.4)	2.6 (0.8 – 4.7)	15.0 (7.2 – 26.5)	3.7 (1.9 – 7.1)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.

$^{\alpha}$Number of heatwave days relative to number of days in year

$^{\phi}$Average duration in days of all heatwave events in year

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Frost days

A substantial decrease in the frequency of days with a risk of a frost is projected by the end of the century.

Humidity

The Central Queensland region can expect a slight decrease in relative humidity during summer. In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 21).

***Table 21**: Average change in humidity for the summer months in Central Queensland under a moderate emissions scenario (RCP 4.5). The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't. area	Relative humidity % Historical annual average (1986-2005)	Relative humidity % Change in mean annual relative humidity 2030	Relative humidity % Change in mean annual relative humidity 2070
Banana Shire	77.1	-1.2 (-8.5 – 1.3)	-1.4 (-6.8 – 1.2)
Central Highlands Regional	76.9	-1.6 (-10.6 – 1.2)	-1.7 (-7.9 – 1.8)
Gladstone Regional	86.2	-1 (-7.8 – 1.9)	-1.1 (-5.9 – 0.4)
Livingstone Regional	86.0	-1 (-7.9 – 1.1)	-1.0 (-5.7 – 0.8)
Rockhampton Regional	83.2	-1.2 (-9.1 – 1.1)	-1.3 (-6.8 – 0.6)
Woorabinda Aboriginal Shire	79.4	-1.5 (-9.9 – 1.1)	-1.6 (-7.2 – 1.3)

Fire weather

Climate change will result in harsher fire weather. Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. The uncertainties in changes in rainfall mean it is difficult to project the magnitude of the change in fire weather (Table 23).

Frost days

A substantial decrease in the frequency of days with a risk of a frost days is projected by the end of the century.

Humidity

The Central Queensland region can expect a slight decrease in relative humidity during summer. In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 22).

***Table 22**: Average change in humidity for the summer months in Central Queensland under a high emissions scenario (RCP 8.5). The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Relative humidity % Historical annual average (1986-2005)	Relative humidity % Change in mean annual relative humidity 2030	Relative humidity % Change in mean annual relative humidity 2070
Banana Shire	77.1	-0.2 (-5.0 – 1.9)	-0.4 (-6.0 – 3.2)
Central Highlands Regional	76.9	-0.6 (-6.5 – 1.8)	-0.7 (-5.9 – 2.8)
Gladstone Regional	86.2	-0.3 (-5.5 – 1.5)	-0.7 (-5.3 – 2.4)
Livingstone Regional	87.3	-0.2 (-4.9 – 1.1)	-0.7 (-4.3 – 1.7)
Rockhampton Regional	87.3	-0.3 (-6.2 – 1.5)	-0.9 (-5.4 – 1.7)
Woorabinda Aboriginal Shire	87.3	-0.4 (-6.1 – 1.7)	-0.9 (-6.4 – 2.5)

Fire weather

Climate change will result in harsher fire weather. Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. The uncertainties in changes in rainfall mean it is difficult to project the magnitude of the change in fire weather (Table 24).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 23**: Average change in seasonal count of days in each level of fire risk in Central Queensland region for RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Banana Shire	59.1	9.3	0.1	9.0 (-1.3 – 29.5)	5.0 (0– 16.7)	0.1 (0 – 0.3)	14.9 (-1.5 – 43.1)	10.7 (0.4 – 39.5)	0.2 (0 – 0.9)
Central Highlands Regional	74.7	17.5	0.2	7.6 (-3.4 – 25.0)	8.6 (0.3 – 28.8)	0.2 (-0.1 – 0.6)	12.1 (-5.7 – 31.3)	15.6 (-0.9 – 46.2)	0.3 (-0.1 – 1.1)
Gladstone Regional	7.5	0.3	0	3.6 (-0.3 – 15.8)	0.1 (-0.2 – 1.0)	0 (0 – 0)	7.0 (0.2 – 29.6)	0.4 (0 – 1.6)	0 (0 – 0.1)
Livingstone Regional	17.7	1.3	0	5.2 (-0.7 – 21.0)	0.6 (-0.4 – 3.7)	0 (0 – 0.1)	7.6 (-0.9 – 24.1)	1.4 (0 – 4.9)	0 (0– 0.1)
Rockhampton Regional	36.8	3.9	0	10 (-3.4 – 37.2)	2.0 (-1.2 – 9.5)	0 (0 – 0.2)	15.3 (0.2 – 45.8)	4.5 (0.3 – 15.8)	0.1 (0 – 0.4)
Woorabinda Aboriginal Shire	66.8	12.7	0.1	8.5 (-3.6 – 31.4)	6.4 (0 – 25.1)	0.1 (-0.1 – 0.5)	13.0 (-6.0 – 38.5)	13.6 (0.2 – 45.2)	0.2 (-0.1 – 0.7)

Rainfall

More intense downpours and high natural variability (e.g. influence of El Niño and La Niña) is likely to remain the major factor influencing rainfall in the next few decades. Projections for 2070 show little change or a decrease, particularly in winter and spring. The intensity of heavy rainfall events is likely to increase.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 24**: Average change in seasonal count of days in each level of fire risk in Central Queensland region for RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Banana Shire	59.1	9.3	0.1	6.4 (-2.6 – 27.2)	2.9 (-2.1– 12.2)	0.1 (-0.1 – 0.2)	17.0 (-2.9– 45.3)	12.9 (1.1 – 33.1)	0.3 (0 – 0.8)
Central Highlands Regional	74.7	17.5	0.2	5.8 (-5.1 – 24.6)	5.2 (-1.3 – 22.6)	0.1 (-0.1 – 0.4)	13.3 (-6.8 – 36.9)	17.5 (-0.1 –41.7)	0.5 (0 – 1.3)
Gladstone Regional	7.5	0.3	0	2.5 (-0.5 – 15.5)	0.2 (-0.3 – 0.8)	0 (0 – 0)	8.5 (0.2 – 28)	0.5 (0– 1.2)	0 (0 – 0.1)
Livingstone Regional	17.7	1.3	0	2.6 (-2.0 – 16.9)	0.5 (-0.2 – 2.6)	0 (0 – 0)	9.6 (-1.3 – 28.1)	1.4 (0.1 – 5.5)	0 (0 – 0.1)
Rockhampton Regional	36.8	3.9	0	4.8 (-3.2 – 35.6)	1.5 (-0.5 – 8.0)	0 (0 – 0.1)	17.7 (-0.7 – 50)	6.1 (0.4 – 16.6)	0.12 (0 – 0.3)
Woorabinda Aboriginal Shire	66.8	12.7	0.1	5.3 (-7.6 – 30.3)	4.1 (-1.2 – 21)	0.1 (-0.1 – 0.2)	14.4 (-5.0 – 45.1)	15.9 (0.6 – 42.8)	0.2 (0 – 0.8)

Rainfall

More intense downpours and high natural variability (e.g. influence of El Niño and La Niña) is likely to remain the major factor influencing rainfall in the next few decades. Projections for 2070 show little change or a decrease, particularly in winter and spring. The intensity of heavy rainfall events is likely to increase.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 25**: Average change in precipitation for Central Queensland under RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Banana Shire	2.4	-0.1 (-0.3 – 0.2)	-0.1 (-0.6 – 0.2)
Central Highlands Regional	2.3	-0.1 (-0.4 – 0.2)	-0.1 (-0.4 – 0.2)
Gladstone Regional	4.4	0 (-0.7 – 0.6)	-0.1 (-0.9 – 0.4)
Livingstone Regional	4.7	0 (-1 – 0.7)	-0.1 (-0.8 – 0.4)
Rockhampton Regional	3.4	-0.1 (-0.8 – 0.4)	-0.2 (-0.7 – 0.1)
Woorabinda Aboriginal Shire	2.6	-0.1 (-0.5 – 0.2)	-0.1 (-0.6 – 0.2)

Changes to drought are less clear

By late this century, it is likely that eastern parts of the region will experience more time in drought.

Sea level rise

Sea level will continue to rise

Sea level is projected to rise by as much as 0.64m above present-day levels by 2100 (see Table 27).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 26**: Average change in precipitation for Central Queensland under RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Banana Shire	2.4	0 (-0.3 – 0.2)	0 (-0.5 – 0.3)
Central Highlands Regional	2.3	-0.1 (-0.4 – 0.1)	0 (-0.4 – 0.3)
Gladstone Regional	4.4	0 (-0.7 – 0.6)	-0.1 (-0.8 – 0.8)
Livingstone Regional	4.7	-0.1 (-0.8 – 0.8)	0.1 (-0.7 – 1.1)
Rockhampton Regional	3.4	0 (-0.7 – 0.5)	-0.1 (-0.6 – 0.6)
Woorabinda Aboriginal Shire	2.6	0 (-0.5 – 0.2)	-0.1 (-0.5 – 0.3)

Changes to drought are less clear

By late this century, under a high emissions scenario, it is likely that eastern parts of the region will experience more time in drought.

Sea level rise

Sea level will continue to rise

Sea level is projected to rise by as much as 0.87m above present-day levels by 2100 (see Table 28).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 27: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time and a moderate emissions scenario RCP4.5 for the Central Queensland area. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Gladstone Regional Council		Rockhampton Regional Council	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.13 (09-0.17)	0.14	0.13 (09-0.17)	0.15
2050 (m)	0.24 (0.16-0.31)	0.26	0.23 (0.16-0.31	0.26
2070 (m)	0.35 (0.23-0.47)	0.41	0.35 (0.23-0.47)	0.38
2090 (m)	0.47 (0.30-0.67)	0.59	0.47 (0.30-0.64)	0.53
Rate of change by 2100 (mm/year)	5.9 (3.2-8.7)	N/A	5.8 (3.1-8.6)	N/A

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 28: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time and a high emissions scenario RCP8.5 for the Central Queensland area. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Gladstone Regional Council		Rockhampton Regional Council	
	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.13 (09-0.18)	0.14	0.13 (09-0.18)	0.14
2050 (m)	0.26 (0.19-0.35)	0.29	0.26 (0.18-0.35	0.28
2070 (m)	0.44 (0.30-0.58)	0.51	0.43 (0.30-0.57)	0.47
2090 (m)	0.65 (0.44-0.87)	0.83	0.64 (0.44-0.87)	0.75
Rate of change by 2100 (mm/year)	11.4 (7.5-16.1)	N/A	11.4 (7.4-16.0)	N/A

4.3 Central West

How will climate change affect the Central West Region?

The Central West HHS region extends from the Northern Territory and South Australian borders in the west, through to Queensland's Central Highlands in the east. It includes the local government councils of Barcaldine Regional, Barcoo Shire, Blackall Tambo Regional, Boulia Shire, Diamantina Shire, Longreach Regional and Winton Shire.

The region occupies 23% of the state's total area but only contains around 0.3% of the population.

4.3.1 Current climate

The Central West HHS region has a semi-arid to arid climate with very hot summers and warm, dry winters. The current average annual temperature is 24 °C. The summer average is 30 °C, autumn is 24 °C, winter 16 °C and spring 25 °C.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broad scale weather patterns, such as the El Niño–Southern Oscillation.

Annual average rainfall is 326 mm. Around half of this falls between December and February.

The region's annual average potential evaporation is more than five times the annual average rainfall, which contributes to the depletion of soil moisture.

4.3.2 Climate projections

This section provides plausible scenarios of the future climate for the Central West region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Temperature Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking. In the near future (2030), the annually averaged maximum temperature for the Central West region is projected to increase by at least 0.1 °C, and as much as 1.8 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.6 °C warmer on average (Table 29). By 2070, the increase in average maximum daily temperatures above the recent climate (1986–2005) by at least 0.7 °C, and as much as 3.1 °C (Table 29). Nights are projected to also be at least 1.2 °C warmer and as much as 3.1 °C warmer.	**Temperature** Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for RCP4.5. Annual average maximum temperatures for the Central West region for this high emissions scenario are projected to increase by as much as 1.9 °C above the recent climate (1986–2005) although some models show a slight decrease. Nighttime minima are expected to be 0.5 – 1.4 °C warmer on average (Table 30). By 2070, there is considerable divergence between temperatures for the high and low emissions scenarios. For this high emissions scenario, the projected increase in average maximum daily temperatures across the region is at least 0.9 °C, with some models showing as much as 4.4 °C above the recent climate (1986–2005) (Table 30). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 29: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Central West region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	**Recent temperatures (1986-2005) °C**		**Mean projected increase in temperatures by 2030 °C**		**Mean projected increase in temperatures by 2070 °C**	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Barcaldine Regional	16.9	29.3	1.0 (0.6 – 1.5)	1.1 (0.4 – 1.8)	1.9 (1.2 – 2.6)	2.0 (0.8 – 2.9)
Barcoo Shire	17.4	30.4	1.2 (0.5 – 1.6)	1.2 (0.3 – 1.8)	2.2 (1.4 – 3.1)	2.2 (0.9 – 3.1)
Blackall Tambo Regional	16.0	28.5	1.0 (0.6 – 1.5)	1.1 (0.5 – 1.9)	2.0 (1.3 – 2.8)	2.1 (0.8 – 3.1)
Boulia Shire	18.6	32.0	1.1 (0.5 – 1.5)	1.1 (0.1 – 1.8)	2.1 (1.3 – 3.0)	2.0 (0.7 – 2.9)
Diamantina Shire	18.1	31.4	1.2 (0.5 – 1.6)	1.1 (0.3 – 1.7)	2.2 (1.4 – 3.0)	2.1 (0.9 – 3.1)
Longreach Regional	17.8	30.2	1.1 (0.5 – 1.6)	1.1 (0.2 – 1.8)	2.1 (1.3– 2.9)	2.1 (0.7 – 2.9)
Winton Shire	18.7	31.3	1.1 (0.5 – 1.6)	1.1 (0.1 – 1.8)	2.1 (1.3– 2.9)	2.0 (0.7 – 2.8)

Hotter and more frequent hot days

There is likely to be at least 35 more days over 35 °C across the region by 2070, with days over 40 °C will be about double the present number by 2070(Table 31).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 30: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Central West region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	**Recent temperatures (1986-2005) °C**		**Mean projected increase in temperatures by 2030 °C**		**Mean projected increase in temperatures by 2070 °C**	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Barcaldine Regional	16.9	29.3	1.1 (0.5 – 1.5)	1.1 (0.2 – 1.9)	3.2 (2.2 – 4.1)	3.0 (1.5 – 4.1)
Barcoo Shire	17.4	30.4	1.2 (0.5 – 1.7)	1.1 (-0.1 – 1.7)	3.6 (2.3 – 4.7)	3.1 (1.4 – 4.4)
Blackall Tambo Regional	16.0	28.5	1.1 (0.6 – 1.5)	1.1 (0.1 – 1.7)	3.3 (2.3 – 4.3)	3.1 (1.5 – 4.3)
Boulia Shire	18.6	32.0	1.2 (0.4 – 1.7)	1.0 (-0.3 – 1.7)	3.5 (2.1 – 4.7)	2.9 (0.9 – 4.1)
Diamantina Shire	18.1	31.4	1.2 (0.4 – 1.7)	1.1 (-0.1 – 1.6)	3.6 (2.3 – 4.8)	3.1 (1.4 – 4.4)
Longreach Regional	17.8	30.2	1.2 (0.5 – 1.6)	1.0 (-0.1 – 1.7)	3.4 (2.3 – 4.5)	3.0 (1.3 – 4.2)
Winton Shire	18.7	31.3	1.2 (0.4 – 1.6)	1.0 (-0.2 – 1.8)	3.4 (2.2 – 4.4)	2.9 (1.1 – 4.0)

Many more hot days and an increase in very hot days.

For this high emissions scenario, by 2070 there is likely to be at least 49 more days over days over 35 °C. Days over 40 °C will be more than double by 2070 (Table 32).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 31**: Average number of projected additional days over 35 °C and 40 °C for the Central West region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Barcaldine Regional	82.8	7.7	23.1 (3.0 – 45.2)	6.4 (0.6 – 11.9)	43.3 (10.6 – 63.2)	16.7 (5.0 – 29.0)
Barcoo Shire	124.2	34.3	20.7 (2.4 – 37.3)	15.5 (0.6 – 30.2)	37.3 (9.9 – 53.2)	33.7 (7.1 – 53.5)
Blackall Tambo Regional	73.0	7.0	21.4 (1.4 – 40.5)	5.7 (0.3 – 11.3)	40.9 (7.8 – 60.1)	14.9 (4.2 – 27.2)
Boulia Shire	147.4	44.9	19.3 (-2.8 – 37.8)	17.3 (-0.7 – 32.9)	36.5 (11.6 – 56.2)	36.6 (7.7 – 59.4)
Diamantina Shire	137.3	47.9	19.6 (2.6 – 33.2)	17.6 (1.8 – 35.3)	35.1 (13.1 – 49.4)	36.5 (9.5 – 54.4)
Longreach Regional	118.8	22.9	22.6 (-1.6 – 42.4)	13.8 (0.7 – 24.9)	40.9 (7.2 – 60.9)	31.5 (7.6 – 49.6)
Winton Shire	137.5	30.6	21.9 (-2.7 – 41.3)	15.9 (0.5 – 26.8)	39.3 (9.0 – 63.4)	34.9 (8.4 – 56.2)

The Central West region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with close to double the days in a year that are under heatwave conditions (Table 33).

By 2070 the average hottest temperature in a heatwave is expected to increase by 1.2-1.4°C (range 0.2-3 °C) across the region. Individual heatwaves are likely to last 1-2 days longer. The number of days in the year that are heatwave days could double.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 32**: Average number of projected additional days over 35 °C and 40 °C for the Central West region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Barcaldine Regional	82.8	7.7	24.0 (2.4 – 44.7)	7.1 (1.1 – 11.8)	62.3 (20.9 – 63.2)	32.9 (11.1 –53.7)
Barcoo Shire	124.2	34.3	19.6 (-8.4 – 33.5)	16.1 (-1.9 – 31.9)	52.2 (9.7 – 76.2)	49.4 (17.0 – 78.1)
Blackall Tambo Regional	73.0	7.0	20.3 (-0.5 – 36.1)	5.9 (1.3 – 11.2)	58.4 (16.9 – 85.2)	28.5 (10.5 – 47.5)
Boulia Shire	147.4	44.9	19.4 (-12.5 – 38.9)	18.8 (-2.0 – 36.8)	51.0 (3.1 – 73.1)	52.9 (10.9 – 84.2)
Diamantina Shire	137.3	47.9	19.2 (-8.8 – 33.1)	18.9 (-1.8 – 36.3)	48.7 (11.6 – 70.1)	51.6 (17.4 – 80.4)
Longreach Regional	118.8	22.9	21.2 (-8.4 – 38.9)	14.6 (0.2 – 27.0)	57.6 (10.1 – 86.4)	49.3 (15.8 – 78.1)
Winton Shire	137.5	30.6	20.8 (-10.9 – 41.3)	17.1 (-0.4 – 31.6)	57.0 (10.3 – 84.7)	52.8 (15.5 – 83.1)

The Central West region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with almost double the days in a year that are under heatwave conditions (Table 34).

By 2070 the average hottest temperatures in a heatwave may have increased by 2 - 2.5°C. Heatwaves are likely to last 3 days longer. The number of days in the year that are heatwave days could increase by more than three times.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 33**: Average change in peak temperature, frequency and duration of heatwaves for the Central West region. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days
Barcaldine Regional	41.1	2.9	4.8	0.5 (-0.3 – 1.6)	2.4 (0.4 – 5.2)	0.6 (-0.2 – 1.5)	1.3 (0.3 – 3.0)	6.9 (1.5 – 11.7)	1.6 (0.7 – 3.0)
Barcoo Shire	43.9	3.2	5.0	0.4 (-0.1 – 1.4)	2.3 (-0.1 – 5.2)	0.6 (0.1 – 1.8)	1.3 (0.6 – 2.6)	6.0 (1.1 – 9.5)	1.5 (0.3 – 2.6)
Blackall Tambo Regional	40.9	3.1	5.0	0.4 (-0.3 – 1.3)	2.5 (0 – 5.2)	0.5 (-0.5 – 1.7)	1.2 (0.5 – 2.8)	6.9 (1.7 – 11.2)	1.6 (0.4 – 2.9)
Boulia Shire	43.8	3.0	4.9	0.5 (0.1 – 1.3)	2.1 (0.4 – 4.0)	0.4 (-0.4 – 1.6)	1.2 (0.4 – 2.6)	6.3 (1.5 – 11.1)	1.5 (0.4 – 2.7)
Diamantina Shire	44.6	3.1	5.0	0.6 (0.2 – 1.3)	2.3 (0.6 – 4.6)	0.6 (-0.2 – 1.8)	1.4 (0.6 – 2.7)	6.1 (1.8 – 9.9)	1.5 (0.2 – 2.5)
Longreach Regional	43.0	3.2	4.9	0.4 (-0.1 – 1.1)	2.6 (0.2 – 5.5)	0.7 (-0.2 – 1.5)	1.2 (0.4 – 2.9)	6.8 (1.6 – 10.6)	1.8 (0.9 – 2.9)
Winton Shire	43.1	2.9	4.8	0.5 (-0.1 – 1.1)	2.5 (0.2 – 4.7)	0.7 (0 – 1.2)	1.3 (0.2 – 2.8)	6.6 (1.7 – 10.6)	1.8 (0.8 – 2.9)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 34**: Average change in peak temperature, frequency and duration of heatwaves for the Central Queensland region. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days
Barcaldine Regional	41.1	2.9	4.8	0.7 (-0.1 – 1.6)	2.8 (0.4 – 4.9)	0.6 (-0.3 – 1.5)	2.2 (0.7 – 3.4)	15.4 (6.4 – 24.7)	4.2 (1.7 – 7.7)
Barcoo Shire	43.9	3.2	5.0	0.5 (-0.3 – 1.2)	2.5 (0.3 – 4.6)	0.6 (-0.2 – 1.7)	2.2 (1.2– 3.2)	11.6 (4.5 – 18.1)	3.0 (1.6 – 5.4)
Blackall Tambo Regional	40.9	3.1	5.0	0.5 (0 – 1.2)	2.7 (0.7 – 4.9)	0.5 (-0.2 – 1.6)	2.0 (0.9 – 2.9)	14.4 (6.4 – 24.6)	3.6 (1.5 – 6.9)
Boulia Shire	43.8	3.0	4.9	0.5 (-0.3 – 1.1)	2.7 (0.6 – 5.0)	0.7 (0 – 1.1)	2.1 (0.7– 3.2)	12.5 (3.5 – 20.2)	3.3 (1.3 – 6.3)
Diamantina Shire	44.6	3.1	5.0	0.7 (0.1 – 1.6)	2.7 (0.7 – 4.7)	0.8 (0 – 1.7)	2.5 (1.4 – 3.5)	11.6 (4.3 – 17.7)	2.9 (1.3 – 5.1)
Longreach Regional	43.0	3.2	4.9	0.5 (-0.5 – 1.3)	2.9 (0.4 – 5.1)	0.7 (0.1 – 1.5)	2.3 (1.0 – 3.7)	13.7 (5.0 – 22.2)	3.9 (1.9 – 7.5)
Winton Shire	43.1	2.9	4.8	0.6 (-0.1 – 1.2)	2.9 (0.3 – 5.2)	0.8 (0.2 – 1.3)	2.4 (0.7– 3.5)	13.4 (4.6 – 21.5)	3.8 (1.7 – 6.9)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Humidity

The Central West region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 35).

***Table 35**: Average change in humidity for the summer months in Central West under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Barcaldine Regional	68.5	-1.8 (-10.9 – 2.1)	-1.7 (-9.2 – 3.2)
Barcoo Shire	54.9	-1.4 (-11.1 – 3.6)	-1.3 (-11.0 – 6.2)
Blackall Tambo Regional	66.3	-1.6 (-10.6 – 2.7)	-1.7 (-9.3 – 3.9)
Boulia Shire	55.7	-0.7 (-9.5 – 5.6)	-0.5 (-10.9 – 6.5)
Diamantina Shire	48.6	-1.0 (-9.2 – 4.2)	-0.8 (-9.9 – 6.3)
Longreach Regional	62.1	-1.7 (-11.4 – 3.8)	-1.5 (-10.6 – 5.3)
Winton Shire	60.9	-1.5 (-11.5 – 4.5)	-1.0 (-11.3 – 5.7)

Fire weather

Harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. Bushfire in the region depends highly on fuel availability, which mainly depends on rainfall. A tendency toward increased fire weather risk is expected in future, due to higher temperature and lower rainfall (Table 37).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Humidity

The Central West region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 36).

***Table 36**: Average change in humidity for the summer months in Central West under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Barcaldine Regional	68.5	-0.9 (-7.5 – 3.0)	-0.5 (-6.9 – 4.6)
Barcoo Shire	54.9	-0.2 (-8.4 – 8.0)	1.2 (-9.0 – 8.8)
Blackall Tambo Regional	66.3	-0.2 (-6.6 – 4.5)	0.1 (-5.9 – 4.9)
Boulia Shire	55.7	-0.1 (-8.3 – 7.9)	2.0 (-9.5 – 12.6)
Diamantina Shire	48.6	-0.3 (-8.1 – 8.7)	2.0 (-8.7 – 11.2)
Longreach Regional	62.1	-0.5 (-7.8 – 5.7)	0.4 (-7.8 – 7.8)
Winton Shire	60.9	-0.6 (-8.7 – 6.1)	0.8 (-9.0 – 9.2)

Fire weather

Harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. Bushfire in the region depends highly on fuel availability, which mainly depends on rainfall. A tendency toward increased fire weather risk is expected in future, due to higher temperature and lower rainfall (Table 38).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 37**: Average change in seasonal count of days in each level of fire risk in Central West region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Barcaldine Regional	112.2	51.7	1.7	2.5 (-12.1 – 16.0)	14 (-0.4– 40.4)	1.1 (0 – 3.9)	4.5 (-8.4 – 17.0)	22.0 (-1.5 – 49.7)	2.3 (-0.2 – 5.6)
Barcoo Shire	115.3	104.6	14.0	-1.4 (-16.0 – 9.1)	8.7 (-5.5 – 35.7)	4.4 (-0.2 – 14.6)	-2.9 (-16.7 – 11.2)	12.8 (-8.9 – 34.4)	9.1 (-0.3 – 20.3)
Blackall Tambo Regional	102.1	44.0	1.5	4.0 (-6.6 – 19.3)	12.8 (-0.5 – 32.5)	1.3 (-0.2 – 3.9)	7.0 (-3.2 – 18.6)	21.3 (-3.7 – 53.7)	2.5 (-0.1 – 6.2)
Boulia Shire	119.6	128.2	21.3	-2.2 (-11.4 – 14.0)	4.4 (-15.8 – 30)	5.6 (-2.7 – 15.9)	-6.9 (-22.2 – 7.4)	7.3 (-13.0 – 27.5)	10.7 (-2.0 – 26.6)
Diamantina Shire	115.6	127.5	23.8	-1.4 (-14.8 – 11.8)	3.6 (-11.6– 22.4)	6.7 (-0.9 – 18.4)	-4.8 (-22.4 – 6.7)	6.4 (-8.3 – 19.6)	13.1 (-0.5 – 30)
Longreach Regional	120.3	84.1	5.7	0.3 (-11.4 – 13.7)	12.3 (-7.2 – 39.1)	2.6 (-0.1 – 8.3)	-1.5 (-17.3 – 14.0)	19.9 (-9.8 – 44.8)	5.1 (-0.3 – 11.2)
Winton Shire	125.5	106.1	10.8	-0.3 (-13.6 – 11.1)	9.1 (-7.4 – 35.6)	3.7 (-0.8 – 11.2)	-4.8 (-18.2 – 12.4)	13.7 (-7.7 – 38.1)	6.9 (-1.1 – 15.8)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 38**: Average change in seasonal count of days in each level of fire risk in Central West region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Barcaldine Regional	112.2	51.7	1.7	2.5 (-18.8 – 16.8)	8.9 (-4.8– 31.6)	0.9 (-0.8 – 2.5)	5.3 (-24.4– 19.6)	23.0 (-1.8 – 46.9)	2.7 (0 – 7.2)
Barcoo Shire	115.3	104.6	14.0	-1.6 (-9.5 – 8.9)	4.9 (-15.9 – 27.0)	3.0 (-2.4 – 9.7)	-3.2 (-17.6 – 12.6)	7.7 (-20.7 – 26.0)	11.8 (-0.1 – 29.5)
Blackall Tambo Regional	102.1	44.0	1.5	2.2 (-10.2 – 9.9)	6.8 (-6.8 – 22.6)	0.8 (-0.9 – 1.9)	7.3 (-21.5 – 21.1)	21.5 (-0.4 – 48.7)	3.1 (0.1 – 8.0)
Boulia Shire	119.6	128.2	21.3	-4.6 (-15.2 – 5.6)	3.3 (-18.5 – 27.6)	4.2 (-3.7 – 14.3)	-10.3 (-27.3 – 3.4)	1.0 (-33.2 – 25.1)	13.9 (-3.6 – 32.5)
Diamantina Shire	115.6	127.5	23.8	-2.6 (-11.1 – 5.3)	2.0 (-19.4– 18.4)	5.2 (-3.1 – 14.7)	-5.8 (-18.5 – 5.4)	-0.8 (-28.2 – 20.5)	16.7 (-1.0 – 38.7)
Longreach Regional	120.3	84.1	5.7	-0.6 (-17.2 – 7.6)	6.2 (-12.7 – 28.0)	1.8 (-1.8 – 5.5)	-1.2 (-26.1 – 17.2)	16.9 (-11.1 – 39.2)	6.5 (-0.3 – 16.9)
Winton Shire	125.5	106.1	10.8	-2.8 (-17.5 – 8.6)	5.6 (-13.0 – 31.8)	2.6 (-2.0 – 8.5)	-5.5 (-20.8 – 18.3)	10.4 (-18.8 – 32.3)	8.9 (-1.2 – 22.3)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Rainfall

More intense downpours

High natural variability (e.g. influence of El Niño and La Niña) is likely to remain the major factor influencing rainfall in the next few decades. Rainfall projections for 2070 show little change or a decrease, particularly in winter and spring. The intensity of heavy rainfall events is likely to increase.

***Table 39**: Average change in precipitation for Central West under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Barcaldine Regional	1.6	-0.1 (-0.3 – 0.2)	-0.1 (-0.2 – 0.2)
Barcoo Shire	1.4	0 (-0.3 – 0.2)	0 (-0.2 – 0.2)
Blackall Tambo Regional	2.0	-0.1 (-0.3 – 0.2)	-0.1 (-0.2 – 0.2)
Boulia Shire	1.2	0 (-0.2 – 0.2)	0.1 (-0.2 – 0.2)
Diamantina Shire	1.0	0 (-0.2 – 0.2)	0 (-0.2 – 0.2)
Longreach Regional	1.6	-0.1 (-0.3 – 0.2)	0 (-0.2 – 0.3)
Winton Shire	1.4	0 (-0.3 – 0.2)	0 (-0.2 – 0.3)

Changes to drought are less clear

Projecting changes in the frequency and duration of drought is difficult. However, by late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Rainfall

More intense downpours

High natural variability (e.g. influence of El Niño and La Niña) is likely to remain the major factor influencing rainfall in the next few decades. Rainfall projections for 2070 show little change or a decrease, particularly in winter and spring. The intensity of heavy rainfall events is likely to increase.

***Table 40**: Average change in precipitation for Central West under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

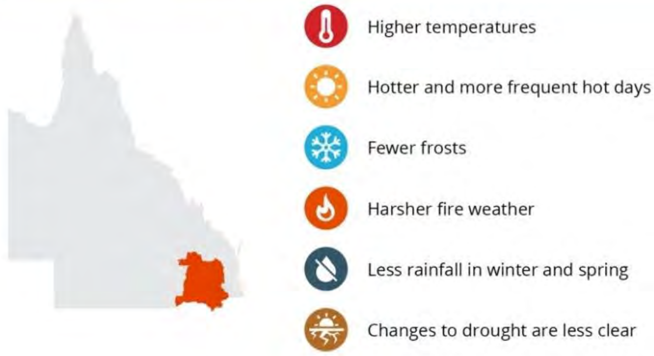
Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Barcaldine Regional	1.6	0 (-0.3 – 0.2)	0 (-0.1 – 0.3)
Barcoo Shire	1.4	0 (-0.2 – 0.3)	0.1 (-0.2 – 0.5)
Blackall Tambo Regional	2.0	0 (-0.2 – 0.3)	0 (-0.1 – 0.4)
Boulia Shire	1.2	0.1 (-0.1 – 0.4)	0.2 (-0.1 – 0.6)
Diamantina Shire	1.0	0 (-0.1 – 0.3)	0.1 (-0.1 – 0.4)
Longreach Regional	1.6	0 (-0.2 – 0.3)	0.1 (-0.1 – 0.4)
Winton Shire	1.4	0 (-0.2 – 0.4)	0.2 (-0.1 – 0.5)

Changes to drought are less clear

Projecting changes in the frequency and duration of drought is difficult. However, by late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

4.4 Darling Downs

How will climate change affect the Darling Downs Region?



The Darling Downs HHS region is located at the headwaters of the Murray–Darling Basin in southern Queensland, and includes the local government councils of Banana Shire, Cherbourg Aboriginal Shire, Goondiwindi Regional, South Burnett Regional, Southern Downs Regional, Toowoomba Regional and Western Downs Regional. It is bordered by New South Wales to the south.

4.4.1 Current climate

The eastern part of the Darling Downs HHS region has a temperate climate with hot summers and cool winters (due to elevation) moving to a semi-arid climate with very hot summers and warm dry winters in the west. The average annual temperature is 19-20 °C, with the warmer averages in the western parts of the region. The summer average temperature is 25-27 °C, in autumn and spring it is 20-21 °C, and in winter 12-13 °C.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño–Southern Oscillation. Annual average rainfall is 517-614 mm, with much occurring from October to March either as heavy thunderstorms or from tropical rain depressions.

The region's annual average potential evaporation is more than twice the annual average rainfall, which contributes to the depletion of soil moisture.

4.4.2 Climate projections

This section provides plausible scenarios of the future climate for the Darling Downs region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

Future scenario 1 assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.

Future scenario 2 assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Temperature Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking. In the near future (2030), the annually averaged maximum temperature for the Darling Downs region is projected to increase by at least 0.2 °C, and as much as 2.0 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.3 °C warmer on average (Table 41). By 2070, the average maximum daily temperatures are expected to increase by at least 0.9 °C, and as much as 3.4 °C above the recent climate (1986–2005) (Table 41). Nights are projected to also be at least 1.2 °C warmer and as much as 2.5 °C warmer.	**Temperature** Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1 (RCP4.50 scenario). By 2030, annual average maximum temperatures for the Darling Downs region for this high emissions scenario are projected to increase by at least 0.4 °C, and as much as 2.0 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.6 – 1.4 °C warmer on average (Table 42). By 2070, there is considerable divergence between temperatures for the high and low emissions scenarios. For this high emissions scenario, the projected increase in average maximum daily temperatures across the region is at least 1.7 °C, with some models showing as much as 4.5 °C above the recent climate (1986–2005) (Table 42). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 41:** Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario for the Darling Downs region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Banana Shire	15.3	27.3	0.9 (0.5 – 1.3)	1.1 (0.5 – 1.8)	1.8 (1.2 – 2.4)	2.1 (1.0 – 3.4)
Cherbourg Aboriginal Shire	14.3	25.8	0.9 (0.5 – 1.3)	1.0 (0.2 – 1.7)	1.8 (1.2 – 2.4)	2.1 (1.1 – 3.3)
Goondiwindi Regional	13.6	25.7	1.0 (0.5 – 1.3)	1.1 (0.6 – 1.8)	1.9 (1.3– 2.5)	2.2 (1.0 – 3.5)
South Burnett Regional	14.0	25.3	0.9 (0.5 – 1.3)	1.0 (0.4 – 1.7)	1.8 (1.2– 2.4)	2.1 (1.1 – 3.3)
Southern Downs Regional	11.9	23.4	0.9 (0.5 – 1.3)	1.1 (0.7 – 1.7)	1.8 (1.3– 2.3)	2.2 (1.1 – 3.2)
Toowoomba Regional	13.3	24.7	0.9 (0.5 – 1.3)	1.1 (0.6 – 1.7)	1.8 (1.3– 2.4)	2.1 (1.1 – 3.3)
Western Downs Regional	14.2	26.3	0.9 (0.5 – 1.3)	1.1 (0.6 – 2.0)	1.9 (1.3– 2.4)	2.2 (0.9 – 3.4)

Hotter and more frequent hot days

There is likely to be more than double the number of days over 35 °C across the region by 2070. The number of days over 40 °C are likely to see a more than fivefold increase by 2070 (Table 43).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 42:** Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario for the Darling Downs region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Banana Shire	15.3	27.3	1.0 (0.6 – 1.3)	1.0 (0.4 – 1.9)	3.0 (2.2 – 3.9)	3.1 (1.7 – 4.2)
Cherbourg Aboriginal Shire	14.3	25.8	1.0 (0.6 – 1.3)	1.0 (0.4 – 1.8)	3.0 (2.2 – 3.9)	3.2 (2.0 – 4.3)
Goondiwindi Regional	13.6	25.7	1.1 (0.6 – 1.4)	1.0 (0.4 – 1.8)	3.2 (2.3 – 4.1)	3.3 (1.8 – 4.5)
South Burnett Regional	14.0	25.3	1.0 (0.6 – 1.3)	1.0 (0.4 – 1.8)	3.0 (2.2 – 3.9)	3.2 (1.9 – 4.3)
Southern Downs Regional	11.9	23.4	1.0 (0.6 – 1.3)	1.1 (0.5 – 1.8)	3.0 (2.2 – 3.9)	3.2 (2.0 – 4.4)
Toowoomba Regional	13.3	24.7	1.0 (0.6 – 1.3)	1.1 (0.5 – 1.8)	3.0 (2.2 – 3.9)	3.2 (1.8 – 4.3)
Western Downs Regional	14.2	26.3	1.0 (0.6 – 1.4)	1.1 (0.4 – 2.0)	3.1 (2.3 – 4.0)	3.2 (1.8 – 4.5)

Many more hot days and an increase in very hot days

For this high emissions scenario, by 2070 there is likely to be double to three-times the number of over 35 °C. There will be 8 – 10 times more days over 40 °C by 2070 (Table 44).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 43**: Average number of projected additional days over 35 °C and 40 °C for the Darling Downs region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35ºC	>40ºC	>35ºC	>40ºC	>35ºC	>40ºC
Banana Shire	29	1.0	13.9 (3.5 – 32.7)	1.1 (-0.6 – 2.6)	31.1 (8.5 – 59.0)	3.8 (0.7 – 10.3)
Cherbourg Aboriginal Shire	10.8	0.2	7.4 (-1.1 – 18.1)	0.4 (-0.1 – 0.9)	18.4 (5.3 – 34.7)	1.1 (0.1 – 3.8)
Goondiwindi Regional	35.2	2.8	14.1 (-1.1 – 30.7)	2.6 (0.1 – 5.7)	29.7 (3.3 – 52.1)	6.8 (1.4 – 15.2)
South Burnett Regional	10.7	0.2	7.3 (0.8 – 17.3)	0.3 (-0.1 – 0.9)	18.0 (4.6 – 33.8)	1.2 (0.2 – 3.8)
Southern Downs Regional	5.4	0.1	4.4 (1.3 – 9.5)	0.2 (0 – 0.6)	9.8 (1.9 – 20.3)	0.7 (0 – 2.2)
Toowoomba Regional	14.2	0.6	8.3 (0.7 – 17.5)	0.7 (-0.4 – 1.8)	18.9 (3.6 – 33.3)	2.4 (0.6 – 6.3)
Western Downs Regional	29.4	1.5	14.0 (-0.4 – 28.7)	1.5 (-0.6 – 3.2)	30.4 (5.2 – 53.3)	4.9 (1.4 – 12.4)

The Darling Downs region will experience an increase in length, peak temperatures and frequency of heatwaves.

Increasing temperatures will result in more frequent heatwave conditions with a slight increase in peak heatwave temperatures and the length of time heatwave conditions persist (Table 45).

By 2030 the average hottest temperature in a heatwave will likely be a little hotter, the heatwave will last a little longer with almost double the days in a year under heatwave conditions – an increase in frequency. By 2070 the average hottest temperature in a heatwave is expected to increase by 1.2-1.6ºC across the region. Individual heatwaves are likely to last 1-2 days longer. The region could experience three times the number of heatwave days in the year.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 44**: Average number of projected additional days over 35 °C and 40 °C for the Darling Downs region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35ºC	>40ºC	>35ºC	>40ºC	>35ºC	>40ºC
Banana Shire	29	1.0	14.3 (4.8 – 31.1)	1.1 (0.1 – 2.8)	48.4 (18.8 – 73.3)	8.9 (2.3 –19.5)
Cherbourg Aboriginal Shire	10.8	0.2	6.6 (0.9 – 16.2)	0.4 (-0.1 – 1.3)	29.6 (12.0 – 45.3)	2.5 (0.1 – 5.5)
Goondiwindi Regional	35.2	2.8	12.7 (2.3 – 26.0)	2.4 (0.3 – 5.4)	45.0 (16.8 – 68.0)	13.3 (5.0 – 22.9)
South Burnett Regional	10.7	0.2	7.1 (1.8 – 16.7)	0.3 (-0.2 – 1.1)	30 (12.0 – 46.6)	2.7 (0.4 – 6.5)
Southern Downs Regional	5.4	0.1	3.8 (0.6 – 9.0)	0.2 (-0.1 – 0.6)	17.3 (7.0 – 28.9)	1.6 (0.3 – 3.5)
Toowoomba Regional	14.2	0.6	7.8 (2.3 – 17.2)	0.8 (0.1 – 2.3)	31.9 (12.2 – 50.5)	5.3 (1.5 – 11.0)
Western Downs Regional	29.4	1.5	13.9 (3.2 – 28.2)	1.7 (0.5 – 4.1)	46.3 (16.2 – 69.7)	10.7 (3.1 – 20.5)

The Darling Downs region will experience an increase in length, peak temperatures and frequency of heatwaves.

Heatwaves are expected to reach higher temperatures, last longer and happen more frequently (Table 46).

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with almost double the number of days in a year under heatwave conditions.

By 2070 the average hottest temperatures in a heatwave may have increased by 2.0-2.4ºC. Heatwave events are likely to last 2.3 – 3.4 days longer. The region could experience four times the number of heatwave days in the year.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 45**: Average change in peak temperature, frequency and duration of heatwaves for the Darling Downs region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days
Banana Shire	38.5	2.6	4.8	0.4 (-0.8 – 1.9)	2.0 (0.3 – 4.1)	0.5 (-0.1 – 1.4)	1.4 (0.4 – 3.1)	6.0 (1.6 – 11.5)	1.3 (-0.1 – 2.5)
Cherbourg Aboriginal Shire	36.5	2.4	4.6	0.8 (-0.4 – 1.8)	2.1 (0.1 – 4.9)	0.7 (-0.4 – 1.9)	1.6 (0.7 – 3.5)	5.7 (1.5 – 10.1)	1.2 (0.2 – 2.2)
Goondiwindi Regional	39.6	2.8	4.9	0.5 (-0.2 – 1.6)	2.2 (0.4 – 3.9)	0.3 (-0.8 – 1.4)	1.2 (0.2 – 2.5)	5.4 (0.8 – 9.3)	0.8 (-0.6 – 1.6)
South Burnett Regional	36.7	2.5	4.7	0.5 (-0.5 – 1.7)	2.0 (0.5 – 4.6)	0.5 (-0.6 – 1.9)	1.5 (0.3 – 3.1)	5.6 (1.8 – 10.3)	1 (-0.5 – 1.9)
Southern Downs Regional	35.2	2.3	4.5	0.6 (-0.1 – 1.4)	2 (0.3 – 3.7)	0.5 (-0.6 – 1.3)	1.4 (-0.3 – 2.6)	5.2 (1.5 – 8.6)	0.8 (-0.6 – 1.8)
Toowoomba Regional	37.5	2.4	4.6	0.5 (-0.4 – 1.3)	2.1 (0.1 – 4.1)	0.4 (-0.9 – 1.5)	1.4 (0.1 – 2.7)	5.4 (1.3 – 9.2)	0.8 (-0.8 – 1.8)
Western Downs Regional	39.0	2.7	4.9	0.5 (-0.6 – 1.3)	2.1 (-0.2 – 4.5)	0.3 (-0.5 – 1.5)	1.2 (0.5 – 2.3)	5.7 (0.8 – 10.3)	0.9 (-0.5 – 1.6)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost is projected by the end of the century.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 46**: Average change in peak temperature, frequency and duration of heatwaves for the Darling Downs region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days
Banana Shire	38.5	2.6	4.8	0.4 (-0.4 – 1.3)	2.1 (0.5 – 3.9)	0.4 (-1.0 – 1.3)	2.4 (0.9 – 4.0)	14.7 (7.1 – 26.1)	3.4 (1.5 – 6.6)
Cherbourg Aboriginal Shire	36.5	2.4	4.6	0.5 (-0.9 – 1.9)	2.0 (0.1 – 4.9)	0.3 (-1.3 – 1.1)	2.3 (0.8 – 3.5)	14.0 (6.6 – 25.0)	3.1 (1.3 – 6.8)
Goondiwindi Regional	39.6	2.8	4.9	0.5 (-0.3 – 1.5)	2.2 (0.4 – 3.9)	0.2 (-0.8 – 1.4)	2.0 (0.7– 3.4)	12.2 (5.5 – 22.8)	2.3 (0.9 – 4.9)
South Burnett Regional	36.7	2.5	4.7	0.4 (-0.8 – 1.8)	2.1 (0.9 – 4.4)	0.2 (-1.3 – 1.1)	2.2 (0.9– 3.6)	14.0 (7.3 – 24.3)	3.0 (1.2 – 5.8)
Southern Downs Regional	35.2	2.3	4.5	0.4 (-0.5 – 1.7)	2 (0.4 – 4.4)	0.3 (-0.6 – 1.3)	2.2 (1.1– 3.6)	12.9 (5.8 – 24.1)	2.6 (0.9 – 6.0)
Toowoomba Regional	37.5	2.4	4.6	0.5 (-0.3 – 1.8)	2.2 (0.4 – 4.8)	0.2 (-1.1 – 1.2)	2.2 (1.0– 3.6)	13.6 (6.6 – 24.6)	2.7 (1.0 – 5.7)
Western Downs Regional	39.0	2.7	4.9	0.5 (-0.4 – 1.5)	2.3 (0.6 – 4.2)	0.2 (-0.8 – 1.1)	2.0 (0.8– 3.2)	13.5 (6.6 – 24.0)	2.6 (1.2 – 5.0)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost days is projected by the end of the century.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Humidity

The Darling Downs region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 47).

Table 47: *Average change in humidity for the summer months in Darling Downs under moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity % Historical annual average (1986-2005)	Relative humidity % Change in mean annual relative humidity 2030	Relative humidity % Change in mean annual relative humidity 2070
Banana Shire	77.1	-1.2 (-8.5 – 1.3)	-1.4 (-6.8 – 1.2)
Cherbourg Aboriginal Shire	81.8	-1.0 (-6.4 – 2.6)	-1.5 (-6.1 – 1.2)
Goondiwindi Regional	72.6	-0.9 (-7.6 – 2.1)	-1.3 (-6.3 – 1.8)
South Burnett Regional	81.0	-0.9 (-6.4 – 2.4)	-1.4 (-6.1 – 1.3)
Southern Downs Regional	81.0	-0.8 (-5.5 – 1.2)	-0.9 (-4.9 – 0.8)
Toowoomba Regional	78.3	-0.8 (-6.1 – 1.4)	-1.1 (-5.4 – 1.3)
Western Downs Regional	73.9	-1 (-7.4 – 1.6)	-1.4 (-6.5 – 1.7)

Humidity

The Darling Downs region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 48).

Table 48: *Average change in humidity for the summer months in Darling Downs under a high emission scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity % Historical annual average (1986-2005)	Relative humidity % Change in mean annual relative humidity 2030	Relative humidity % Change in mean annual relative humidity 2070
Banana Shire	77.1	-0.2 (-5.0 – 1.9)	-0.4 (-6.0 – 3.2)
Cherbourg Aboriginal Shire	81.8	0 (-3.3 – 2.4)	-0.6 (-5.5 – 2.4)
Goondiwindi Regional	72.6	0.5 (-3.7 – 3.2)	0 (-5.6 – 3.3)
South Burnett Regional	81.0	-0.1 (-3.7 – 2.2)	-0.7 (-5.1 – 2.3)
Southern Downs Regional	87.3	0.2 (-3.2 – 2.1)	-0.1 (-4.1 – 2.6)
Toowoomba Regional	78.3	0.1 (-3.4 – 2.0)	-0.5 (-4.6 – 2.5)
Western Downs Regional	73.9	0 (-4.3 – 2.6)	-0.3 (-5.7 – 3.2)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 49**: Average change in seasonal count of days in each level of fire risk in Darling Downs region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	**Historical annual average (1986-2005)**			***Change* in average annual fire risk 2030**			***Change* in average annual fire risk 2070**		
	High fire risk days	**Very high fire risk days**	**Severe fire risk days**	**High fire risk days**	**Very high fire risk days**	**Severe fire risk days**	**High fire risk days**	**Very high fire risk days**	**Severe fire risk days**
Banana Shire	59.1	9.3	0.1	9.0 (-1.3 – 29.5)	5.0 (0– 16.7)	0.1 (0 – 0.3)	14.9 (-1.5 – 43.1)	10.7 (0.4 – 39.5)	0.2 (0 – 0.9)
Cherbourg Aboriginal Shire	23.5	2.0	0	6.6 (-0.7 – 23.2)	1.2 (-0.3 – 4.9)	0 (-0.1 – 0.1)	13.8 (0.7 – 37.3)	3.5 (-0.3 – 15.2)	0.1 (0 – 0.4)
Goondiwindi Regional	58.7	13.6	0.4	7.3 (-1.0 – 18.6)	7.1 (-0.6 – 21.7)	0.3 (-0.3 – 1.1)	12.6 (-3.1 – 24.4)	13.7 (-1.4– 40.3)	1.3 (0 – 4.4)
South Burnett Regional	28.5	2.6	0	7.5 (-2.6 – 25.0)	1.7 (-0.3 – 7.1)	0 (0 – 0.1)	13.4 (-1.2 – 36.9)	4.5 (0– 17.6)	0.1 (0 – 0.4)
Southern Downs Regional	20.1	1.7	0	5.8 (-0.4 – 16.2)	1.5 (0.1 – 5.3)	0 (0 – 0)	10.1 (-0.7 – 30.5)	3.6 (-0.1– 13.0)	0.1 (0 – 0.3)
Toowoomba Regional	35.4	4.8	0.1	8.4 (-2.7 – 24.2)	3.2 (0 – 11.2)	0.1 (0 – 0.2)	13.0 (-2.3 – 33.7)	7.1 (-0.5– 23.9)	0.3 (0 – 1.2)
Western Downs Regional	60.5	10.7	0.2	8.7 (-5.1 – 24.6)	6.4 (-0.2 – 18.5)	0.1 (-0.1 – 0.5)	14.1 (-3.7 – 30.3)	12.5 (-0.6 – 41.1)	0.5 (-0.1 – 2.3)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 50**: Average change in seasonal count of days in each level of fire risk in Darling Downs region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	**Historical annual average (1986-2005)**			***Change* in average annual fire risk 2030**			***Change* in average annual fire risk 2070**		
	High fire risk days	**Very high fire risk days**	**Severe fire risk days**	**High fire risk days**	**Very high fire risk days**	**Severe fire risk days**	**High fire risk days**	**Very high fire risk days**	**Severe fire risk days**
Banana Shire	59.1	9.3	0.1	6.4 (-2.6 – 27.2)	2.9 (-2.1– 12.2)	0.1 (-0.1 – 0.2)	17.0 (-2.9– 45.3)	12.9 (1.1 – 33.1)	0.3 (0 – 0.8)
Cherbourg Aboriginal Shire	23.5	2.0	0	2.8 (-3.1 – 16.0)	0.6 (-1.7 – 2.2)	0 (-0.1 – 0.1)	14.5 (2.2 – 37.4)	4.7 (0 – 13.3)	0.1 (-0.1 – 0.4)
Goondiwindi Regional	58.7	13.6	0.4	4.5 (-3.2 – 18.3)	3.4 (-6.8 – 12.2)	0.3 (-0.3 – 0.9)	14.2 (-6.5 – 29.0)	15.4 (1.5 – 43.3)	1.7 (0.1 – 4.3)
South Burnett Regional	28.5	2.6	0	3.9 (-3.5 – 19.0)	0.8 (-2.0 – 3.6)	0 (0 – 0.1)	14.8 (0.4 – 36.9)	5.9 (0.5 – 14.7)	0.1 (0 – 0.5)
Southern Downs Regional	20.1	1.7	0	2.7 (-3.5 – 14.5)	0.9 (-1.4 – 3.6)	0 (0 – 0.1)	10.9 (0.2 – 29.7)	4.5 (0.3 – 12.6)	0.2 (0 – 0.4)
Toowoomba Regional	35.4	4.8	0.1	4.6 (-3.4 – 20.2)	1.4 (-4.0 – 6.3)	0.1 (-0.1 – 0.3)	15.1 (-1.8 – 37.5)	8.5 (0.3 – 24.6)	0.5 (0 – 1.3)
Western Downs Regional	60.5	10.7	0.2	6.1 (-3.6 – 25.3)	2.8 (-6.8 – 10.7)	0.2 (-0.1 – 0.4)	16.6 (-3.0 – 37.0)	14.9 (0.9 – 38.7)	0.8 (0 – 2.0)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Fire weather

Harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. Bushfire in the region depends highly on fuel availability, which mainly depends on rainfall. A tendency toward increased fire weather risk is expected in future, due to higher temperature and lower rainfall (Table 49 – previous page).

***Table 51**: Average change in precipitation for Darling Downs under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Banana Shire	2.4	-0.1 (-0.3 – 0.2)	-0.1 (-0.6 – 0.2)
Cherbourg Aboriginal Shire	2.7	-0.1 (-0.5 – 0.3)	-0.1 (-0.5 – 0.1)
Goondiwindi Regional	2.6	-0.1 (-0.3 – 0.2)	-0.1 (-0.4 – 0.2)
South Burnett Regional	2.5	-0.1 (-0.4 – 0.2)	-0.1 (-0.5 – 0.1)
Southern Downs Regional	2.5	-0.1 (-0.4 – 0.2)	-0.1 (-0.3 – 0.1)
Toowoomba Regional	2.4	-0.1 (-0.4 – 0.3)	-0.1 (-0.4 – 0.1)
Western Downs Regional	2.4	-0.1 (-0.4 – 0.1)	-0.1 (-0.5 – 0.2)

Fire weather

Harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. Bushfire in the region depends highly on fuel availability, which mainly depends on rainfall. A tendency toward increased fire weather risk is expected in future, due to higher temperature and lower rainfall (Table 50 – previous page).

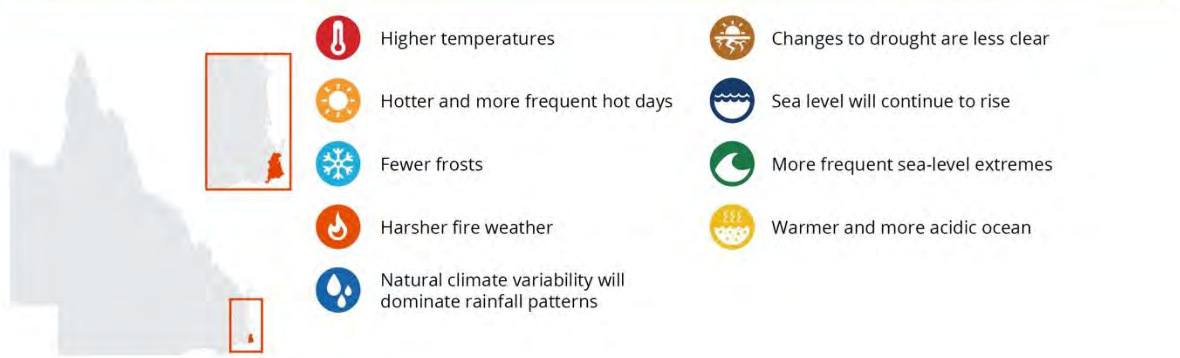
***Table 52**: Average change in precipitation for Darling Downs under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Banana Shire	2.4	0 (-0.3 – 0.2)	0 (-0.5 – 0.3)
Cherbourg Aboriginal Shire	2.7	0 (-0.5 – 0.3)	-0.1 (-0.5 – 0.3)
Goondiwindi Regional	2.6	0 (-0.3 – 0.3)	0 (-0.4 – 0.4)
South Burnett Regional	2.5	0 (-0.4 – 0.3)	0 (-0.4 – 0.3)
Southern Downs Regional	2.5	0 (-0.3 – 0.2)	0 (-0.3 – 0.1)
Toowoomba Regional	2.4	0 (-0.4 – 0.2)	0 (-0.4 – 0.3)
Western Downs Regional	2.4	0 (-0.4 – 0.2)	0 (-0.4 – 0.3)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Rainfall **Less rainfall in winter and spring** High natural variability (e.g. as a result of the El Niño -Southern Oscillation) is likely to remain the major factor influencing rainfall changes in the next few decades. Decreases in winter and spring rainfall are projected by 2070, although high natural variability will continue to influence rainfall patterns. The intensity of heavy rainfall events is likely to increase. **Changes to drought are less clear** Projecting changes in the frequency and duration of drought is difficult. However, by late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.	**Rainfall** **Less rainfall in winter and spring** High natural variability (e.g. as a result of the El Niño -Southern Oscillation) is likely to remain the major factor influencing rainfall changes in the next few decades. Decreases in winter and spring rainfall are projected by 2070, although high natural variability will continue to influence rainfall patterns. The intensity of heavy rainfall events is likely to increase. **Changes to drought are less clear** Projecting changes in the frequency and duration of drought is difficult. However, by late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

4.5 Gold Coast

How will climate change affect the Gold Coast Region?



The Gold Coast region is in southeast Queensland and includes the local government councils of Gold Coast City and parts of Scenic Rim.

4.5.1 Current climate

The Gold Coast HHS region has a sub-tropical climate influenced by tropical systems from the north and fluctuations in the high-pressure ridge to the south. The average daily maximum temperature in summer (Dec – Feb) range from 28.7 °C (Scenic Rim) to 29.4 °C (Ipswich) with winter maximums averaging 19.5 to 20.3 °C. Overnight average minimum temperature in summer range from 18.6 °C (Scenic Rim) to 19.5 °C (Ipswich), with winter minimums falling to 10 to 10.6 °C.

Annual and seasonal average rainfalls are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño– Southern Oscillation. Most rainfall occurs in summer and autumn (388 mm and 295 mm per year, respectively).

The area experiences high relative humidity (%), with the annual average across the region over 80%. Spring has the lowest average humidity (82 % in Ipswich, 84% in Scenic Rim), and winter the highest (89 % in Ipswich, 91% in Somerset).

The region's annual average potential evaporation is almost 50% greater than the annual average rainfall, which contributes to the depletion of soil moisture.

4.5.2 Future climate scenarios

This section provides plausible scenarios of the future climate for the Gold Coast region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking.

In the near future (2030), the annually averaged maximum temperature for the Gold Coast region is projected to increase by at least 0.6 °C, and as much as 1.7 °C above the recent climate (1986–2005). Nighttime minima may become 0.6 – 1.2 °C warmer on average (Table 53).

By 2070, the average maximum daily temperatures are expected to increase by at least 1.2 °C, and as much as 3.2 °C above the recent climate (1986–2005) (Table 53). Nights are projected to also be at least 1.2 °C warmer and as much as 2.2 °C warmer.

Table 53: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Gold Coast region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	**Recent temperatures (1986-2005) °C**		**Mean projected increase in temperatures by 2030 °C**		**Mean projected increase in temperatures by 2070 °C**	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Gold Coast City	16.4	24.2	0.9 (0.6 – 1.2)	0.9 (0.6 – 1.2)	1.6 (1.2 – 2.2)	1.8 (1.2 – 2.5)
Scenic Rim Shire	14.3	24.6	0.9 (0.6 – 1.2)	1.0 (0.6 – 1.7)	1.7 (1.2 – 2.2)	2.1 (1.2 – 3.2)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1 (RCP4.5 scenario). By 2030, annual average maximum temperatures for the Gold Coast region for this high emissions scenario are projected to increase by at least 0.4 °C, and as much as 2.0 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.6 – 1.4 °C warmer on average (Table 54). By 2070, there is considerable divergence between temperatures for the high and low emissions scenarios.

For this high emissions scenario, the projected increase in average maximum daily temperatures across the region is at least 1.7 °C, with some models showing as much as 4.5 °C above the recent climate (1986–2005) (Table 54). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Table 54: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Gold Coast region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	**Recent temperatures (1986-2005) °C**		**Mean projected increase in temperatures by 2030 °C**		**Mean projected increase in temperatures by 2070 °C**	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Gold Coast City	16.4	24.2	0.9 (0.6 – 1.2)	0.9 (0.6 – 1.2)	2.7 (2.1 – 3.6)	2.8 (2.1 – 3.7)
Scenic Rim Shire	14.3	24.6	0.9 (0.6 – 1.3)	1.0 (0.5 – 1.7)	2.9 (2.1 – 3.7)	3.2 (2.2 – 4.4)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Hotter and more frequent hot days

There is likely more than double the number of days over 35 °C across the region by 2070, with the Gold Coast region expecting a bigger increase. Days over 40 °C show a modest increase (Table 55).

Table 55*: Average number of projected additional days over 35 °C and 40 °C for the Gold Coast region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Gold Coast City	1	0	1.2 (-0.1 – 2.3)	0.1 (0 – 0.1)	4.1 (1.1 – 6.5)	0.2 (0.1 – 0.4)
Scenic Rim Shire	4.5	0.1	3.7 (0.1 – 8.9)	0.1 (0 – 0.3)	9.4 (2.5 – 15.9)	0.5 (0 – 1.2)

The Gold Coast region will experience an increase in length, peak temperatures and frequency of heatwaves.

Increasing temperatures will result in more frequent heatwave conditions. By 2030 the average hottest temperature in a heatwave will likely be half a degree hotter and last a little longer with a doubling of the days in a year that are under heatwave conditions (Table 57).

By 2070 the average hottest temperature in a heatwave is expected to increase by 1.6°C (range 0.5-2.8°C) across the region. Individual heatwaves are likely to last 1-2 days longer. The number of days in the year that are heatwave days could increase threefold.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Many more hot days and an increase in very hot days.

For this high emissions scenario, by 2070 there is likely to be four times the days over 35 °C on the Scenic Rim and more than 10 times days over 35 °C on the Gold Coast. There will be an extra day over 40 °C by 2070 (Table 56).

Table 56*: Average number of projected additional days over 35 °C and 40 °C for the Gold Coast region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Gold Coast City	1	0	1.3 (-0.1 – 3.1)	0.1 (0 – 0.2)	11.7 (2.7 – 24.0)	0.4 (0.1 –1.0)
Scenic Rim Shire	4.5	0.1	3.3 (0.1 – 7.2)	0.2 (0 – 0.6)	18.7 (4.8 – 36.3)	1.2 (0.2 – 2.9

The Gold Coast region will experience an increase in length, peak temperatures and frequency of heatwaves.

In the near future, projections of heatwaves are similar for a low emissions scenario. By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with a doubling of the days in a year that are under heatwave conditions (Table 58).

By 2070, however, the average hottest temperatures in a heatwave may have increased by 2.3-2.6°C (range 0.6-4.1°C). Heatwave events are likely to last 3 - 6 days longer. The number of days in the year that are heatwave days could increase by more than 6 times.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 57**: Average change in peak temperature, frequency and duration of heatwaves for the Gold Coast region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days
Gold Coast City	33.4	2.2	4.5	0.5 (-0.1 – 1.3)	2.2 (0.2 – 4.6)	0.8 (-0.8 – 2.1)	1.6 (0.7 – 2.4)	6.9 (2.6 – 10.6)	1.7 (0 – 2.7)
Scenic Rim Shire	34.8	2.3	4.6	0.5 (-0.69 – 1.71)	2.3 (0.6 – 4.6)	0.5 (-1.2 – 1.9)	1.6 (0.5 – 2.8))	6.0 (2.3 – 9.2)	1.1 (-0.8 – 1.9)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost is projected by the end of the century.

Humidity

The Gold Coast region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 59).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 58**: Average change in peak temperature, frequency and duration of heatwaves for the Gold Coast region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days
Gold Coast City	33.4	2.2	4.5	0.3 (-0.5 – 1.5)	2.6 (0.8 – 6.1)	0.7 (-0.8 – 2.3)	2.6 (1.0 – 3.7)	17.9 (8.2 – 29.6)	5.9 (2.2 – 11.6)
Scenic Rim Shire	34.8	2.3	4.6	0.3 (-1.1 – 1.4)	2.2 (0.9 – 5.2)	0.3 (-1.8 – 1.7)	2.3 (0.6 – 4.1)	15.2 (5.4 – 27.6)	3.6 (1 – 8.1)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost days is projected by the end of the century.

Humidity

The Gold Coast region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 60).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 59**: Average change in humidity for the summer months in Gold Coast under region under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity % Historical annual average (1986-2005)	Relative humidity % Change in mean annual relative humidity 2030	Relative humidity % Change in mean annual relative humidity 2070
Gold Coast City	88.5	-0.5 (-3.4 – 0.6)	-0.7 (-4.2 – 0.3)
Scenic Rim Shire	87.2	-1.0 (-6.2 – 1.2)	-1.2 (-5.7 – 0.5)

Fire weather

Harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. Bushfire in the region depends highly on fuel availability, which mainly depends on rainfall. A tendency toward increased fire weather risk is expected in future, due to higher temperature and lower rainfall (Table 61).

Rainfall

Natural climate variability will dominate rainfall patterns

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

By 2070, projections of total rainfall show little change or a possible decrease, particularly in winter and spring. However, the intensity of heavy rainfall events is likely to increase.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 60**: Average change in humidity for the summer months in Gold Coast under region under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity % Historical annual average (1986-2005)	Relative humidity % Change in mean annual relative humidity 2030	Relative humidity % Change in mean annual relative humidity 2070
Gold Coast City	88.5	0.3 (-1.4 – 2.1)	-0.2 (-3.2 – 1.4)
Scenic Rim Shire	87.2	0.1 (-3.5 – 2.6)	-0.7 (-4.4 – 2.1)

Fire weather

Harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. Bushfire in the region depends highly on fuel availability, which mainly depends on rainfall. A tendency toward increased fire weather risk is expected in future, due to higher temperature and lower rainfall (Table 62).

Rainfall

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High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

By 2070, projections of total rainfall show little change or a possible decrease, particularly in winter and spring. However, the intensity of heavy rainfall events is likely to increase.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 61**: Average change in seasonal count of days in each level of fire risk in Gold Coast region for a moderate emission scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Gold Coast City	0.1	0	0	0.1 (-0.4 – 0.5)	0 (0 – 0.1)	0 (0 – 0)	0.2 (0 – 0.7)	0 (0 – 0.1)	0 (0 – 0)
Scenic Rim Shire	5.6	0.6	0	3.3 (-0.3 – 11)	0.5 (-0.2 – 1.8)	0 (0 – 0)	6.3 (-0.2 – 16)	1.2 (0– 4.4)	0 (0 – 0.2)

***Table 63**: Average change in precipitation for Gold Coast under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Gold Coast City	5.8	0 (-0.7 – 0.7)	-0.1 (-0.8 – 0.4)
Scenic Rim Shire	4.0	-0.1 (-0.5 – 0.5)	-01 (-0.6 – 0.3)

Changes to drought are less clear

By late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 62**: Average change in seasonal count of days in each level of fire risk in Gold Coast region for a high emission scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Gold Coast City	0.1	0	0	0 (-0.8 – 0.2)	0 (0 – 0)	0 (0 – 0)	0.1 (0 – 0.5)	0 (0 – 0.2)	0 (0 – 0)
Scenic Rim Shire	5.6	0.6	0	0.7 (-5.3 – 8.4)	0.2 (-1.2 – 1.3)	0 (0 – 0)	6.6 (0.4 – 20.7)	1.3 (0.1 – 3.5)	0.1 (0 – 0.2)

***Table 64**: Average change in precipitation for Gold Coast under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Gold Coast City	5.8	0.2 (-0.5 – 0.7)	0 (-0.6 – 1.1)
Scenic Rim Shire	4.0	0 (-0.4 – 0.3)	0 (-0.4 – 0.5)

Changes to drought are less clear

By late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Future scenario 1 (RCP4.5)

Sea level rise

Sea level will continue to rise

Sea level is projected to rise by as much as 0.6m above present-day levels by 2100 (see Table 65).

Table 65: *Mean sea-level rise (relative to average sea level between 1986-2005) for the Gold Coast region for a given point in time under a moderate emissions scenario RCP4.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised to provide the same level of protection as is experienced today.*

Year	Gold Coast City	
	Sea-level rise (relative to average 1986-2005)	Allowance
2030 (m)	0.14 (09-0.18)	0.15
2050 (m)	0.24 (0.17-0.31)	0.27
2070 (m)	0.36 (0.24-0.48)	0.44
2090 (m)	0.48 (0.31-0.65)	0.66
Rate of change by 2100 (mm/year)	5.9 (3.2-8.7)	N/A

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 2 (RCP8.5)

Sea level rise

Sea level will continue to rise

Sea level is projected to rise by as much as 0.8m above present-day levels by 2100 (see Table 66).

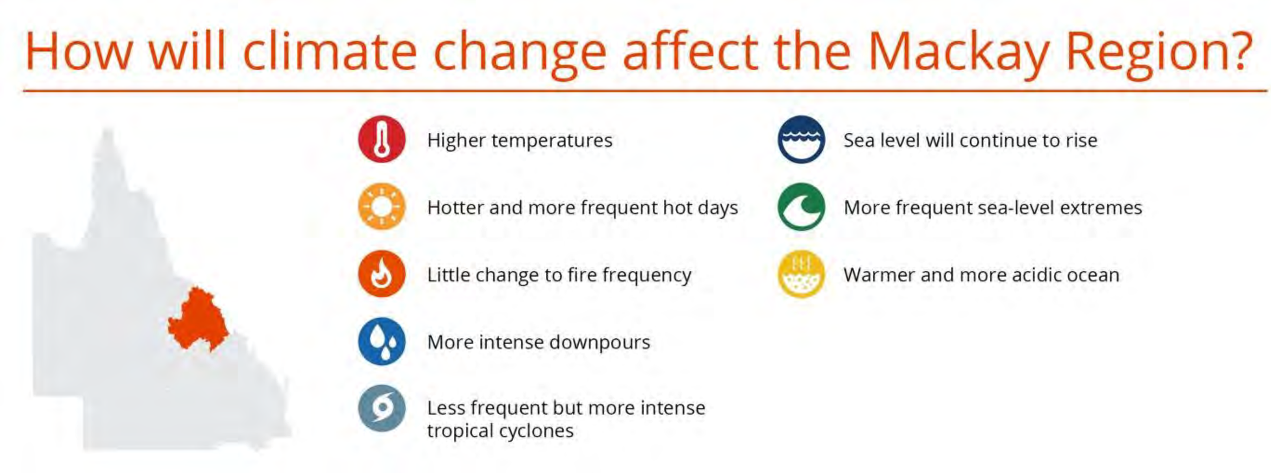
Table 66: *Mean sea-level rise (relative to average sea level between 1986-2005) for the Gold Coast region for a given point in time under a high emissions scenario RCP8.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised to provide the same level of protection as is experienced today.*

Year	Gold Coast City	
	Sea-level rise (relative to average 1986-2005)	Allowance
2030 (m)	0.14 (09-0.18)	0.15
2050 (m)	0.27 (0.19-0.35)	0.31
2070 (m)	0.44 (0.31-0.58)	0.55
2090 (m)	0.66 (0.46-0.88)	0.93
Rate of change by 2100 (mm/year)	11.5 (7.6-16.1)	N/A

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

4.6 Mackay



Centrally located on the Queensland coastline, the Mackay HHS region extends from the Styx River in the south to Cape Upstart in the north, and west beyond the Gregory Highway. The Mackay HHS region includes the local government councils of Barcaldine Regional, Isaac Regional, Mackay Regional and Whitsunday Regional.

4.6.1 Current climate

Summers are generally hot and wet, while the coast has the benefit of regular afternoon sea breezes.

The area experiences a tropical cyclone season from December to April.

The average annual temperature is 22 °C. The summer average is 27 °C, and in winter it is 17 °C.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño–Southern Oscillation. The annual average rainfall is 689 mm, occurring predominantly between November and April.

The region's annual average potential evaporation is more than twice the annual average rainfall, which contributes to the depletion of soil moisture.

4.6.2 Climate projections

This section provides plausible scenarios of the future climate for the Mackay region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking.

In the near future (2030), the annually averaged maximum temperature for the Mackay region is projected to increase by at least 0.3 °C, and as much as 1.9 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.5 °C warmer on average (Table 67).

By 2070, the average maximum daily temperatures are expected to increase by at least 0.8 °C, and as much as 2.9 °C above the recent climate (1986–2005) (Table 67). Nights are projected to also be at least 0.8 °C warmer and as much as 2.6 °C warmer.

Table 67: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Mackay region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Barcaldine Regional	16.9	29.3	1.0 (0.6 – 1.5)	1.1 (0.4 – 1.8)	1.9 (1.2 – 2.6)	2.0 (0.8 – 2.9)
Isaac Regional	17.1	28.2	0.9 (0.6 – 1.4)	1.0 (0.4 – 1.9)	1.8 (1.2 – 2.4)	1.9 (0.9 – 2.8)
Mackay Regional	18.6	26.4	0.8 (0.5 – 1.3)	0.8 (0.5 – 1.3)	1.4 (0.8– 1.9)	1.7 (1.0 – 2.2)
Whitsunday Regional	18.2	24.2	0.8 (0.5 – 1.3)	0.9 (0.3 – 1.7)	1.7 (1.1– 2.3)	1.7 (0.9 – 2.5)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1.

By 2030, annual average maximum temperatures for the Mackay region for this high emissions scenario are projected to increase by at least 0.2 °C, and as much as 1.9 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.5 – 1.5 °C warmer on average (Table 68).

By 2070, the projected increase in average maximum daily temperatures across the region is at least 1.75 °C, with some models showing as much as 4.1 °C above the recent climate (1986–2005) (Table 68). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Table 68: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Mackay region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Barcaldine Regional	16.9	29.3	1.1 (0.5 – 1.5)	1.1 (0.2 – 1.9)	3.2 (2.2 – 4.1)	3.0 (1.5 – 4.1)
Isaac Regional	17.1	28.2	1.0 (0.5 – 1.3)	1.0 (0.2 – 1.9)	2.9 (2.2 – 3.8)	2.9 (1.6 – 3.9)
Mackay Regional	18.6	26.4	0.9 (0.5 – 1.2)	0.9 (0.5 – 1.3)	2.4 (1.8 – 3.1)	2.7 (1.9 – 3.5)
Whitsunday Regional	18.2	24.2	0.9 (0.5 – 1.3)	0.9 (0.3 – 1.8)	2.8 (2.1 – 3.6)	2.7 (1.6 – 3.5)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Hotter and more frequent hot days

There is likely to be a few more weeks of days over 35 °C across the region by 2070, with Mackay experiencing three times the number of days of 35 °C. Days over 40 °C will at least double across the region (Table 69).

***Table 69**: Average number of projected additional days over 35 °C and 40 °C for the Mackay region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Barcaldine Regional	82.8	7.7	23.1 (3.0 – 45.2)	6.4 (0.6 – 11.9)	43.3 (10.6 – 63.2)	16.7 (5.0 – 29.0)
Isaac Regional	45.4	2.3	16.4 (4.4 – 34.7)	2.2 (0.4 – 4.9)	33.2 (9.0 – 52.0)	6.7 (2.3 – 12.0)
Mackay Regional	3.5	0.3	3.5 (1.5 – 7.1)	0.1 (0 – 0.6)	10.6 (2.7 – 19.6)	0.3 (0 – 0.8)
Whitsunday Regional	29.0	0.9	12.8 (1.9 – 25.6)	1.4 (0.1 – 3.0)	28.2 (7.5 – 48.0)	4.2 (1.4 – 7.6)

The Mackay region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with a doubling of the days in a year that are under heatwave conditions (Table 71).

By 2070 the average hottest temperature in a heatwave is expected to increase by 0.9-1.7°C (range 0.3-3.0°C) across the region. Individual heatwaves are likely to last 1-3 days longer. The number of days in the year that are heatwave days is likely to double.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Many more hot days and an increase in very hot days.

For this high emissions scenario, by 2070 there is likely to be several weeks more of days over 35 °C. For the Barcaldine Regional Council this might equate to more than 140 days of the year over 35 °C. For most of the region there might an additional 2-4 weeks' worth of days over 40 °C by 2070 (Table 70). The coast region around Mackay will only experience about 2 additional days of this very hot weather.

***Table 70**: Average number of projected additional days over 35 °C and 40 °C for the Mackay region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Barcaldine Regional	82.8	7.7	24.0 (2.4 – 44.7)	7.1 (1.1 – 11.8)	62.3 (20.9 – 63.2)	32.9 (11.1 –53.7)
Isaac Regional	45.4	0.1	17.2 (3.9 – 35.3)	2.6 (0.6 – 5.0)	51.1 (18.5 – 74.5)	15.9 (4.9 – 30.1)
Mackay Regional	3.5	0.3	4.1 (0.7 – 8.4)	0.1 (0 – 0.4)	28.4 (16.1 – 54.3)	1.6 (0.2 – 4.2)
Whitsunday Regional	29.0	0.9	13.9 (2.3 – 28.3)	1.5 (0.4 – 2.7)	48.8 (16.9 – 72.2)	12.0 (3.4 – 22.1)

The Mackay region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with a doubling of the days in a year that are under heatwave conditions (Table 72).

By 2070 the average hottest temperatures in a heatwave may have increased by 1.8-2.9 °C. Heatwaves are likely to last 4-10 days longer. The number of days in the year that are heatwave days could increase by 5 to 10 times.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 71**: Average change in peak temperature, frequency and duration of heatwaves for the Mackay region. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency ᵅ %	Duration ᶲ Days	Peak temp* °C	Frequency ᵅ %	Duration ᶲ Days	Peak temp* °C	Frequency ᵅ %	Duration ᶲ Days
Barcaldine Regional	41.1	2.9	4.8	0.5 (-0.3 – 1.6)	2.4 (0.4 – 5.2)	0.6 (-0.2 – 1.5)	1.3 (0.3 – 3.0)	6.9 (1.5 – 11.7)	1.6 (0.7 – 3.0)
Isaac Regional	38.9	2.5	4.6	0.6 (-0.3 – 2.2)	2.2 (0.9 – 4.2)	0.6 (0.1 – 1.1)	1.5 (0.2 – 3.0)	6.7 (1.7 – 11.6)	1.7 (0.7 – 3.0)
Mackay Regional	35	2.1	4.6	0.4 (-0.4 – 1.7)	2.2 (1.3 – 3.7)	1.0 (0.5 – 1.4)	0.9 (0 – 1.6)	7.8 (2.4 – 14.6)	2.6 (0.6 – 4.0)
Whitsunday Regional	37.7	2.5	4.7	0.8 (-0.2 – 2.1)	2 (0.2 – 3.9)	0.7 (-0.3 – 1.5)	1.7 (0.4 – 2.7)	6.6 (1.8 – 11.2)	1.9 (0.8 – 3.0)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
ᵅNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 72:** Average change in peak temperature, frequency and duration of heatwaves for the Central Queensland region. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency ᵅ %	Duration ᶲ Days	Peak temp* °C	Frequency ᵅ %	Duration ᶲ Days	Peak temp* °C	Frequency ᵅ %	Duration ᶲ Days
Barcaldine Regional	41.1	2.9	4.8	0.7 (-0.1 – 1.6)	2.8 (0.4 – 4.9)	0.6 (-0.3 – 1.5)	2.2 (0.7 – 3.4)	15.4 (6.4 – 24.7)	4.2 (1.7 – 7.7)
Isaac Regional	38.9	2.5	4.6	0.7 (-0.5 – 1.8)	2.6 (0.2 – 4.6)	0.8 (-0.5 – 1.6)	2.5 (0.8 – 4.0)	18.0 (8.4 – 30.9)	5.3 (2.4 – 11.3)
Mackay Regional	35	2.1	4.6	0.4 (-0.1 – 0.9)	2.8 (0.7 – 6.4)	0.9 (-0.3 – 2.3)	1.8 (0.7– 3.1)	23.3 (14.1 – 37.2)	9.6 (4.5 – 20.2)
Whitsunday Regional	37.7	2.5	4.7	0.8 (0.2 – 1.8)	2.4 (0.3 – 4.5)	0.7 (-0.8 – 1.9)	2.9 (1.1– 4.6)	19.6 (8.5 – 35.8)	6.6 (2.5 – 15.4)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
ᵅNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Humidity

The Central Queensland region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 73).

Humidity

The Central Queensland region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 74).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 73**: Average change in humidity for the summer months in Mackay under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Barcaldine Regional	68.5	-1.8 (-10.9 – 2.1)	-1.7 (-9.2 – 3.2)
Isaac Regional	78.8	-1.5 (-9.0 – 1.4)	-1.6 (-7.7 – 1.2)
Mackay Regional	88.7	-0.6 (-3.8 – 1.3)	-0.8 (-3.8 – 0.6)
Whitsunday Regional	82.9	-1 (-6.3 – 1.6)	-1.1 (-5.9 – 1.0)

Fire weather

Little change in fire frequency

There is likely to be little change to fire frequency. However, when and where fire does occur, its behaviour is likely to be more extreme (Table 75).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 74**: Average change in humidity for the summer months in Mackay under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Barcaldine Regional	68.5	-0.9 (-7.5 – 3.0)	-0.5 (-6.9 – 4.6)
Isaac Regional	78.8	-0.8 (-6.6 – 1.3)	-1.1 (-6.3 – 2.0)
Mackay Regional	88.7	-0.4 (-3.2 – 0.6)	-0.8 (-3.3 – 0.9)
Whitsunday Regional	82.9	0.6 (-5.4 – 1.4)	-0.9 (-4.9 – 1.8)

Fire weather

Little change in fire frequency

There is likely to be little change to fire frequency. However, when and where fire does occur, its behaviour is likely to be more extreme (Table 76).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 75**: Average change in seasonal count of days in each level of fire risk in Mackay region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Barcaldine Regional	112.2	51.7	1.7	2.5 (-12.1 – 16.0)	14 (-0.4–40.4)	1.1 (0 – 3.9)	4.5 (-8.4 – 17.0)	22.0 (-1.5 – 49.7)	2.3 (-0.2 – 5.6)
Isaac Regional	73.9	23.7	0.2	6.5 (-6.9 – 22.5)	8.2 (-0.8 – 28.1)	0.2 (-0.2 – 0.8)	10 (-2.0 – 25.6)	14.2 (-1.2– 38.5)	0.5 (-0.1 – 1.3)
Mackay Regional	3.8	0.2	0	1.2 (-0.4 – 5.8)	0.1 (0 – 0.8)	0 (0 – 0)	2.2 (-0.3 – 5.4)	0.2 (-0.1 – 0.6)	0 (0 – 0)
Whitsunday Regional	55.0	14.4	0.1	6.2 (-4.1 – 23.9)	4.4 (-1.2 – 16.1)	0.2 (0 – 0.5)	9.4 (-1.1 – 28.5)	8.3 (-1.3 – 22.4)	0.3 (-0.1 – 0.3)

Rainfall

More intense downpours

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades. Total rainfall may change but may be either wetter or drier. The intensity of heavy rainfall events is expected to increase.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 76**: Average change in seasonal count of days in each level of fire risk in Mackay region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Barcaldine Regional	112.2	51.7	1.7	2.5 (-18.8 – 16.8)	8.9 (-4.8–31.6)	0.9 (-0.8 – 2.5)	5.3 (-24.4–19.6)	23.0 (-1.8 – 46.9)	2.7 (0 – 7.2)
Isaac Regional	73.9	23.7	0.2	5.1 (-9.2 – 29.2)	5.2 (-1.1 – 22.2)	0.2 (-0.1 – 1.0)	10.8 (-8.7 – 28.3)	16.2 (-2.1 – 37.7)	0.6 (0 – 2.0)
Mackay Regional	3.8	0.2	0	1.0 (-0.4 – 4.5)	0.1 (-0.1 – 0.4)	0 (0 – 0)	3.2 (-0.2 – 8.2)	0.3 (-0.1 – 0.7)	0 (0 – 0)
Whitsunday Regional	55.0	14.4	0.1	4.6 (-5.1 – 27.0)	3.1 (-0.7 – 13.4)	0.1 (0 – 0.7)	11.4 (-5.6 – 31.3)	10.2 (-2.0 – 24.7)	0.4 (0 – 1.0)

Rainfall

More intense downpours

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades. Total rainfall may change but may be either wetter or drier. The intensity of heavy rainfall events is expected to increase.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 78**: Average change in precipitation for Mackay under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Barcaldine Regional	1.6	-0.1 (-0.3 – 0.2)	-0.1 (-0.2 – 0.2)
Isaac Regional	2.4	-0.1 (-0.6 – 0.2)	-0.1 (-0.4 – 0.1)
Mackay Regional	5.7	-0.1 (-1.0 – 0.5)	-0.2 (-0.6 – 0.2)
Whitsunday Regional	3.6	-0.1 (-0.8 – 0.3)	-0.1 (-0.7 – 0.1)

Tropical cyclones

Less intense, but more frequent tropical cyclones

Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.

Sea level rise

Sea level will continue to rise

Sea level is projected to rise by as much as 0.6m above present-day levels by 2100 (see Table 79).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 78**: Average change in precipitation for Mackay under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Barcaldine Regional	1.6	0 (-0.3 – 0.2)	0 (-0.1 – 0.3)
Isaac Regional	2.4	-0.1 (-0.5 – 0.2)	0 (-0.4 – 0.4)
Mackay Regional	4.0	0 (-0.8 – 0.9)	-0.1 (-0.9 – 0.9)
Whitsunday Regional	3.6	0 (-0.8 – 0.5)	0 (-0.6 – 0.7)

Tropical cyclones

Less intense, but more frequent tropical cyclones

Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.

Sea level rise

Sea level will continue to rise

Sea level is projected to rise by as much as 0.8m above present-day levels by 2100 (see Table 80).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Table 79: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Mackay Region under a moderate emissions scenario RCP4.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Mackay Regional Council		Whitsunday Regional Council	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.15 (09-0.18)	0.14	0.13 (09-0.18)	0.14
2050 (m)	0.24 (0.16-0.31)	0.25	0.24 (0.16-0.31)	0.25
2070 (m)	0.35 (0.23-0.47)	0.38	0.35 (0.23-0.47)	0.39
2090 (m)	0.47 (0.30-0.65)	0.53	0.47 (0.30-0.64)	0.55
Rate of change by 2100 (mm/year)	5.9 (3.1-8.7)	N/A	5.9 (3.2-8.7)	N/A

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Warmer and more acidic ocean

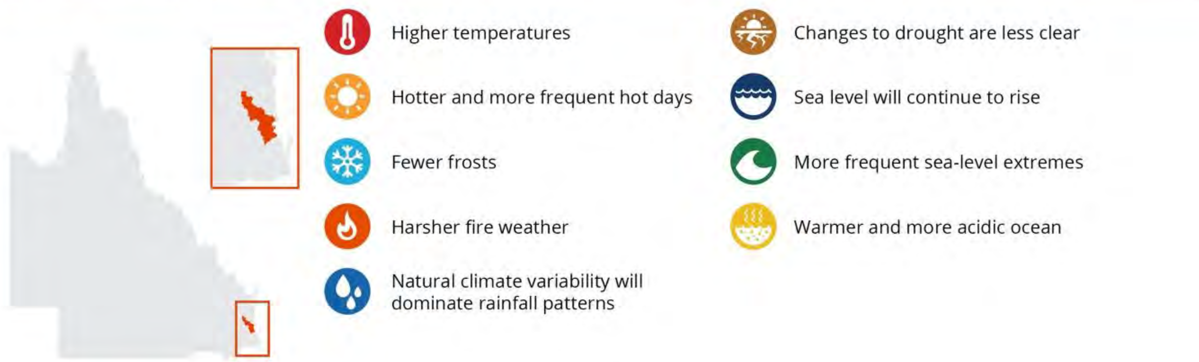
Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Table 80: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Mackay Region under a high emissions scenario RCP8.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Mackay Regional Council		Whitsunday Regional Council	
	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.13 (09-0.18)	0.14	0.14 (09-0.18)	0.14
2050 (m)	0.27 (0.19-0.35)	0.28	0.267 (0.19-0.35)	0.28
2070 (m)	0.44 (0.31-0.58)	0.47	0.44 (0.31-0.58)	0.48
2090 (m)	0.65 (0.45-0.87)	0.73	0.65 (0.45-0.87)	0.76
Rate of change by 2100 (mm/year)	11.5 (7.5-16.1)	N/A	11.4 (7.4-16.2)	N/A

4.7 Metro North

How will climate change affect the Metro North Region?



The Metro North HHS region is in southeast Queensland and includes the local government councils of Moreton Bay City, Brisbane City and Somerset Regional.

4.7.1 Current climate

South East Queensland has a sub-tropical climate influenced by tropical systems from the north and fluctuations in the high-pressure ridge to the south.

The average annual temperature is 19 °C with summer average temperature 24 °C, autumn and spring 20 °C, and winter 14 °C.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño– Southern Oscillation. Most rainfall occurs in summer and autumn (388 mm and 295 mm per year, respectively).

The region's annual average potential evaporation is almost 50% greater than the annual average rainfall, which contributes to the depletion of soil moisture.

4.7.2 Climate projections

This section provides plausible scenarios of the future climate for the Metro North region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking.

In the near future (2030), the annually averaged maximum temperature for the Metro North region is projected to increase by at least 0.6 °C, and as much as 1.7 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.2 °C warmer on average (Table 81).

By 2070, the average maximum daily temperatures are expected to increase by at least 1.2 °C, and as much as 3.2 °C above the recent climate (1986–2005) (Table 81). Nights are projected to also be at least 1.2 °C warmer and as much as 2.3 °C warmer.

Table 81: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Metro North region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Moreton Bay City	15.9	24.6	0.9 (0.6 – 1.2)	0.9 (0.7 – 1.3)	1.7 (1.2 – 2.2)	1.9 (1.2 – 2.6)
Brisbane City	16.5	24.8	0.9 (0.6 – 1.2)	1.0 (0.6 – 1.2)	0.9 (1.2 – 2.2)	0.9 (1.1 – 2.5)
Somerset Shire	14.4	24.8	0.9 (0.5 – 1.2)	1.0 (0.6 – 1.7)	1.7 (1.2– 2.3)	2.1 (1.2 – 3.2)

Hotter and more frequent hot days

There is likely to be more than double the number of days over 35 °C across the region by 2070, Days over 40 °C show a modest increase (Table 83).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1.

By 2030, annual average maximum temperatures for the Metro North region for this high emissions scenario are projected to increase by at least 0.4 °C, and as much as 1.6 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.6 – 1.3 °C warmer on average (Table 82).

By 2070, the projected increase in average maximum daily temperatures across the region is at least 2.0 °C, with some models showing as much as 4.4 °C above the recent climate (1986–2005) (Table 82). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Table 82: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Metro North region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Moreton Bay City	15.9	24.6	0.9 (0.6 – 1.2)	0.9 (0.6 – 1.3)	2.8 (2.1 – 3.7)	3.0 (2.2 – 3.9)
Brisbane City	16.5	24.8	0.9 (0.6 – 1.2)	0.9 (0.6 – 1.2)	2.8 (2.1 – 3.7)	2.8 (2.0 – 3.7)
Somerset Shire	14.4	24.8	0.9 (0.6 – 1.3)	1.0 (0.4 – 1.6)	2.9 (2.2 – 3.8)	3.2 (2.1 – 4.4)

Many more hot days and an increase in very hot days.

For this high emissions scenario, by 2070 there is likely to be four to six times the number of days over 35 °C. Days over 40 °C will still be uncommon by 2070 (Table 84).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 83**: Average number of projected additional days over 35 °C and 40 °C for Metro North region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Moreton Bay City	1.6	0	1.5 (-0.1 – 3.3)	0 (0 – 0.1)	4.9 (1.7 – 7.0)	0.1 (0 – 0.3)
Brisbane City	2.1	0	1.7 (0 – 3.7)	0.1 (0 – 0.1)	5.4 (2.1 – 8.0)	0.2 (0.1 – 0.6)
Somerset Shire	6.3	0.1	4.5 (0.1 – 9.9)	0.2 (0 – 0.6)	11.9 (4.4 – 18.8)	0.7 (0 – 1.9)

The Metro North region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with twice the number days in a year that are under heatwave conditions (Table 85).

By 2070 the average hottest temperature in a heatwave is expected to increase by 1.5 °C (range 0.5-2.4°C) across the region. Individual heatwaves are likely to last 1-2 days longer. There might be two to three times the number of days in the year that are heatwave days (Table 85).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 84**: Average number of projected additional days over 35 °C and 40 °C for the Metro North region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Moreton Bay City	1.6	0	1.3 (-0.5 – 3.5)	0 (0 – 0.2)	12.1 (2.9 – 26.2)	0.3 (0 –0.8)
Brisbane City	2.1	0	1.7 (-0.4 – 5.0)	0.1 (0 – 0.2)	13.75 (3.9 – 29.6)	0.4 (0.1 –0.9)
Somerset Shire	6.3	0.1	4.0 (-0.4 – 9.5)	0.3 (-0 – 0.2)	23.9 (7.6 – 45.5)	1.6 (0.2 – 3.5)

The Metro North region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with almost twice the number of days in a year that are under heatwave conditions (Table 86).

By 2070 the average hottest temperatures in a heatwave may have increased by 2.3°C. Heatwaves are likely to last three to six days longer. The number of days in the year that are heatwave days could increase by seven to eight times the number (Table 86).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 85**: Average change in peak temperature, frequency and duration of heatwaves for the Metro North region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Duration ɸ Days	Peak temp* °C	Frequency α %	Duration ɸ Days	Peak temp* °C	Frequency α %	Duration ɸ Days
Moreton Bay City	33.9	2.1	4.5	0.4 (-0.6 – 1.1)	2.1 (0.3 – 4.7)	0.8 (-0.6 – 2.4)	1.5 (0.5 – 2.2)	6.5 (2.7 – 11.0)	1.7 (0.3 – 2.8)
Brisbane City	33.9	2.2	4.5	0.5 (0.1 – 1.1)	2.2 (0.3 – 4.4)	0.8 (-0.8 – 2.1)	1.5 (0.7 – 2.4)	6.6 (2.3 – 10.5)	1.7 (0.1 – 2.7)
Somerset Shire	35.7	2.3	4.5	0.5 (-0.8 – 1.6)	2 (0.4 – 4.2)	0.4 (-0.9 – 1.9)	1.5 (0.6 – 2.3)	5.5 (1.7 – 9)	1 (-0.6 – 1.8)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ɸAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost is projected by the end of the century.

Humidity

The Metro North region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 87).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 86**: Average change in peak temperature, frequency and duration of heatwaves for the Metro North region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Duration ɸ Days	Peak temp* °C	Frequency α %	Duration ɸ Days	Peak temp* °C	Frequency α %	Duration ɸ Days
Moreton Bay City	33.9	2.1	4.5	0.3 (-0.9 – 1.5)	2.4 (1.0 – 5.7)	0.6 (-0.8 – 2.6)	2.3 (0.8 – 3.3)	17.2 (8.3 – 29.4)	5.6 (2.5 – 11.3)
Brisbane City	33.9	2.2	4.5	0.4 (-0.3 – 1.3)	2.5 (0.9 – 5.6)	0.6 (-1.0 – 2.3)	2.3 (1.4 – 3.5)	17.0 (8.6 – 28.5)	5.5 (2.2 – 11.1)
Somerset Shire	35.7	2.3	4.5	0.3 (-0.9 – 1.5)	2 (0.5 – 4.9)	0.3 (-1.4 – 1.7)	2.3 (0.7– 3.8)	14.5 (5.8 – 26.3)	3.4 (0.9 – 7.9)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ɸAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost days is projected by the end of the century.

Humidity

The Metro North region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 88).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 87: *Average change in humidity for the summer months in Metro North under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	**Relative humidity %**	**Relative humidity %**	**Relative humidity %**
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Moreton Bay City	89.3	-0.6 (-4.5 – 0.5)	-0.8 (-4.4 – 0.2)
Brisbane City	84.1	-0.4 (-3.9 – 1.0)	-0.7 (-4.3 – 0.4)
Somerset Shire	87.3	-1 (-6.2 – 1.3)	-1.3 (-5.7 – 0.9)

Fire weather

Harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. The Somerset Shire will likely see more high fire risk days (Table 89).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 88: *Average change in humidity for the summer months in Metro North under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	**Relative humidity %**	**Relative humidity %**	**Relative humidity %**
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Moreton Bay City	89.3	0.3 (-1.8 – 2.1)	-0.6 (-3.4 – 1.1)
Brisbane City	84.1	0.3 (-1.8 – 2.0)	-0.3 (-3.3 – 1.2)
Somerset Shire	87.3	0.1 (-2.8 – 1.8)	-1.0 (-4.8 – 1.5)

Fire weather

Climate change will result in harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. Somerset Shire will likely see more high fire risk days (Table 90).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 89**: Average change in seasonal count of days in each level of fire risk in Metro North region for RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Moreton Bay City	0.4	0	0	0.3 (-0.4 – 1.5)	0.1 (0– 0.2)	0 (0 – 0)	0.7 (0 – 2.7)	0.1 (0 – 0.5)	0 (0 – 0)
Brisbane City	0.8	0.1	0	0.4 (-0.2 – 2.0)	0.1 (-0.1– 0.3)	0 (0 – 0)	1.0 (0 – 5.1)	0.2 (0 – 0.6)	0 (0 – 0)
Somerset Shire	7.6	0.9	0	3.2 (-0.4 – 11.7)	0.5 (-0.2 – 2.8)	0 (0 – 0)	6 (-0.3 – 21.9)	1.4 (0 – 5.5)	0 (0 – 0.2)

Rainfall

Natural climate variability will dominate rainfall patterns

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

By 2070, projections of total rainfall show little change or a decrease, particularly in winter and spring. However, the intensity of heavy rainfall events is likely to increase.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 90**: Average change in seasonal count of days in each level of fire risk in Metro North region for RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Moreton Bay City	8.3	1	0	0 (-1.5 – 0.7)	0 (-0.2– 0.2)	0 (0 – 0)	0.6 (0– 2.5)	0.1 (0 – 0.4)	0 (0 – 0)
Brisbane City	0.8	0.1	0	-0.1 (-2.1 – 1.2)	0 (-0.3– 0.1)	0 (0 – 0)	1.1 (0 1– 4.1)	0.2 (0 – 0.5)	0 (0 – 0.1)
Somerset Shire	7.6	0.9	0	0.4 (-7.3 – 7.1)	0.2 (-1.6 – 1.4)	0 (0 – 0)	6.8 (0.1 – 18.5)	6.8 (0.1 – 5.1)	0 (0 – 0.2)

Rainfall

Natural climate variability will dominate rainfall patterns

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

By 2070, projections of total rainfall show little change or a decrease, particularly in winter and spring. However, the intensity of heavy rainfall events is likely to increase.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 91**: Average change in precipitation for Metro North under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Moreton Bay City	5.6	-0 (-0.6 – 1.0)	-0.1 (-0.8 – 0.4)
Brisbane City	5.1	-0 (-0.6 – 0.9)	-0.1 (-0.7 – 0.4)
Somerset Shire	3.7	-0.1 (-0.5 – 0.5)	-0.1 (-0.4 – 0.5)

Changes to drought are less clear

By late this century, it is likely that eastern parts of the region will experience more time in drought.

Sea level rise

Sea level will continue to rise

Sea level is projected to rise by as much as 0.6m above present-day levels by 2100 (see Table 93).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 92**: Average change in precipitation for Metro North under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Moreton Bay City	5.6	0.1 (-0.7 – 0.8)	0 (-0.6 – 1.1)
Brisbane City	5.1	0.1 (-0.7 – 0.6)	0 (-0.6 – 1.1)
Somerset Shire	3.7	0 (-0.4 – 0.5)	0 (-0.4 – 0.7)

Changes to drought are less clear

By late this century, under a high emissions scenario, it is likely that eastern parts of the region will experience more time in drought.

Sea level rise

Sea level will continue to rise

Sea level is projected to rise by as much as 0.8m above present-day levels by 2100 (see Table 94).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 93: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Metro North Region under a moderate emissions scenario. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Brisbane City		Moreton Bay	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.14 (09-0.18)	0.15	0.13 (09-0.18)	0.14
2050 (m)	0.24 (0.17-0.32)	0.27	0.24 (0.16-0.31)	0.27
2070 (m)	0.36 (0.24-0.48)	0.43	0.35 (0.23-0.47)	0.43
2090 (m)	0.48 (0.31-0.65)	0.64	0.47 (0.30-0.65)	0.63
Rate of change by 2100 (mm/year)	6.0 (3.2-8.7)	N/A	5.9 (3.2-8.6)	N/A

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

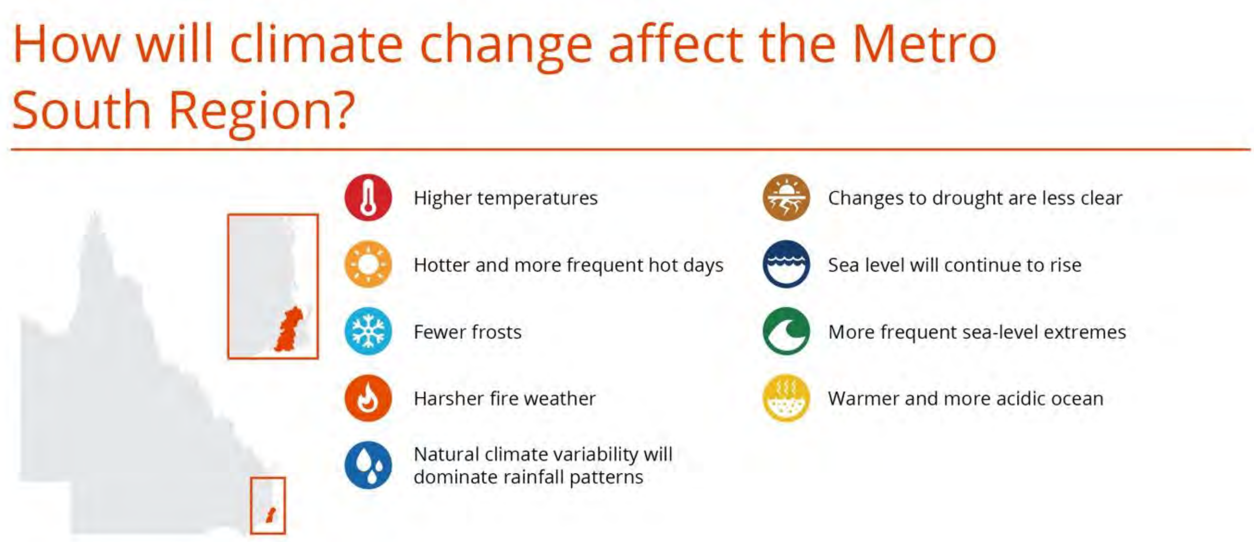
Table 94: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Mackay Region under a high emissions scenario. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Brisbane City		Moreton Bay	
	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.14 (09-0.18)	0.15	0.13 (09-0.18)	0.14
2050 (m)	0.27 (0.19-0.35)	0.31	0.27 (0.19-0.35)	0.30
2070 (m)	0.44 (0.31-0.58)	0.54	0.44 (0.31-0.58)	0.54
2090 (m)	0.66 (0.46-0.88)	0.90	0.63 (0.45-0.87)	0.89
Rate of change by 2100 (mm/year)	11.5 (7.6-16.1)	N/A	11.4 (7.5-16)	N/A

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

4.8 Metro South (including Children's Health Queensland and Mater Public Hospitals)



The Metro South HHS region is in southeast Queensland and includes the local government councils of Brisbane City, Logan City, Redland City and parts of Scenic Rim.

4.8.1 Current climate

South East Queensland has a sub-tropical climate influenced by tropical systems from the north and fluctuations in the high-pressure ridge to the south.

The average annual temperature is 19 °C with summer average temperature 24 °C, autumn and spring 20 °C, and winter 14 °C.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño– Southern Oscillation. Most rainfall occurs in summer and autumn (388 mm and 295 mm per year, respectively).

The region's annual average potential evaporation is almost 50% greater than the annual average rainfall, which contributes to the depletion of soil moisture.

4.8.2 Climate projections

This section provides plausible scenarios of the future climate for the Metro South region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, the second scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in this column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in the atmosphere stabilises (RCP4.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking.

In the near future (2030), the annually averaged maximum temperature for the Metro South region is projected to increase by at least 0.6 °C, and as much as 1.7 °C above the recent climate (1986–2005). Nighttime minima may become 0.6 – 1.3 °C warmer on average (Table 95).

By 2070, the average maximum daily temperatures are expected to increase by at least 1.1 °C, and as much as 3.2 °C above the recent climate (1986–2005) (Table 95). Nights are projected to also be at least 1.1 °C warmer and as much as 2.3 °C warmer.

Table 95: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Metro South region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Brisbane City	16.5	24.8	0.9 (0.6 – 1.2)	1.0 (0.6 – 1.2)	0.9 (1.2 – 2.2)	0.9 (1.1 – 2.5)
Logan City	15.3	25.0	0.9 (0.6 – 1.3)	0.9 (0.6 – 1.5)	1.7 (1.2 – 2.3)	1.9 (1.2 – 3.0)
Redland City	18.4	23.8	0.8 (0.6 – 1.2)	0.8 (0.6 – 1.1)	1.6 (1.1 – 2.1)	1.6 (1.1 – 2.1)
Scenic Rim Shire	14.3	24.6	0.9 (0.6 – 1.2)	1.0 (0.6 – 1.7)	1.7 (1.2 – 2.2)	2.1 (1.2 – 3.2)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1.

By 2030, annual average maximum temperatures for the Metro South region for this high emissions scenario are projected to increase by at least 0.5 °C, and as much as 1.7 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.6 – 1.3 °C warmer on average (Table 96).

By 2070, the projected increase in average maximum daily temperatures across the region is at least 1.9 °C, with some models showing as much as 4.4 °C above the recent climate (1986–2005) (Table 96). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Table 96: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Metro South region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Brisbane City	16.5	24.8	0.9 (0.6 – 1.2)	0.9 (0.6 – 1.2)	2.8 (2.1 – 3.7)	2.8 (2.0 – 3.7)
Logan City	15.3	25.0	1.0 (0.6 – 1.2)	0.9 (0.6 – 1.5)	2.9 (2.2 – 3.8)	3.0 (2.1 – 4.0)
Redland City	18.4	23.8	0.9 (0.6 – 1.2)	0.9 (0.6 – 1.1)	2.6 (2.0 – 3.5)	2.6 (1.9 – 3.3)
Scenic Rim Shire	14.3	24.6	0.9 (0.6 – 1.3)	1.0 (0.5 – 1.7)	2.9 (2.1 – 3.7)	3.2 (2.2 – 4.4)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in the atmosphere stabilises (RCP4.5)

Hotter and more frequent hot days

There is likely to be at least twice as many days over 35 °C across the region by 2070. Days over 40 °C show a modest increase (Table 97).

***Table 97**: Average number of projected additional days over 35 °C and 40 °C for the Metro South region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Brisbane City	2.1	0	1.7 (0 – 3.7)	0.1 (0 – 0.1)	5.4 (2.1 – 8.0)	0.2 (0.1 – 0.6)
Logan City	2.7	0.1	2.3 (-0.4 – 6.1)	0.1 (-0.1 – 0.1)	6.6 (2.3 – 9.6)	0.4 (0.1 – 1.0)
Redland City	0.7	0	1.6 (0.3 – 2.9)	0 (0 – 0.1)	5.8 (1.3 – 9.3)	0.1 (0 – 0.1)
Scenic Rim Shire	4.5	0.9	3.7 (0.1 – 8.9)	0.1 (0 – 0.3)	9.4 (2.5 – 15.9)	0.5 (0 – 1.2)

The Metro South region will experience an increase in length, peak temperatures and frequency of heatwaves

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with a doubling of the days in a year that are under heatwave conditions (Table 99).

By 2070 the average hottest temperature in a heatwave is expected to increase by 1.5-2.0°C (range 0.3-3.0°C) across the region. Individual heatwaves are likely to last 1-23 days longer. The number of days in the year that are heatwave days could increase by three times.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Many more hot days and an increase in very hot days.

For this high emissions scenario, by 2070 there is likely to be at least four times as many days over 35 °C with Redland Bay likely to have 20 more days over 35 °C. Days over 40 °C show a modest increase by 2070 (Table 98).

***Table 98**: Average number of projected additional days over 35 °C and 40 °C for the Metro South region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Brisbane City	2.1	0	1.7 (-0.4 – 5.0)	0.1 (0 – 0.2)	13.75 (3.9 – 29.6)	0.4 (0.1 –0.9)
Logan City	2.7	0.1	2.2 (-0.5 – 6.0)	0.2 (0 – 0.4)	15.3 (2.5 – 34.6)	0.7 (0.1 – 1.5)
Redland City	0.7	0	1.6 (0.6 – 4.1)	0 (0 – 0)	22.5 (6.7 – 41.5)	0.1 (0 – 0.3)
Scenic Rim Shire	4.5	0.1	3.3 (0.1 – 7.2)	0.2 (0 – 0.6)	18.7 (4.8 – 36.3)	1.2 (5.0 – 30.1)

The Metro South region will experience an increase in length, peak temperatures and frequency of heatwaves

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with a doubling of the number of days in a year that are under heatwave conditions (Table 100).

By 2070 the average hottest temperatures in a heatwave may have increased by 2.3 – 3.0°C. Heatwave events are likely to last 4 - 9 days longer. The number of days in the year that are heatwave days could increase by seven times or more.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in the atmosphere stabilises (RCP4.5)

***Table 99**: Average change in peak temperature, frequency and duration of heatwaves for the moderate emissions scenario RCP4.5 in the Metro South region. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days
Brisbane City	33.9	2.2	4.5	0.5 (0.1 – 1.1)	2.2 (0.3 – 4.4)	0.8 (-0.8 – 2.1)	1.5 (0.7 – 2.4)	6.6 (2.3 – 10.5)	1.7 (0.1 – 2.7)
Logan City	34.6	2.3	4.6	0.4 (-0.4 – 1.3)	2.1 (0.1 – 4.8)	0.5 (-1.3 – 2.3)	1.5 (0.3 – 2.7)	5.9 (2.1 – 9.2)	1.2 (-0.6 – 2.1)
Redland City	32.9	2.4	4.8	0.9 (0.5 – 1.4)	3.0 (0.7 – 4.9)	1.1 (-0.6 – 3.0)	2.0 (1.1 – 3.0)	9.1 (3.3 – 13.3)	2.9 (0.5 – 4.2)
Scenic Rim Shire	34.8	2.3	4.6	0.5 (-0.7 – 1.7)	2.3 (0.6 – 4.6)	0.5 (-1.2 – 1.9)	1.6 (0.5 – 2.8)	6.0 (2.3 – 9.2)	1.1 (-0.8 – 1.9)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost is projected by the end of the century.

Humidity

The Metro South region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 101).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 100**: Average change in peak temperature, frequency and duration of heatwaves for the Metro South region. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days
Brisbane City	33.9	2.2	4.5	0.4 (-0.3 – 1.3)	2.5 (0.9 – 5.6)	0.6 (-1.0 – 2.3)	2.3 (1.4 – 3.5)	17.0 (8.6 – 28.5)	5.5 (2.2 – 11.1)
Logan City	34.6	2.3	4.6	0.3 (-0.9 – 1.5)	2.2 (0.3 – 5.1)	0.4 (-1.5 – 1.7)	2.3 (0.6 – 3.8)	15.8 (6.1 – 28.0)	4.2 (0.9 – 9.0)
Redland City	32.9	2.4	4.8	0.8 (0.2 – 1.7)	3.8 (1.7 – 8.3)	1.3 (0.1 – 3.8)	3.0 (2.2 – 3.8)	21.4 (12 – 32.3)	9.5 (4.1 – 17.3)
Scenic Rim Shire	34.8	2.3	4.6	0.3 (-1.1 – 1.4)	2.2 (0.9 – 5.2)	0.3 (-1.8 – 1.7)	2.3 (0.6 – 4.1)	15.2 (5.4 – 27.6)	3.6 (1 – 8.1)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost days is projected by the end of the century.

Humidity

The Metro South region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 102).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in the atmosphere stabilises (RCP4.5)

***Table 101**: Average change in humidity for the summer months in Metro South under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Brisbane City	84.1	-0.4 (-3.9 – 1.0)	-0.7 (-4.3 – 0.4)
Logan City	87.0	-0.8 (-5.8 – 2.0)	-1.1 (-5.9 – 0.9)
Redland City	84.0	-0.1 (-2.1 – 1.0)	-0.1 (-3.9 – 1.0)
Scenic Rim Shire	87.2	-1.0 (-6.2 – 1.2)	-1.2 (-5.7 – 0.5)

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 103).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 102**: Average change in humidity for the summer months in Metro South under under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Brisbane City	84.1	0.3 (-1.8 – 2.0)	-0.3 (-3.3 – 1.2)
Logan City	87.0	-0.3 (-3.2 – 3.4)	-0.9 (-4.6 – 1.9)
Redland City	84.0	-0.4 (-0.6 – 1.9)	0.6 (-1.9 – 1.7)
Scenic Rim Shire	87.2	0.1 (-3.5 – 2.6)	-0.7 (-4.4 – 2.1)

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 104).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in the atmosphere stabilises (RCP4.5)

***Table 103**: Average change in seasonal count of days in each level of fire risk in Metro South region for RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Brisbane City	0.8	0.1	0	0.4 (-0.2 – 2.0)	0.1 (-0.1– 0.3)	0 (0 – 0)	1.0 (0 – 5.1)	0.2 (0 – 0.6)	0 (0 – 0)
Logan City	1.8	0.2	0	1.5 (-0.1 – 6.0)	0.1 (-0.4– 0.6)	0 (0 – 0.1)	3.1 (0 – 12.7)	0.3 (0 – 1.0)	0 (0 – 0)
Redland City	0.1	0	0	0 (-0.1 – 0.3)	0 (0 – 0)	0 (0 – 0)	0 (0 – 0.2)	0 (0 – 0.1)	0 (0 – 0)
Scenic Rim Shire	5.6	0.6	0	3.3 (-0.3 – 11)	0.5 (-0.2 – 1.8)	0 (0 – 0)	6.3 (-0.2 – 16)	1.2 (0– 4.4)	0 (0 – 0.2)

Rainfall

Natural climate variability will dominate rainfall patterns.

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

By 2070, projections of total rainfall show little change or a decrease, particularly in winter and spring. However, the intensity of heavy rainfall events is likely to increase.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 104**: Average change in seasonal count of days in each level of fire risk in Metro South region for RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Brisbane City	0.8	0.1	0	-0.1 (-2.1 – 1.2)	0 (-0.3– 0.1)	0 (0 – 0)	1.1 (0 1– 4.1)	0.2 (0 – 0.5)	0 (0 – 0.1)
Logan City	1.8	0.2	0	0.1 (-4.3 – 3.4)	0 (-0.8– 0.3)	0 (0 – 0)	3.5 (0.2 – 10.4)	0.3 (0 – 0.7)	0 (0 – 0.1)
Redland City	0.1	0	0	0 (-0.3 – 0)	0 (0 – 0)	0 (0 – 0)	0.1 (0 – 0.2)	0 (0 – 0.1)	0 (0 – 0)
Scenic Rim Shire	5.6	0.6	0	0.7 (-5.3 – 8.4)	0.2 (-1.2 – 1.3)	0 (0 – 0)	6.6 (0.4 – 20.7)	1.3 (0.1 – 3.5)	0.1 (0 – 0.2)

Rainfall

Natural climate variability will dominate rainfall patterns.

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

By 2070, projections of total rainfall show little change or a decrease, particularly in winter and spring. However, the intensity of heavy rainfall events is likely to increase.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in the atmosphere stabilises (RCP4.5)

***Table 105**: Average change in precipitation for Metro South under the moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Brisbane City	5.1	-0 (-0.6 – 0.9)	-0.1 (-0.7 – 0.4)
Logan City	5.0	0 (-0.5 – 0.7)	-0.1 (-0.8 – 0.4)
Redland City	5.3	0 (-0.5 – 0.8)	-0.1 (-0.7 – 0.3)
Scenic Rim Shire	4.0	-0.1 (-0.5 – 0.5)	-01 (-0.6 – 0.3)

Changes to drought are less clear

By late this century, it is likely that eastern parts of the region will experience more time in drought.

Sea-level rise

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 106**: Average change in precipitation for Metro South under the high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Brisbane City	5.1	0.1 (-0.7 – 0.6)	0 (-0.6 – 1.1)
Logan City	5.0	0.1 (-0.5 – 0.5)	0 (-0.6 – 0.9)
Redland City	5.3	0.1 (-0.7 – 0.6)	-0.1 (-0.6 – 1.2)
Scenic Rim Shire	4.0	0 (-0.4 – 0.3)	0 (-0.4 – 0.5)

Changes to drought are less clear

By late this century, under a high emissions scenario, it is likely that eastern parts of the region will experience more time in drought.

Sea-level rise

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in the atmosphere stabilises (RCP4.5)

Table 107: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Metro South Region under a moderate emissions scenario RCP4.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Brisbane City		Redland City	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.14 (09-0.18)	0.15	0.14 (09-0.18)	0.15
2050 (m)	0.24 (0.17-0.32)	0.27	0.24 (0.17-0.31)	0.27
2070 (m)	0.36 (0.24-0.48)	0.43	0.36 (0.24-0.48)	0.44
2090 (m)	0.48 (0.31-0.65)	0.64	0.48 (0.31-0.65)	0.65
Rate of change by 2100 (mm/year)	6.0 (3.2-8.7)	N/A	5.9 (3.2-8.7)	N/A

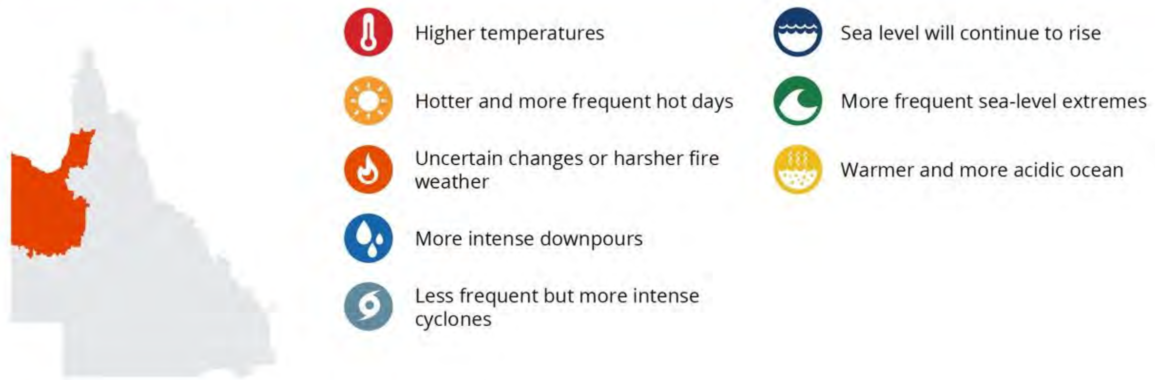
Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 108: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Metro South Region under a high emissions scenario RCP8.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Brisbane City		Redland City	
	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance
2030 (m)	0.14 (09-0.18)	0.15	0.14 (09-0.18)	0.15
2050 (m)	0.24 (0.17-0.32)	0.27	0.27 (0.19-0.35)	0.31
2070 (m)	0.36 (0.24-0.48)	0.43	0.44 (0.31-0.58)	0.55
2090 (m)	0.48 (0.31-0.65)	0.64	0.66 (0.46-0.88)	0.92
Rate of change by 2100 (mm/year)	6.0 (3.2-8.7)	N/A	11.5 (7.6-16.1)	N/A

4.9 North West

How will climate change affect the North West Region?



The North West HHS region stretches from the Northern Territory border in the west, north to the Gulf of Carpentaria and the Coleman River, and east to the Carpentaria and McKinlay local government areas. Major centres include Julia Creek, Cloncurry, Mount Isa, Burketown and Normanton. It includes the local government councils of Boulia Shire, Burke Shire, Carpentaria Shire, Cloncurry Shire, Doomadgee Aboriginal Shire, McKinlay Shire, Mornington Shire and Mount Isa City.

4.9.1 Current climate

The North West HHS region has a semi-arid climate with hot humid summers and dry warm winters to the south while the northern half is in the wet-dry tropics (savanna) and is generally hot to very hot throughout the year.

The average annual temperature is 25-26 °C, with the warmer average in the western part of the region. The summer average temperature is 30 °C, and the winter average temperature is 19-22 °C.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño–Southern Oscillation. Annual average rainfall is 453 mm in the south and with most rain falling during the summer wet season (October–March) either as thunderstorms or rain depressions. In the northern parts annual average rainfall is 751 mm with a distinct hot and humid wet season (November–March) in which rainfall is generated by heavy thunderstorms, monsoonal lows or tropical cyclones.

The region’s annual average potential evaporation is approximately four times the annual average rainfall.

4.9.2 Climate projections

This section provides plausible scenarios of the future climate for the North West region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.

Future scenario 2 assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Temperature Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking. In the near future (2030), the annually averaged maximum temperature for the North West region is projected to increase by up to 2.2 °C above the recent climate (1986–2005). Nighttime minima may become 0.4 – 1.5 °C warmer on average (Table 109). By 2070, the average maximum daily temperatures are expected to increase by at least 0.6 °C, and as much as 3.0 °C above the recent climate (1986–2005) (Table 109). Nights are projected to also be at least 1.1 °C warmer and as much as 3 °C warmer.	**Temperature** Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1. By 2030, annual average maximum temperatures for the South West region for this high emissions scenario are projected to increase by as much as 2.1 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.4 – 1.7 °C warmer on average (Table 110). By 2070, the projected increase in average maximum daily temperatures across the region is at least 0.8 °C, with some models showing as much as 4.1 °C above the recent climate (1986–2005) (Table 110). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 109: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the North West region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Boulia Shire	18.6	32.0	1.1 (0.5 – 1.5)	1.1 (0.1 – 1.8)	2.1 (1.3 – 3.0)	2.0 (0.7 – 2.9)
Burke Shire	20.5	32.0	1.0 (0.5 – 1.4)	1.0 (0.1 – 2.1)	1.9 (1.2 – 2.5)	1.8 (0.7 – 3.0)
Carpentaria Shire	21.1	32.5	0.9 (0.5 – 1.3)	1.0 (0.3 – 2.0)	1.8 (1.1 – 2.4)	1.7 (0.8 – 2.8)
Cloncurry Shire	19.0	31.9	1.1 (0.4 – 1.5)	1.0 (0 – 1.8)	2.0 (1.2 – 2.8)	1.9 (0.6 – 2.6)
Doomadgee Aboriginal Shire	20.5	31.6	1.0 (0.5 – 1.4)	1.0 (0.2 – 2.2)	1.9 (1.2 – 2.5)	1.8 (0.8 – 3.0)
McKinlay Shire	19.9	32.1	1.0 (0.4 – 1.5)	1.0 (0 – 1.8)	2.0 (1.2 – 2.7)	1.8 (0.6 – 2.6)
Mornington Shire	23.5	29.0	0.8 (0.4 – 1.2)	0.8 (0.4 – 1.2)	1.5 (1.1 – 2.2)	1.5 (0.9 – 2.1)
Mount Isa City	19.2	32.3	1.0 (0.4 – 1.5)	1.0 (-0.1 – 1.9)	2.0 (1.2– 2.8)	1.8 (0.6 – 2.7)

Hotter and more frequent hot days

There is likely to be 36 or more additional days over 35 °C across the region by 2070. Days over 40 °C show a marked increase with more than double the current number by 2070 (Table 111).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 110: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the North West region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Boulia Shire	18.6	32.0	1.2 (0.4 – 1.7)	1.0 (-0.3 – 1.7)	3.5 (2.1 – 4.7)	2.9 (0.9 – 4.1)
Burke Shire	20.5	32.0	1.1 (0.5 – 1.5)	1.1 (0.1 – 2.0)	3.2 (2.1 – 4.1)	2.8 (1.3 – 3.8)
Carpentaria Shire	21.1	32.5	1.0 (0.6 – 1.4)	1.0 (0.3 – 1.8)	2.9 (2.1 – 3.8)	2.7 (1.4 – 3.5)
Cloncurry Shire	19.0	31.9	1.2 (0.4 – 1.6)	1.0 (-0.3 – 1.8)	3.4 (2.0 – 4.4)	2.8 (0.8 – 3.9)
Doomadgee Aboriginal Shire	20.5	31.6	1.1 (0.5 – 1.4)	1.1 (0.3 – 2.1)	3.1 (2.2 – 4.0)	2.8 (1.4 – 3.8)
McKinlay Shire	19.9	32.1	1.1 (0.4 – 1.5)	1.0 (-0.1 – 1.8)	3.3 (2.1 – 4.2)	2.8 (1.0 – 3.7)
Mornington Shire	23.5	29.0	0.9 (0.5 – 1.2)	0.9 (0.4 – 1.2)	2.6 (1.9 – 3.3)	2.4 (1.7 – 3.2)
Mount Isa City	19.2	32.3	1.1 (0.4 – 1.6)	1.0 (-0.3 – 1.8)	3.3 (2.0 – 4.4)	2.7 (0.8 – 3.8)

Many more hot days and an increase in very hot days

For this high emissions scenario, by 2070 there is likely to be from about 50 to over 100 additional days over 35 °C for the region. With the except ion of the Mornington Shire, that will equate to over 200 days in the year that are over 35 °C. There will be significant increase in days over 40 °C by 2070 (Table 112), with some parts likely to have over 50 additional days over 40 °C.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 111**: Average number of projected additional days over 35 °C and 40 °C for the North West region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Boulia Shire	147.4	44.9	19.3 (-2.8 – 37.8)	17.3 (-0.7 – 32.9)	36.5 (11.6 – 56.2)	36.6 (7.7 – 59.4)
Burke Shire	126.0	7.7	32.8 (1.6 – 71.5)	6.3 (0.6 – 12.7)	65.0 (24.9 – 111.6)	15.9 (4.6 – 28.8)
Carpentaria Shire	128.2	4.8	36.2 (7.9 – 72.2)	5.8 (1.5 – 11.1)	71.4 (25.0 – 126.6)	15.4 (4.5 – 29.4)
Cloncurry Shire	143.9	26.4	21.7 (-6.3 – 46.3)	14.2 (-0.7 – 25.4)	43.4 (11.1 – 74.4)	32.1 (6.4 – 55.7)
Doomadgee Aboriginal Shire	106.3	3.9	35.7 (4.3 – 77.1)	3.7 (0.3 – 7.4)	69.5 (27.1 – 118.6)	10 (3.2 – 19.0)
McKinlay Shire	159.4	30.7	24.1 (-3.7 – 46.5)	16.1 (-0.9 – 29.2)	48.6 (12.4 – 90.5)	34.8 (6.6 – 61.1)
Mornington Shire	29.3	0.2	27.3 (13.9 – 44.7)	0.4 (0 – 1.0)	61.9 (32.2 – 94.1)	2.0 (0.1 – 5.2)
Mount Isa City	146.7	26.3	21.9 (-8.4 – 49.4)	13.6 (-1.4 – 26.2)	44.9 (12.6 – 76.3)	31.0 (6.4 – 55.0)

The North West region will experience an increase in length, peak temperatures and frequency of heatwaves

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with almost double the days in a year that are under heatwave conditions (Table 113). By 2070 the average hottest temperature in a heatwave is expected to increase by 1.1-1.2°C (range -0.2 - 2.6°C) across the region. Individual heatwaves are likely to last 1-3 days longer. The number of days in the year that are heatwave days could more than double.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 112**: Average number of projected additional days over 35 °C and 40 °C for the North West region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local governmen t area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Boulia Shire	147.4	44.9	19.4 (-12.5 – 38.9)	18.8 (-2.0 – 36.8)	51.0 (3.1 – 73.1)	52.9 (10.9 – 84.2)
Burke Shire	126.0	7.7	35.2 (-0.2 – 66.7)	7.4 (2.1 – 13.9)	107.0 (58.8 – 159.3)	30.3 (10.4 – 52.1)
Carpentari a Shire	128.2	4.8	37.5 (6.4 – 61.0)	6.9 (2.3 – 12.2)	117.2 (72.0 – 179.2)	30.3 (12.1 – 52.9)
Cloncurry Shire	143.9	26.4	22.9 (-13.2 – 47.1)	15.7 (-0.1 – 30.1)	64.8 (15.1 – 98.3)	50.2 (11.8 – 84.0)
Doomadgee e Aboriginal Shire	106.3	3.9	38.5 (5.5 – 70.9)	4.6 (1.6 – 8.7)	115.4 (67.8 – 171.2)	22.9 (8.0 – 39.4)
McKinlay Shire	159.4	30.7	24.8 (-13.1 – 47.3)	17.4 (1.0 – 34.4)	77.0 (34.7 – 121.8)	53.5 (12.4 – 87.3)
Mornington Shire	29.3	0.2	32.3 (12.9 – 49.2)	0.5 (-0.1 – 1.1)	104.5 (73.0 – 144.6)	10.3 (1.1 – 27.4)
Mount Isa City	146.7	26.3	23.6 (-15.3 – 49.9)	15.2 (-0.2 – 30.6)	66.5 (11.7 – 101.5)	49.0 (10.6 – 86.4)

The North West region will experience an increase in length, peak temperatures and frequency of heatwaves

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with almost double the days in a year that are under heatwave conditions (Table 114). By 2070 the average hottest temperatures in a heatwave may have increased by 1.9 - 2.4°C. Heatwaves are likely to last at least 3 days longer and up to 17 extra days in the Mornington Shire. The number of days in the year that are heatwave days could increase by five times the present-day number.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 113**: Average change in peak temperature, frequency and duration of heatwaves for the North West region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency ᵅ %	Durationᶲ Days	Peak temp* °C	Frequency ᵅ %	Durationᶲ Days	Peak temp* °C	Frequency ᵅ %	Durationᶲ Days
Boulia Shire	43.8	3.0	4.9	0.5 (0.1 – 1.3)	2.1 (0.4 – 4.0)	0.4 (-0.4 – 1.6)	1.2 (0.4 – 2.6)	6.3 (1.5 – 11.1)	1.5 (0.4 – 2.7)
Burke Shire	40.7	2.6	4.7	0.5 (-0.3 – 1.1)	1.9 (0.4 – 3.8)	0.3 (-0.6 – 1.3)	1.2 (0.3 – 2.2)	6.3 (2.2 – 12.0)	1.6 (0.4 – 3.6)
Carpentaria Shire	40.2	2.2	4.8	0.5 (0 – 0.8)	2.2 (0.7 – 4.0)	0.7 (-0.2 – 1.8)	1.1 (0.6 – 1.5)	6.9 (2.5 – 13.3)	2.7 (1.3 – 6.3)
Cloncurry Shire	42.5	2.7	4.7	0.5 (-0.2 – 1.3)	2.2 (0.2 – 4.4)	0.5 (-0.3 – 1.0)	1.2 (-0.2 – 2.4)	6.5 (1.5 – 11.8)	1.8 (0.6 – 3.3)
Doomadgee Aboriginal Shire	40	2.7	4.7	0.5 (-0.3 – 1.0)	1.8 (0.4 – 3.5)	0.3 (-0.8 – 1.4)	1.2 (0.6 – 2.0)	6.4 (2.4 – 12.2)	1.7 (0.3 – 3.4)
McKinlay Shire	42.6	2.8	4.8	0.4 (-0.2 – 1.1)	2.5 (0.3 – 4.8)	0.7 (0 – 1.4)	1.1 (-0.1 – 2.1)	7.0 (1.8 – 13.1)	2.2 (1.1 – 3.7)
Mornington Shire	37.4	2.4	4.8	0.5 (-0.5 – 1.1)	2.9 (0.7 – 6.0)	0.9 (-0.4 – 2.4)	1.2 (0.3 – 2.1)	11.8 (4.4 – 26.6)	4.3 (1.1 – 9.4)
Mount Isa City	42.4	2.8	4.7	0.4 (-0.4 – 1.3)	2.0 (-0.1 – 4.5)	0.3 (-0.7 – 0.9)	1.2 (-0.2 – 2.4)	6.5 (1.5 – 12.6)	1.7 (0.1 – 3.2)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
ᵅNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 114**: Average change in peak temperature, frequency and duration of heatwaves for the North West region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency ᵅ %	Durationᶲ Days	Peak temp* °C	Frequency ᵅ %	Durationᶲ Days	Peak temp* °C	Frequency ᵅ %	Durationᶲ Days
Boulia Shire	43.8	3.0	4.9	0.5 (-0.3 – 1.1)	2.7 (0.6 – 5.0)	0.7 (0 – 1.1)	2.1 (0.7– 3.2)	12.5 (3.5 – 20.2)	3.3 (1.3 – 6.3)
Burke Shire	40.7	2.6	4.7	0.6 (0.1 – 1.4)	2.6 (0.7 – 4.8)	0.7 (0 – 1.7)	2.4 (0.9 – 3.6)	17.5 (6.6 – 30.6)	5.2 (2.8 – 11.7)
Carpentaria Shire	40.2	2.2	4.8	0.5 (0.2 – 0.8)	2.8 (0.9 – 4.3)	1.1 (0.7 – 2.4)	1.9 (1.2 – 3.0)	17.4 (7.0 – 29.0)	6.7 (3.9 – 12.2)
Cloncurry Shire	42.5	2.7	4.7	0.5 (0 – 1.2)	2.8 (0.5 – 5.1)	0.8 (0 – 1.6)	2.1 (0.4– 3.5)	13.9 (4.2 – 22.9)	4.2 (1.9 – 7.8)
Doomadgee Aboriginal Shire	40	2.7	4.7	0.8 (0.1 – 1.5)	2.5 (0.9 – 5.0)	0.7 (0.1 – 1.5)	2.4 (1.3 – 3.3)	18.2 (7.6 – 32.0)	6.0 (2.6 – 13.9)
McKinlay Shire	42.6	2.8	4.8	0.5 (0.1 – 1.3)	3.0 (0.7 – 5.7)	1.0 (0.5 – 1.6)	1.9 (0.5 – 3.2)	14.7 (4.7 – 23.1)	4.8 (2.5 – 9.1)
Mornington Shire	37.4	2.4	4.8	0.6 (-0.1 – 1.4)	4.0 (1.1 – 7.8)	1.4 (0.1 – 3.3)	2.2 (1.6 – 3.0)	30.5 (17.5 – 52)	17.9 (5.4 – 41.4)
Mount Isa City	42.4	2.8	4.7	0.5 (-0.3 – 1.2)	2.8 (0.4 – 5.6)	0.6 (-0.6 – 1.5)	2.2 (0.3 – 3.6)	15.0 (4.6 – 25.4)	4.5 (2.3 – 8.8)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
ᵅNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Humidity

The North West region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 115).

***Table 115**: Average change in humidity for the summer months in North West under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Boulia Shire	55.7	-0.7 (-9.5 – 5.6)	-0.5 (-10.9 – 6.5)
Burke Shire	82.3	-1.1 (-8.1 – 1.7)	-1.0 (-9.6 – 1.7)
Carpentaria Shire	83.1	-0.9 (-7.5 – 1.6)	-0.8 (-7.4 – 1.3)
Cloncurry Shire	67.2	-0.9 (-10.1 – 4.8)	-0.6 (-11.0 – 5.2)
Doomadgee Aboriginal Shire	84.5	-1.1 (-7.5 – 1.1)	-1.1 (-8.8 – 1.1)
McKinlay Shire	69.5	-1.0 (-10.6 – 4.1)	-0.7 (-10.8 – 4.7)
Mornington Shire	85.5	-0.4 (-2.3 – 0.4)	-0.5 (-3.0 – 0.3)
Mount Isa City	69.8	-0.7 (-9.5 – 4.8)	-0.5 (-10.9 – 4.7)

Humidity

The North West region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 116).

***Table 116**: Average change in humidity for the summer months in North West under high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Boulia Shire	55.7	-0.1 (-8.3 – 7.9)	2.0 (-9.5 – 12.6)
Burke Shire	82.3	-1.0 (-6.5 – 1.8)	-1.3 (-8.3 – 2.6)
Carpentaria Shire	83.1	-0.7 (-4.8 – 0.8)	-0.6 (-5.9 – 1.8)
Cloncurry Shire	67.2	-0.4 (-8.0 – 5.2)	0.9 (-9.2 – 9.3)
Doomadgee Aboriginal Shire	84.5	-1.0 (-6.0 – 1.3)	-1.7 (-7.8 – 1.5)
McKinlay Shire	69.5	-0.5 (-7.9 – 4.1)	0.6 (-8.6 – 7.7)
Mornington Shire	85.5	-0.4 (-2.0 – 0.5)	-0.4 (-2.2 – 0.3)
Mount Isa City	69.8	-0.4 (-7.9 – 4.7)	0.5 (-8.9 – 8.2)

Fire weather

Uncertain changes or harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. In the north of the region changes to the fire frequency depends on the variability of future rainfall (Table 118).

Fire weather

Uncertain changes or harsher fire weather

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme. In the north of the region changes to the fire frequency depends on the variability of future rainfall (Table 118).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 118**: Average change in seasonal count of days in each level of fire risk in North West region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Boulia Shire	119.6	128.2	21.3	-2.2 (-11.4 – 14.0)	4.4 (-15.8 – 30)	5.6 (-2.7 – 15.9)	-6.9 (-22.2 – 7.4)	7.3 (-13.0 – 27.5)	10.7 (-2.0 – 26.6)
Burke Shire	119.7	62.8	2.6	3.0 (-5.8 – 12.2)	6.7 (-4.6 – 33.5)	0.5 (-0.2 – 1.8)	3.2 (-2.5 – 14.0)	10 (-2.3 – 36.3)	0.9 (-0.2 – 2.3)
Carpentaria Shire	115.9	65.5	1.5	2.8 (-3.1 – 10)	6.8 (-1.6 – 29.9)	0.4 (-0.1 – 1.3)	3.2 (-2.5 – 14.0)	10 (-2.3 – 36.3)	0.9 (-0.2 – 2.3)
Cloncurry Shire	127.0	101.8	9.1	-2.6 (-9.9 – 10.1)	7.8 (-8.8 – 36.1)	2.9 (-1.1 – 9.2)	-5.7 (-15.7 – 8.4)	13.0 (-8.4 – 40)	5.6 (-1.1 – 12.7)
Doomadgee Aboriginal Shire	107.1	49.5	1.6	4.8 (-4.0 – 17.0)	6.2 (-3.4– 31.1)	0.5 (-0.2 – 2.0)	5.7 (-8.1 – 20.2)	10.2 (-1.5 – 36.2)	0.8 (-0.1 – 1.8)
McKinlay Shire	127.5	102.2	9.2	-2.1 (-11.5 – 7.2)	8.3 (-6.9 – 33.4)	2.7 (-1.2 – 8.6)	-5.1 (-15.1 – 11.2)	13.1 (-8.2 – 37.5)	5.3 (-1.2 – 12.6)
Mornington Shire	30.2	2.7	0	2.9 (-0.6 – 14.3)	0.4 (-0.4 – 1.6)	0 (-0.1 – 0.1)	5.0 (-0.2– 18.4)	0.6 (-0.4 – 1.7)	0 (0 – 0.1)
Mount Isa City	126.0	103.5	9.3	-2.8 (-8.7 – 10)	7.5 (-10.5 – 37.2)	2.3 (-1.1 – 7.6)	-4.9 (-16.6 – 11.5)	12.5 (-9.7 – 41.0)	5.3 (-0.8 – 13.1)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 118**: Average change in seasonal count of days in each level of fire risk in North West region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Boulia Shire	119.6	128.2	21.3	-4.6 (-15.2 – 5.6)	3.3 (-18.5 – 27.6)	4.2 (-3.7 – 14.3)	-10.3 (-27.3 – 3.4)	1.0 (-33.2 – 25.1)	13.9 (-3.6 – 32.5)
Burke Shire	119.7	62.8	2.6	3.3 (-8.3 – 14.8)	6.6 (-3.7 – 26.8)	0.6 (-0.4 – 1.7)	0.1 (-14.5 – 12.3)	14.3 (-4.3 – 36.9)	2.2 (-0.1 – 5.0)
Carpentaria Shire	115.9	65.5	1.5	1.2 (-8.9 – 6.9)	5.7 (-2.1 – 24.0)	0.4 (-0.1 – 1.3)	0.6 (-11.8 – 14.3)	11.4 (-5.1 – 29.4)	1.2 (-0.1 – 3.1)
Cloncurry Shire	127.0	101.8	9.1	-3.1 (-17.4 – 3.1)	5.8 (-13.3 – 32.3)	2.2 (-1.6 – 8.0)	-9.6 (-25.3 – 11.2)	11.3 (-16.3 – 37.6)	7.3 (-1.5 – 17.2)
Doomadgee Aboriginal Shire	107.1	49.5	1.6	4.5 (-4.6 – 19.2)	6.2 (-2.5 – 24.3)	0.4 (-0.2 – 1.2)	3.2 (-8.3 – 14.9)	13.9 (-1.0 – 33.7)	1.4 (-0.2 – 3.3)
McKinlay Shire	127.5	102.2	9.2	-2.6 (-16.1 – 6.2)	6.2 (-9.6 – 31.9)	2.1 (-1.1 – 6.7)	-8.6 (-22.4 – 13.9)	13.3 (-13.4- 34.6)	6.1 (-1.0 – 13.8
Mornington Shire	30.2	2.7	0	3.8 (-1.7 – 11.5)	0.4 (-0.2 – 1.5)	0 (-0.1 – 0.1)	7.7 (2.8 – 16.7)	0.7 (0 – 1.8)	0.1 (0 – 0.2)
Mount Isa City	126.0	103.5	9.3	-2.5 (-15.3 – 4.9)	5.7 (-14.2 – 33.1)	1.9 (-1.9 – 7.3)	-11.7 (-24.8 – 8.2)	11.8 (-16.6 – 38.7)	6.9 (-1.5 – 15.8)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Rainfall

More intense downpours

High natural variability is likely to remain the major influence on rainfall changes in the next few decades.

In 2070, rainfall changes continue to show a large amount of variability, with the possibility of a drier or wetter climate. Winter and spring rainfall declines are possible towards the end of the century. The intensity of heavy rainfall events is likely to increase.

Table 119*: Average change in precipitation for North West under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	Mm/day		
Boulia Shire	1.2	0 (-0.2 – 0.2)	0.1 (-0.2 – 0.2)
Burke Shire	3.1	-0.1 (-1.0 – 0.5)	0.1 (-1.0 – 0.4)
Carpentaria Shire	3.2	-0.1 (-0.8 – 0.4)	0 (-0.8 – 0.4)
Cloncurry Shire	1.6	0 (-0.3 – 0.3)	0.1 (-0.2 – 0.3)
Doomadgee Aboriginal Shire	3.5	-0.1 (-1.2 – 0.5)	0.1 (-1.1 – 0.5)
McKinlay Shire	1.7	0 (-0.3 – 0.3)	0.1 (-0.3 – 0.3)
Mornington Shire	6.8	-0.3 (-3.1 – 1.2)	0.1 (-3.4 – 1.2)
Mount Isa City	1.6	0.1 (-0.3 – 0.4)	0.1 (-0.2 – 0.3)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Rainfall

More intense downpours

High natural variability is likely to remain the major influence on rainfall changes in the next few decades.

In 2070, rainfall changes continue to show a large amount of variability, with the possibility of a drier or wetter climate. Winter and spring rainfall declines are possible towards the end of the century. The intensity of heavy rainfall events is likely to increase.

Table 120*: Average change in precipitation for North West under a moderate emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	Mm/day		
Boulia Shire	1.2	0.1 (-0.1 – 0.4)	0.2 (-0.1 – 0.6)
Burke Shire	3.1	-0.1 (-0.9 – 0.3)	0.1 (-0.8 – 0.8)
Carpentaria Shire	3.2	-0.1 (-0.7 – 0.2)	0.1 (-0.6 – 0.7)
Cloncurry Shire	1.6	0.1 (-0.2 – 0.4)	0.2 (-0.1 – 0.8)
Doomadgee Aboriginal Shire	3.5	-0.1 (-1.0 – 0.2)	0.1 (-0.9 – 0.8)
McKinlay Shire	1.7	0 (-0.2 – 0.4)	0.2 (-0.1 – 0.7)
Mornington Shire	6.8	-0.4 (-2.7 – 0.5)	0.1 (-3.0 – 2.2)
Mount Isa City	1.6	0.1 (-0.2 – 0.5)	0.3 (-0.1 – 0.7)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Tropical cyclone

Less frequent but more intense cyclones

Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.

Sea levels

Sea level will continue to rise

Sea level is projected to rise by as much as 0.6m above present-day levels by 2100 (Table 121).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Table 121: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the North West Region under a moderate emissions scenario RCP4.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Mornington Shire		Carpentaria	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance
2030 (m)	0.11 (07-0.16)	0.12	0.11 (07-0.15)	0.15
2050 (m)	0.21 (0.13-0.29)	0.22	0.21 (0.13-0.28)	0.27
2070 (m)	0.32 (0.20-0.44)	0.35	0.31 (0.19-0.43)	0.44
2090 (m)	0.44 (0.27-0.61)	0.51	0.43 (0.26-0.61)	0.65
Rate of change by 2100 (mm/year)	5.8 (3.1-8.5)	N/A	5.9 (3.1-8.8)	N/A

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Tropical cyclone

Less frequent but more intense cyclones

Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.

Sea levels

Sea level will continue to rise

Sea level is projected to rise by as much as 0.8m above present-day levels by 2100 (Table 122).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Table 122: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the North West Region under a high emissions scenario RCP8.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Mornington Shire		Carpentaria	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.11 (07-0.16)	0.12	0.11 (07-0.16)	0.15
2050 (m)	0.21 (0.13-0.29)	0.22	0.23 (0.15-0.32)	0.27
2070 (m)	0.32 (0.20-0.44)	0.35	0.39 (0.26-0.53)	0.44
2090 (m)	0.44 (0.27-0.61)	0.51	0.59 (6.7-0.82)	0.65
Rate of change by 2100 (mm/year)	5.8 (3.1-8.5)	N/A	10.8 (6.7-15.6)	N/A

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Warmer and more acidic ocean Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.	**Warmer and more acidic ocean** Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

4.10 South West

How will climate change affect the South West Region?

- Higher temperatures
- Hotter and more frequent hot days
- Fewer frosts
- Harsher fire weather
- More intense downpours, less rainfall in winter and spring
- Changes to drought are less clear

The South West HHS region is one of the most remote areas in Queensland. Occupying the south-west corner of the state, the region is bordered by NSW and South Australia. Towns of the region include Charleville, Quilpie, Roma and Thargominda. It includes the local government councils of Balonne Shire, Bulloo Shire, Maranoa Regional, Murweh Shire, Paroo Shire and Quilpie Shire.

4.10.1 Current climate

The South West HHS region has a semi-arid to arid climate with very hot summers and generally warm dry winters. The summer average temperature is 27-29 °C, autumn is 20-22 °C, winter 13-14 °C and spring 21-23 °C, with the warmer averages in the most western parts of the region.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño–Southern Oscillation. It also varies across the region. In the east (Balonne and Maranoa districts) the annual average is 517 mm, with most rain occurring from October to March either as heavy thunderstorms or as tropical rain depressions. In the west, average annual rainfall is 339 mm, with most rain falling during October to March either as heavy thunderstorms or rain depressions.

The region's annual average potential evaporation is approximately three to four times the annual average rainfall, which contributes to the depletion of soil moisture.

4.10.2 Climate projections

This section provides plausible scenarios of the future climate for the South West region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking.

In the near future (2030), the annually averaged maximum temperature for the South West region is projected to increase by at least 0.3 °C, and as much as 2.1 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.7 °C warmer on average (Table 123).

By 2070, the average maximum daily temperatures are expected to increase by at least 1.0 °C, and as much as 3.6 °C above the recent climate (1986–2005) (Table 123). Nights are projected to also be at least 1.31 °C warmer and as much as 2.9 °C warmer.

Table 123: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the South West region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Balonne Shire	14.6	26.6	1.0 (0.6 – 1.5)	1.2 (0.4 – 1.9)	2.0 (1.3 – 2.9)	2.3 (0.9 – 3.6)
Bulloo Shire	15.6	28.6	1.1 (0.5 – 1.7)	1.2 (0.3 – 1.9)	2.1 (1.3 – 2.9)	2.3 (0.8 – 3.3)
Maranoa Regional	14.2	26.6	1.0 (0.6 – 1.4)	1.2 (0.6 – 2.1)	2.0 (1.3 – 2.7)	2.2 (1.0 – 3.5)
Murweh Shire	14.8	27.6	1.0 (0.6 – 1.4)	1.2 (0.5 – 2.0)	2.0 (1.3– 2.9)	2.3 (0.9 – 3.4)
Paroo Shire	15.0	27.5	1.1 (0.6 – 1.6)	1.2 (0.5 – 2.1)	2.1 (1.4 – 3.0)	2.3 (0.9 – 3.5)
Quilpie Shire	16.1	28.9	1.1 (0.6 – 1.6)	1.2 (0.4 – 1.9)	2.2 (1.4 – 3.1)	2.2 (0.9 – 3.3)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1.

By 2030, annual average maximum temperatures for the South West region for this high emissions scenario are projected to increase by as much as 1.9 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.6 – 1.6 °C warmer on average (Table 124).

By 2070, the projected increase in average maximum daily temperatures across the region is at least 1.5 °C, with some models showing as much as 4.7 °C above the recent climate (1986–2005) (Table 124). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Table 124: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the South West region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Balonne Shire	14.6	26.6	1.1 (0.7 – 1.5)	1.1 (0.2 – 1.7)	3.4 (2.4 – 4.4)	3.4 (1.6 – 4.7)
Bulloo Shire	15.6	28.6	1.2 (0.6 – 1.6)	1.2 (0 – 1.7)	3.5 (2.4 – 4.5)	3.3 (1.6 – 4.7)
Maranoa Regional	14.2	26.6	1.1 (0.7 – 1.4)	1.1 (0.4 – 1.9)	3.3 (2.4 – 4.2)	3.3 (1.7 – 4.6)
Murweh Shire	14.8	27.6	1.1 (0.7 – 1.5)	1.1 (0.2 – 1.7)	3.4 (2.4 – 4.4)	3.3 (1.5 – 4.5)
Paroo Shire	15.0	27.5	1.2 (0.7 – 1.6)	1.1 (0 – 1.8)	3.4 (2.4 – 4.5)	3.3 (1.5 – 4.6)
Quilpie Shire	16.1	28.9	1.2 (0.6 – 1.6)	1.1 (-0.1 – 1.7)	3.5 (2.4 – 4.6)	3.2 (1.4 – 4.5)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Hotter and more frequent hot days

There is likely to be 30-40 more days over 35 °C across the region by 2070. Days over 40 °C more than double (Table 125).

***Table 125**: Average number of projected additional days over 35 °C and 40 °C for the South West region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical mean annual number of days (1986-2005)		***Increase*** in mean annual number of days for 2030		***Increase*** in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Balonne Shire	61.6	9	17.3 (-0.4 – 5.3)	6.3 (0.6 – 15.4)	35.6 (5.0 – 58.5)	15.0 (2.8 – 25.7)
Bulloo Shire	98.2	28.5	19.2 (2.3 – 34.0)	13.1 (-0.5 – 9.4)	34.9 (6.1 – 49.4)	29.3 (5.4 – 43.6)
Maranoa Regional	45.0	3.6	16.6 (0.2 – 33.9)	3.0 (0.4 – 7.0)	34.3 (7.1 – 56.8)	8.3 (2.1 – 17.0)
Murweh Shire	63.8	7.2	18.1 (0.6 – 34.9)	5.4 (0.3 – 12.5)	37.0 (7.6 – 57.5)	13.9 (3.4 – 25.1)
Paroo Shire	78.2	15.2	18.0 (-0.2 – 5.5)	9.2 (0.5 – 23.0)	35.6 (4.1 – 54.7)	21.2 (3.3 – 34.9)
Quilpie Shire	101.3	23.1	20.5 (2.9 – 37.1)	12.1 (0.4 – 26.1)	37.9 (7.9 – 54.8)	27.6 (5.5 – 44.1)

The South West region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with almost double the days in a year that are under heatwave conditions (Table 127).

By 2070 the average hottest temperature in a heatwave is expected to increase by 1.1-1.4°C (range 0.3-2.5°C) across the region. Individual heatwaves are likely to last 1-2 days longer. The number of days in the year that are heatwave days could close to double.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Many more hot days and an increase in very hot days.

For this high emissions scenario, by 2070 there is likely to be about 50 more days over 35 °C in the South West region. There will be significantly more days over 40 °C by 2070, including more than double in most areas (Table 126).

***Table 126**: Average number of projected additional days over 35 °C and 40 °C for the South West region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical mean annual number of days (1986-2005)		***Increase*** in mean annual number of days for 2030		***Increase*** in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Balonne Shire	61.6	9	15.3 (1.0 – 7.1)	5.8 (0.7 – 12.7)	51.1 (17.2 – 79.0)	25.3 (10.1 – 40.9)
Bulloo Shire	98.2	28.5	18.5 (-5.8 – .5)	13.6 (-1.9 – 25.0)	48.4 (19.6 – 74.3)	42.1 (17.1 – 64.1)
Maranoa Regional	45.0	3.6	15.7 (3.5 – 9.8)	3.0 (0.7 – 6.5)	50.6 (20.2 – 74.9)	16.3 (6.3 – 28.2)
Murweh Shire	63.8	7.2	17.1 (0.3 – 9.4)	5.3 (1.2 – 11.4)	53.0 (14.0 – 78.0)	25.1 (9.9 – 41.4)
Paroo Shire	78.2	15.2	16.7 (-4.6 – .4)	8.9 (0.8 – 19.6)	49.7 (14.5 – 72.8)	33.4 (13.1 – 51.6)
Quilpie Shire	101.3	23.1	19.0 (-5.6 – .3)	12.2 (-0.5 – 23.7)	53.0 (11.9 – 79.1)	42.1 (16.5 – 66.0)

The South West region will experience an increase in length, peak temperatures and frequency of heatwaves.

Heatwaves are expected to reach higher temperatures, last longer and happen more frequently (Table 128).

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with almost double the days in a year that are under heatwave conditions. By 2070 the average hottest temperatures in a heatwave may have increased by about 2 °C. Heatwaves are likely to last 2-3 days longer. There could be three times the number of days in the year that are heatwave days.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 127**: Average change in peak temperature, frequency and duration of heatwaves for the South West region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10^{th} and 90^{th} percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days
Balonne Shire	41.7	3.2	5.2	0.5 (-0.1 – 1.6)	2.3 (0.1 – 5.2)	0.5 (-0.2 – 2.1)	1.3 (0.4 – 2.5)	5.5 (0.9 – 8.9)	1.2 (0.5 – 2.0)
Bulloo Shire	43.9	3.2	5.1	0.7 (0 – 1.7)	2.2 (-0.6 – 5.2)	0.7 (-0.5 – 2.3)	1.3 (0.3 – 2.4)	5.5 (0.8 – 8.4)	1.4 (0 – 2.6)
Maranoa Regional	40	3.0	5.0	0.5 (-0.3 – 1.3)	2.3 (0 – 5.1)	0.3 (-0.3 – 1.5)	1.3 (0.5 – 2.3)	6.0 (1.3 – 10.1)	1.1 (0.2 – 2.2)
Murweh Shire	40.9	3.2	5.0	0.4 (-0.1 – 1.4)	2.2 (0 – 4.8)	0.5 (-0.1 – 1.6)	1.2 (0.5 – 2.4)	6.1 (1.5 – 10.3)	1.4 (0.7 – 2.3)
Paroo Shire	42.5	3.3	5.3	0.5 (-0.2 – 1.8)	2.2 (-0.2 – 5.2)	0.5 (-0.3 – 2.5)	1.2 (0.3 – 2.4)	5.3 (1.1 – 8.7)	1.2 (0.4 – 2.2)
Quilpie Shire	43.1	3.3	5.2	0.4 (-0.2 – 1.3)	2.3 (-0.3 – 5.2)	0.6 (0 – 2.0)	1.1 (0.5 – 2.2)	5.8 (1.1 – 9.2)	1.4 (0.1 – 2.5)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 128**: Average change in peak temperature, frequency and duration of heatwaves for the South West region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10^{th} and 90^{th} percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days	Peak temp* °C	Frequency α %	Durationᶲ Days
Balonne Shire	41.7	3.2	5.2	0.6 (-0.2 – 1.2)	2.3 (0.7 – 4.2)	0.5 (-0.6 – 1.7)	2.0 (0.7 – 3.8)	10.9 (5.6 – 19.5)	2.4 (1.2 – 3.8)
Bulloo Shire	43.9	3.2	5.1	0.6 (0 – 1.5)	2.3 (-0.3 – 4.3)	0.8 (-0.5 – 2.3)	2.2 (1.2 – 3.2)	9.6 (3.8 – 14.6)	2.3 (1.3 – 3.5)
Maranoa Regional	40	3.0	5.0	0.6 (0 – 1.2)	2.4 (0.8 – 4.5)	0.5 (-0.4 – 1.3)	2.0 (0.8 – 3.4)	13.2 (6.7 – 23.9)	2.8 (1.4 – 5.8)
Murweh Shire	40.9	3.2	5.0	0.5 (0.1 – 2.0)	2.3 (0.7 – 4.3)	0.6 (-0.1 – 1.6)	1.9 (1.2 – 2.9)	12.7 (5.9 – 22.8)	3.0 (1.6 – 5.9)
Paroo Shire	42.5	3.3	5.3	0.5 (-0.1 – 1.5)	2.1 (0.3 – 4.3)	0.6 (-0.6 – 2.1)	2.1 (0.9 – 3.6)	10 (4.5 – 16.7)	2.3 (1.3 – 4.1)
Quilpie Shire	43.1	3.3	5.2	0.4 (-0.3 – 1.1)	2.3 (0.2 – 4.5)	0.5 (-0.6 – 1.7)	1.9 (1.0– 2.5)	11.2 (4.6 – 18.1)	2.8 (1.7 – 4.8)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ᶲAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost is projected by the end of the century.

Frost days

A substantial decrease in the frequency of days with a risk of a frost days is projected by the end of the century.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Humidity

The South West region can expect a slight decrease in humidity during the summer season.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 129).

***Table 129**: Average change in humidity for the summer months in South West under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Balonne Shire	66.9	-1.2 (-10.2 – 3.3)	-2.0 (-9.4 – 3.1)
Bulloo Shire	51.3	-0.9 (-10.2 – 4.4)	-1.4 (-10 – 7.2)
Maranoa Regional	70.8	-1.4 (-10.1 – 1.9)	-2.0 (-8.4 – 1.9)
Murweh Shire	66.6	-1.3 (-10.4 – 3.2)	-1.9 (-9.4 – 3.0)
Paroo Shire	61.0	-1.1 (-11.5 – 4.3)	-1.9 (-11.1 – 5.3)
Quilpie Shire	58.4	-1.3 (-11.1 – 4.0)	-1.6 (-10.7 – 5.6)

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 131).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Humidity

The South West region can expect a slight decrease in humidity for the year as a whole.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 130).

***Table 130**: Average change in humidity for the summer months in South West under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Balonne Shire	66.9	0.6 (-4.9 – 5.4)	0.1 (-5.8 – 5.6)
Bulloo Shire	51.3	0.2 (-7.5 – 8.8)	1.6 (-7.4 – 8.6)
Maranoa Regional	70.8	0 (-5.7 – 4.0)	-0.4 (-5.7 – 3.8)
Murweh Shire	66.6	0.3 (-6.0 – 5.4)	-0.3 (-5.9 – 5.4)
Paroo Shire	61.0	0.7 (-6.3 – 7.2)	0.9 (-7.1 – 7.1)
Quilpie Shire	58.4	0.1 (-7.4 – 6.3)	-1.0 (-7.8 – 7.0)

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 132).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 131**: Average change in seasonal count of days in each level of fire risk in South West region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high ire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Balonne Shire	78.3	37.5	2.2	3.3 (-7.4 – 20.5)	11.2 (-3.0 – 8.1)	1.1 (-0.6 – 4.7)	7.3 (-2.0 – 19.3)	19.2 (-5.1 – 48.9)	4.0 (-0.3-12.4)
Bulloo Shire	98.8	98.0	14.5	0.8 (-8.1 – 1.1)	6.9 (-6.4 – 4.8)	4.9 (-1.6 – 7.2)	0.5 (-11.9 – 11.5)	11.5 (-14.9 – 8.4)	11.1 (0 – 24.8)
Maranoa Regional	73.6	23.8	0.6	5.9 (-4.3 – 21.2)	9.9 (-1.2 – 28.8)	0.5 (-0.2 – 1.6)	9.9 (-1.3 – 20)	17.0 (-2.4 – 8.3)	1.6 (-0.1 – 5.4)
Murweh Shire	7.6	0.9	0	3.8 (-9.0 – 20.4)	10.5 (-1.6 – 29.8)	1.2 (-0.3 – 3.9)	7.7 (-3.1 – 18.0)	18.7 (-4.5 – 9.0)	3.2 (-0.2 – 10)
Paroo Shire	89.1	64.3	5.6	1.4 (-10.5 – 12.7)	10.1 (-7.7 – 38.5)	2.6 (-0.4 – 9.8)	4.4 (-4.5 – 14.7)	18.1 (-9.2- 39.6)	7.8 (1 – 20.1)
Quilpie Shire	103.3	81.7	8.9	0.5 (-10.3 – 9.7)	9.9 (-3.6 – 35.6)	3.4 (-0.3 – 0.5)	1.8 (-7.6 – 14.4)	16.7 (-8.9 – 7.4)	7.7 (-0.1 – 9.9)

Rainfall

More intense downpours, less rainfall in winter and spring

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades. In 2070, projections of rainfall changes are highly variable, with possibilities of a drier or wetter climate. Decreases in winter and spring rainfall for eastern parts of the region are projected by 2070. The intensity of heavy rainfall events is likely to increase.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 132**: Average change in seasonal count of days in each level of fire risk in South West region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high ire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Balonne Shire	78.3	37.5	2.2	-0.1 (-9.7 – 10.2)	5.2 (-8.1– 20.7)	0.9 (-0.7 – 3.1)	6.7 (-17.3– 17.9)	18.8 (-1.1 – 46.6)	4.7 (0.3 – 13.0)
Bulloo Shire	98.8	98.0	14.5	0.1 (-9.0 – 0.8)	3.6 (-17.8 – 0.7)	3.7 (-2.9 – 4.1)	-0.5 (-13.6 – 7.9)	7.2 (-15.6 – 27.1)	13.2 (0.5 – 32.1)
Maranoa Regional	73.6	23.8	0.6	3.0 (-6.0 – 4.8)	4.8 (-6.3 – 16.3)	0.4 (-0.3 – 1.0)	11.2 (-11.6 – 22.2)	18.4 (1.2 – 45.8)	2.0 (0.1 – 5.2)
Murweh Shire	7.6	0.9	0	1.4 (-6.4 – 0.3)	5.2 (-6.6 – 17.6)	0.8 (0 – 0)	7.5 (-18.4 – 18.1)	18.2 (-1.2 – 41.5)	3.7 (0.1 – 9.4)
Paroo Shire	89.1	64.3	5.6	-0.5 (-9.6 – 11.1)	5.1 (-12.4 – 23.7)	1.9 (-1.3 – 7.3)	2.5 (-20.2 – 15.3)	14.4 (-9.7 – 36.7)	7.8 (1 – 20.1)
Quilpie Shire	103.3	81.7	8.9	0.5 (-8.9 – 11.5)	5.2 (-14.8 – 5.6)	2.2 (-1.5 – 7.4)	1.7 (-19.1 – 9.2)	12.8 (-14.3 – 3.1)	9.2 (0.6 – 22.4)

Rainfall

More intense downpours, less rainfall in winter and spring

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades. In 2070, projections of rainfall changes are highly variable, with possibilities of a drier or wetter climate. Decreases in winter and spring rainfall for eastern parts of the region are projected by 2070. The intensity of heavy rainfall events is likely to increase.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 133**: Average change in precipitation for South West under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Balonne Shire	2.3	-0.1 (-0.3 – 0.3)	-0.1 (-0.4 – 0.2)
Bulloo Shire	1.3	0 (-0.3 – 0.2)	0 (-0.3 – 0.3)
Maranoa Regional	2.3	-0.1 (-0.4 – 0.1)	-0.1 (-0.3 – 0.2)
Murweh Shire	2.1	0 (-0.2 – 0.2)	-0.1 (-0.3 – 0.2)
Paroo Shire	1.9	-0.1 (-0.4 – 0.3)	-0.1 (-0.3 – 0.3)
Quilpie Shire	1.7	0 (-0.3 – 0.2)	0 (-0.3 – 0.2)

Changes to drought are less clear

Projecting changes in the frequency and duration of drought is difficult. However, by late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

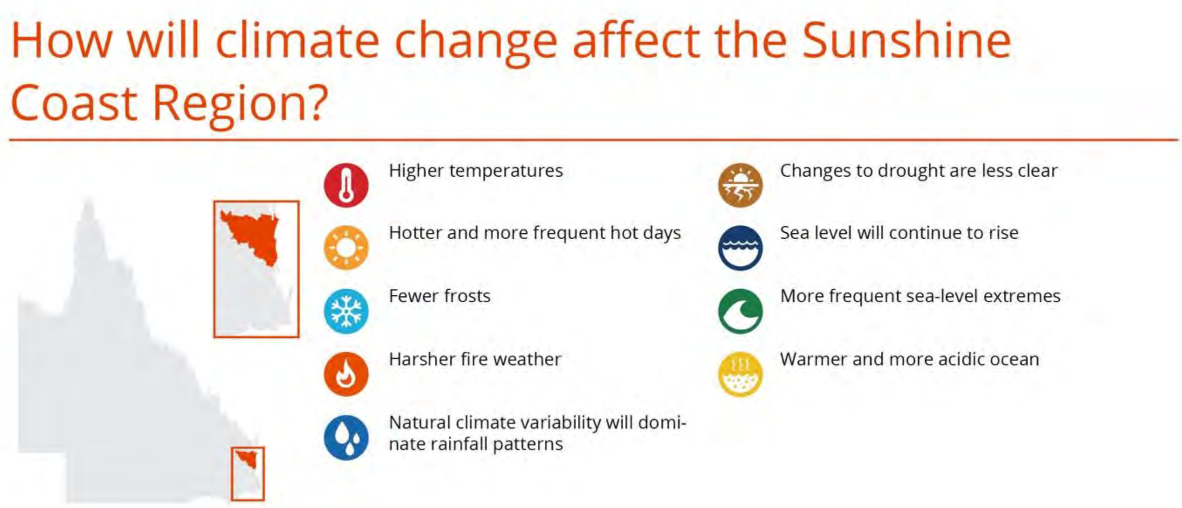
***Table 134**: Average change in precipitation for South West under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Balonne Shire	2.3	0 (-0.3 – 0.3)	0 (-0.3 – 0.4)
Bulloo Shire	4.0	0 (-0.2 – 0.3)	0.1 (-0.3 – 0.4)
Maranoa Regional	2.3	0 (-0.3 – 0.3)	0 (-0.3 – 0.3)
Murweh Shire	2.1	0 (-0.2 – 0.3)	0.1 (-0.1 – 0.4)
Paroo Shire	1.9	0 (-0.3 – 0.3)	-0.1 (-0.2 – 0.4)
Quilpie Shire	1.7	0 (-0.2 – 0.3)	0.1 (-0.2 – 0.5)

Changes to drought are less clear

Projecting changes in the frequency and duration of drought is difficult. However, by late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

4.11 Sunshine Coast



The Sunshine Coast HHS region is in southeast Queensland and includes the local government councils of Gympie Regional, Noosa Shire and Sunshine Coast Regional.

4.11.1 Current climate

The Sunshine Coast HHS region has a sub-tropical climate influenced by tropical systems from the north and fluctuations in the high-pressure ridge to the south.

The average annual temperature is 19 °C with summer average temperature 24 °C, autumn and spring 20 °C, and in winter 14 °C.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño– Southern Oscillation. Most rainfall occurs in summer and autumn (388 mm and 295 mm per year, respectively).

The region's annual average potential evaporation is almost 50% greater than the annual average rainfall, which contributes to the depletion of soil moisture.

4.11.2 Climate projections

This section provides plausible scenarios of the future climate for the Sunshine Coast region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Future scenario 1

Temperature

Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking.

In the near future (2030), the annually averaged maximum temperature for the Sunshine Coast region is projected to increase by at least 0.4 °C, and as much as 1.6 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.3 °C warmer on average (Table 135).

By 2070, the average maximum daily temperatures are expected to increase by at least 1.2 °C, and as much as 2.9 °C above the recent climate (1986–2005) (Table 135). Nights are projected to also be at least 1.1 °C warmer and as much as 2.3 °C warmer.

Table 135: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Sunshine Coast region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	**Recent temperatures (1986-2005) °C**		**Mean projected increase in temperatures by 2030 °C**		**Mean projected increase in temperatures by 2070 °C**	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Gympie Regional	15.6	25.6	0.9 (0.5 – 1.3)	1.0 (0.4 – 1.6)	1.7 (1.2 – 2.3)	2.0 (1.2 – 2.9)
Noosa Shire	17.3	25.0	0.8 (0.6 – 1.3)	0.9 (0.6 – 1.1)	1.7 (1.1 – 2.3)	1.8 (1.2 – 2.3)
Sunshine Coast Regional	16.2	24.8	0.9 (0.6 – 1.3)	0.9 (0.6 – 1.3)	1.7 (1.2– 2.3)	1.9 (1.2 – 2.5)

Future scenario 2

Temperature

Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1.

By 2030, annual average maximum temperatures for the Sunshine Coast region for this high emissions scenario are projected to increase by 0.5 °C and as much as 1.6 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.5 – 1.3 °C warmer on average (Table 136).

By 2070, the projected increase in average maximum daily temperatures across the region is at least 2.1 °C, with some models showing as much as 4.0 °C above the recent climate (1986–2005) (Table 136). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Table 136: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Sunshine Coast region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	**Recent temperatures (1986-2005) °C**		**Mean projected increase in temperatures by 2030 °C**		**Mean projected increase in temperatures by 2070 °C**	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Gympie Regional	15.6	25.6	0.9 (0.5 – 1.3)	0.9 (0.5 – 1.6)	2.9 (2.1 – 3.8)	3.1 (2.2 – 4.0)
Noosa Shire	17.3	25.0	0.9 (0.5 – 1.3)	0.9 (0.6 – 1.2)	2.7 (2.0 – 3.6)	2.8 (2.1 – 3.6)
Sunshine Coast Regional	16.2	24.8	0.9 (0.6 – 1.2)	1.0 (0.6 – 1.3)	2.8 (2.1 – 3.7)	3.0 (2.2 – 3.9)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Hotter and more frequent hot days

There is likely to be more than double the number of days over 35 °C across the region by 2070. Days over 40 °C show a modest increase (Table 137).

***Table 137**: Average number of projected additional days over 35 °C and 40 °C for the Sunshine Coast region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35ºC	>40ºC	>35ºC	>40ºC	>35ºC	>40ºC
Gympie Regional	6.2	0.7	4.6 (-0.9 – 11.6)	0.2 (0 – 0.4)	12.3 (4.7 – 19.8)	0.6 (0.1 – 2.1)
Noosa Shire	2.4	0	2.4 (0.1 – 4.6)	0.1 (0 – 0.2)	8.0 (2.8 – 12.6)	0.3 (0 – 0.6)
Sunshine Coast Regional	1.7	0	1.5 (0 – 3.2)	0.1 (0 – 0.1)	4.8 (1.8 – 6.6)	0.2 (0 – 0.5)

The Sunshine Coast region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with a doubling of the days in a year that are under heatwave conditions (Table 139).

By 2070 the average hottest temperature in a heatwave is expected to increase by about 1.5ºC (range 0.3-2.6ºC) across the region. Individual heatwaves are likely to last 1-3 days longer. The number of days in the year that are heatwave will more than double.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Many more hot days and an increase in very hot days

For this high emissions scenario, by 2070 there is likely to be about four to six times more days over 35 ºC. There will be 1-2 extra days over 40 ºC by 2070 (Table 138).

***Table 138**: Average number of projected additional days over 35 °C and 40 °C for the Sunshine Coast region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35ºC	>40ºC	>35ºC	>40ºC	>35ºC	>40ºC
Gympie Regional	6.2	0.7	4.2 (1.1 – 10.2)	0.2 (0 – 0.7)	25.5 (8.5 – 49.1)	1.2 (0.2 –2.5)
Noosa Shire	2.4	0	2.5 (0.1 – 6.5)	0.1 (0 – 0.3)	21.0 (7.6 – 46.0)	0.5 (0 – 1.1)
Sunshine Coast Regional	1.7	0	1.4 (-0.4 – 3.4)	0.1 (0 – 0.1)	12.0 (2.8 – 25.6)	0.3 (0 – 0.9)

The Sunshine Coast region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with a doubling of the days in a year that are under heatwave conditions (Table 140).

By 2070 the average hottest temperatures in a heatwave may have increased by about 2ºC. Heatwaves are likely to last several days longer. There might be as many as eight times more days in the year that are heatwave days than in the recent past.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 139**: Average change in peak temperature, frequency and duration of heatwaves for the Sunshine Coast region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days
Gympie Regional	35.6	2.3	4.5	0.4 (-0.3 – 1.5)	2.2 (0.2 – 4.8)	0.7 (-0.4 – 2.3)	1.3 (0.5 – 2.6)	6.1 (2.1 – 9.5)	1.4 (0.2 – 2.5)
Noosa Shire	34.7	2.3	4.5	0.4 (-0.1 – 1.2)	2.4 (0.3 – 4.4)	0.9 (0 – 2.1)	1.5 (0.4 – 2.4)	7.6 (3.0 – 12.5)	2.4 (0.6 – 4.0)
Sunshine Coast Regional	33.9	2.2	4.5	0.4 (-0.5 – 1.1)	2.1 (0 – 4.5)	0.7 (-0.5 – 2.4)	1.5 (0.3 – 2.5)	6.6 (2.7 – 11.1)	1.5 (0.1 – 2.6)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost is projected by the end of the century.

Humidity

The Sunshine Coast region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 141).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 140**: Average change in peak temperature, frequency and duration of heatwaves for the Sunshine Coast region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days	Peak temp* °C	Frequency α %	Durationϕ Days
Gympie Regional	35.6	2.3	4.5	0.4 (-0.6 – 1.4)	2.2 (0.5 – 5.2)	0.6 (-1.0 – 1.5)	2.0 (0.8 – 2.7)	16.5 (6.8 – 29.2)	4.6 (1.3 – 10.8)
Noosa Shire	34.7	2.3	4.5	0.5 (-0.4 – 1.3)	2.9 (1.3 – 7.3)	0.9 (-0.1 – 2.9)	2.2 (1.2 – 2.7)	19.8 (10.1 – 32.2)	7.8 (3.4 – 15.4)
Sunshine Coast Regional	33.9	2.2	4.5	0.4 (-0.8 – 1.2)	2.4 (1.0 – 5.8)	0.6 (-0.6 – 2.0)	2.2 (0.9– 3.3)	17.8 (8.6 – 30)	5.4 (2.0 – 11.6)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost days is projected by the end of the century.

Humidity

The Sunshine Coast region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 142).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 141**: Average change in humidity for the summer months in Sunshine Coast under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Gympie Regional	87.2	-0.9 (-7.1 – 2.1)	-1.2 (-5.6 – 0.9)
Noosa Shire	88.6	-0.5 (-4.5 – 0.8)	-0.6 (-3.3 – 0.5)
Sunshine Coast Regional	90.8	-0.6 (-4.2 – 0.5)	-0.7 (-4.1 – 0.4)

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 143).

***Table 143**: Average change in seasonal count of days in each level of fire risk in Sunshine Coast region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Gympie Regional	7.1	0.5	0	2.8 (-0.4 – 11.1)	0.4 (-0.1– 1.7)	0 (0 – 0)	5.7 (-0.3 – 20.2)	1.0 (0 – 4.2)	0 (0 – 0.1)
Noosa Shire	0.3	0	0	0.2 (-0.2 – 1.1)	0 (0 – 0.1)	0 (0 – 0)	0.5 (0 – 1.6)	0.1 (0– 0.3)	0 (0 – 0)
Sunshine Coast Regional	0.2	0	0	0.1 (-0.2 – 0.8)	0 (0 – 0.1)	0 (0 – 0)	0.3 (0 – 1.1)	0 (0 – 0.2)	0 (0 – 0)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 142**: Average change in humidity for the summer months in Sunshine Coast under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Gympie Regional	87.2	0.1 (-3.5 – 2.0)	-0.8 (-4.9 – 2.0)
Noosa Shire	88.6	0.2 (-2.0 – 1.6)	-0.1 (-2.6 – 1.3)
Sunshine Coast Regional	90.8	0.2 (-1.6 – 1.3)	-0.5 (-3.0 – 0.9)

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 144).

***Table 144**: Average change in seasonal count of days in each level of fire risk in Sunshine Coast region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Gympie Regional	7.1	0.5	0	1.1 (-1.1 – 8.8)	0.2 (-0.5– 1.2)	0 (0 – 0)	6.6 (0 4– 16.2)	1.3 (0 – 3.3)	0.1 (0 – 0.1)
Noosa Shire	0.3	0	0	0.1 (-0.7 – 0.9)	0 (-0.1 – 0.1)	0 (0 – 0)	0.5 (0 – 1.5)	0.1 (0 – 0.2)	0 (0 – 0)
Sunshine Coast Regional	0.2	0	0	0 (-0.6 – 0.3)	0 (0 – 0)	0 (0 – 0)	0.2 (0 – 1.0)	0 (0 – 0.2)	0 (0 – 0)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Rainfall

Natural climate variability will dominate rainfall patterns

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

By 2070, projections of total rainfall show little change or a decrease, particularly in winter and spring. The intensity of heavy rainfall events is likely to increase.

***Table 145**: Average change in precipitation for Sunshine Coast under RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Gympie Regional	4.2	-0.1 (-0.5 – 0.5)	-0.2 (-0.6 – 0.1)
Noosa Shire	6.1	-0.1 (-0.7 – 0.6)	-0.2 (-0.7 – 0.1)
Sunshine Coast Regional	6.0	0 (-0.7 – 0.8)	-0.2 (-0.6 – 0.1)

Changes to drought are less clear

By late this century, it is likely that eastern parts of the region will experience more time in drought.

Sea-level rise

Sea level will continue to rise

Sea level is projected to rise by 0.8 m above present-day levels by 2100 (Table 147).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Rainfall

Natural climate variability will dominate rainfall patterns

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

By 2070, projections of total rainfall show little change or a decrease, particularly in winter and spring. The intensity of heavy rainfall events is likely to increase.

***Table 146**: Average change in precipitation for Sunshine Coast under RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Gympie Regional	4.2	0 (-0.6 – 0.4)	-0.1 (-0.5 – 0.7)
Noosa Shire	6.1	0.1 (-0.9 – 0.7)	-0.1 (-0.6 – 1.2)
Sunshine Coast Regional	3.7	0.1 (-0.8 – 0.7)	-0.1 (-0.6 – 1.1)

Changes to drought are less clear

By late this century, under a high emissions scenario, it is likely that eastern parts of the region will experience more time in drought.

Sea-level rise

Sea level will continue to rise

Sea level is projected to rise by 0.8 m above present-day levels by 2100 (Table 148).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 147: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Sunshine Coast Region under a moderate emissions scenario RCP4.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Sunshine Council*		Gympie	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.13 (09-0.17)	0.14	0.13 (09-0.18)	0.14
2050 (m)	0.24 (0.16-0.31)	0.27	0.24 (0.17-0.31)	0.26
2070 (m)	0.35 (0.23-0.47)	0.43	0.35 (0.24-0.47)	0.42
2090 (m)	0.47 (0.30-0.65)	0.63	0.47 (0.31-0.65)	0.62
Rate of change by 2100 (mm/year)	5.9 (3.2-8.6)	N/A	5.9 (3.2-8.7)	N/A

*Sea-level rise projection values for Noosa Council are almost identical to those for Sunshine Coast

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 148: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Sunshine Coast Region under a high emissions scenario RCP8.5. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

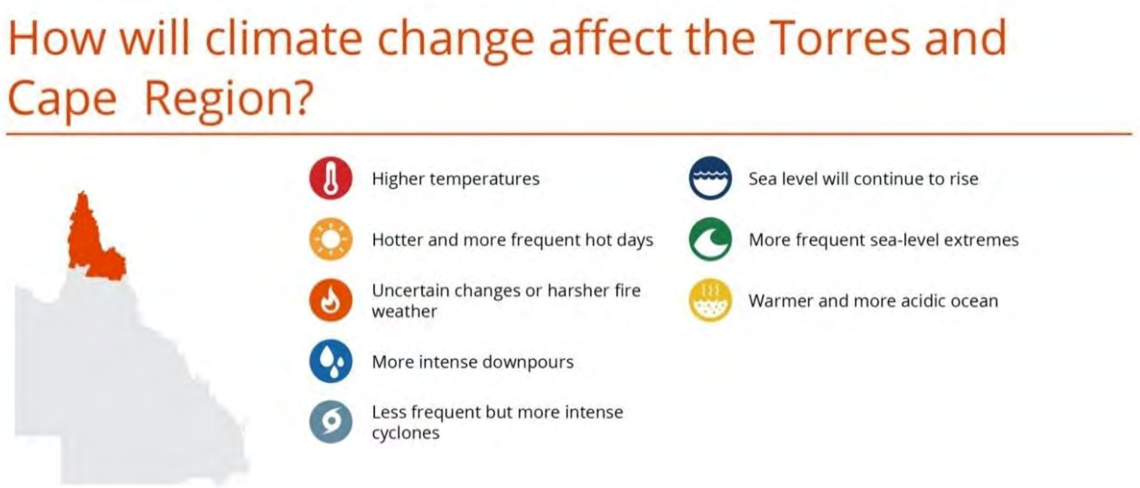
Year	Sunshine Council		Noosa	
	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance
2030 (m)	0.13 (09-0.18)	0.12	0.14 (09-0.18)	0.14
2050 (m)	0.27 (0.19-0.35)	0.24	0.27 (0.19-0.35)	0.30
2070 (m)	0.44(0.31-0.58)	0.42	0.44 (0.31-0.58)	0.53
2090 (m)	0.65 (0.45-0.87)	0.66	0.65 (0.45-0.87)	0.86
Rate of change by 2100 (mm/year)	11.4 (7.5-16)	N/A	11.4 (7.5-16.1)	N/A

*Sea-level rise projection values for Noosa Council are almost identical to those for Sunshine Coast

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

4.12 Torres and Cape



The Torres and Cape HHS region covers the most northern parts of Queensland. It stretches from the Cook Shire Council region to the most northerly islands of the Torres Strait. It includes the local government councils of Aurukun Shire, Cook Shire, Kowanyama Aboriginal Shire, Hope Vale Aboriginal Shire, Lockhart River Aboriginal Shire, Mapoon Aboriginal Shire, Napranum Aboriginal Shire, Northern Peninsula Area Regional, Pormpuraaw Aboriginal Shire, Torres Shire, Torres Strait Island Regional and Weipa Town.

4.12.1 Current climate

The Torres and Cape HHS region has a tropical climate, experiencing high to very high temperatures throughout the year. The region is characterised by two seasons: the monsoonal wet season (generally from December to April), which is dominated by prevailing north-westerly winds; and the dry season (May to November), when south-easterly trade winds dominate.

The December – February average temperature is 28°C with an average of 23°C for July- August. Daily mean temperatures show little variation across the region in summer, with temperatures mostly from 27 to 30 °C although a little cooler in the higher terrain areas further inland (24 to 27 °C).

The annual average rainfall for the region is 1305 mm and is highly seasonal with most rain falling in the wet season (October-March). Local topography, vegetation, El Niño -Southern Oscillation and monsoonal influences create regional variability.

4.12.2 Climate projections

This section provides plausible scenarios of the future climate for the Torres and Cape region region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as “worst case”. In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Temperature Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking. In the near future (2030), the annually averaged maximum temperature for the Torres and Cape region region is projected to increase by at least 0.4 °C, and as much as 2.1 °C above the recent climate (1986–2005). Nighttime minima may become 0.4 – 1.3 °C warmer on average (Table 149). By 2070, the average maximum daily temperatures are expected to increase by at least 0.7 °C, and as much as 2.9 °C above the recent climate (1986–2005) (Table 149). Nights are projected to also be at least 0.8 °C warmer and possibly as much as 2.8 °C warmer.	**Temperature** Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1. By 2030, annual average maximum temperatures for the Torres and Cape region region for this high emissions scenario are projected to increase by 0.5 °C and as much as 1.2 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.5 – 1.2 °C warmer on average (Table 150). By 2070, the projected increase in average maximum daily temperatures across the region is at least 1.5 °C, with some models showing as much as 3.5 °C above the recent climate (1986–2005) (Table 150). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 149: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario for the Torres and Cape region. The range in the brackets below the average is the 10^{th} and 90^{th} percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Aurukun Shire	22.1	32.7	0.8 (0.5 – 1.3)	0.9 (0.4 – 1.8)	1.6 (1.0 – 2.2)	1.6 (0.8 – 2.6)
Cook Shire	21.6	31.2	0.8 (0.5 – 1.2)	0.9 (0.4 – 1.6)	1.5 (1.0 – 2.2)	1.6 (0.9 – 2.4)
Kowanyama Aboriginal Shire	21.6	32.5	0.8 (0.5 – 1.2)	1.0 (0.5 – 2.1)	1.6 (1.0 – 2.2)	1.7 (0.9 – 2.9)
Hope Vale Aboriginal Shire	23.4	28.4	0.7 (0.4 – 1.1)	0.7 (0.4 – 1.1)	1.3 (0.9 – 2.0)	1.4 (0.9 – 2.0)
Lockhart River Aboriginal Shire	22.9	29.7	0.7 (0.4 – 1.2)	0.8 (0.4 – 1.1)	1.4 (0.9 – 2.0)	1.4 (1.0 – 1.9)
Mapoon Aboriginal Shire	23.5	31.2	0.8 (0.4 – 1.2)	0.8 (0.4 – 1.4)	1.5 (1.0 – 2.0)	1.5 (0.8 – 2.0)
Napranum Aboriginal Shire	22.7	32.0	0.8 (0.5 – 1.2)	0.9 (0.4 – 1.4)	1.5 (1.0 – 2.1)	1.5 (0.8 – 2.3)
Northern Peninsula Area Regional	24.0	30.4	0.7 (0.4 – 1.1)	0.7 (0.4 – 1.2)	1.4 (1.0– 2.0)	1.4 (0.9 – 1.9)
Pormpuraaw Aboriginal Shire	21.7	32.5	0.8 (0.5 – 1.3)	1.0 (0.4 – 2.0)	1.7 (0.8 – 2.8)	1.6 (1.0 – 2.2)
Torres Shire	25.0	29.3	0.7 (0.4 – 1.1)	0.7 (0.4 – 1.1)	1.3 (0.9 – 2.0)	1.3 (0.9 – 1.9)
Torres Strait Island Regional	26.0	27.9	0.6 (0.4 – 1.1)	0.6 (0.3 – 1.1)	1.3 (0.9 – 1.9)	1.3 (0.9 – 1.9)
Weipa Town	22.6	32.3	0.8 (0.5 – 1.2)	0.9 (0.4 – 1.7)	1.5 (1.0– 2.1)	1.6 (0.7 – 2.4)

Hotter and more frequent hot days

There is likely to be a considerable increase in the number of days over 35 °C across the region by 2070, with median projections ranging from about 10 extra days to more than 50. Days over 40 °C show a small increase (Table 151).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 150: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario for the Torres and Cape region. The range in the brackets below the average is the 10^{th} and 90^{th} percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Aurukun Shire	22.1	32.7	0.9 (0.5 – 1.2)	1.0 (0.4 – 1.5)	2.6 (2.0 – 3.4)	2.5 (1.8 – 3.5)
Cook Shire	21.6	31.2	0.9 (0.5 – 1.1)	1.0 (0.4 – 1.5)	2.5 (1.9 – 3.3)	2.5 (1.8 – 3.3)
Kowanyama Aboriginal Shire	21.1	32.5	0.9 (0.6 – 1.2)	1.0 (0.4 – 1.7)	2.7 (2.1 – 3.5)	2.6 (1.8 – 3.5)
Hope Vale Aboriginal Shire	23.4	28.4	0.8 (0.5 – 1.0)	0.8 (0.4 – 1.1)	2.2 (1.7 – 2.9)	2.3 (1.8 – 3.0)
Lockhart River Aboriginal Shire	22.9	29.7	0.8 (0.5 – 1.0)	0.9 (0.4 – 1.2)	2.3 (1.8 – 3.0)	2.3 (1.8 – 3.0)
Mapoon Aboriginal Shire	23.5	31.2	0.8 (0.5 – 1.0)	0.9 (0.4 – 1.3)	2.4 (1.9 – 3.1)	2.3 (1.7 – 3.2)
Napranum Aboriginal Shire	22.7	32.0	0.9 (0.5 – 1.1)	1.0 (0.4 – 1.4)	2.5 (1.9 – 3.2)	2.5 (1.8 – 3.4)
Northern Peninsula Area Regional	24.0	30.4	0.8 (0.5 – 1.0)	0.8 (0.4 – 1.1)	2.3 (1.8– 3.0)	2.3 (1.6 – 2.9)
Pormpuraaw Aboriginal Shire	21.7	32.5	0.9 (0.6 – 1.2)	1.0 (0.4 – 1.6)	2.6 (1.8 – 3.5)	2.7 (2.0 – 3.5)
Torres Shire	25.0	29.3	0.7 (0.5 – 1.0)	0.7 (0.4 – 1.0)	2.2 (1.7– 2.9)	2.2 (1.6 – 2.9)
Torres Strait Island Regional	26.0	27.9	0.7 (0.5 – 1.0)	0.7 (0.4 – 1.0)	2.1 (1.6 – 2.8)	2.1 (1.5 – 2.8)
Weipa Town	22.6	32.3	0.9 (0.5 – 1.1)	1.0 (0.4 – 1.5)	2.5 (1.9 – 3.2)	2.5 (1.8 – 3.4)

Many more hot days and an increase in very hot days.

By 2070 there is likely more than twice the number of days over 35 °C, the Torres Strait Islands possibly experience more than a hundred extra days over 35 °C. There will be several more days over 40 °C in some parts of the region by 2070 (Table 152).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 151**: Average number of projected additional days over 35 °C and 40 °C for the Torres and Cape region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Aurukun Shire	58.4	0.1	17.6 (6.7 – 47.0)	0.4 (0 – 1.0)	31.7 (12.7 – 67.5)	2.0 (0.4 – 4.7)
Cook Shire	39.5	0.2	15.7 (5.7 – 35.1)	0.7 (0.1 – 1.9)	31.4 (15.4 – 56.8)	2.7 (0.6 – 5.9)
Kowanyama Aboriginal Shire	88.9	0.6	26.3 (6.5 – 67.8)	1.6 (0.5 – 4.2)	53.8 (17.7 – 96.4)	6.6 (2.1 – 14.1)
Hope Vale Aboriginal Shire	6.9	0.2	12.5 (2.6 – 25.2)	0.5 (-0.1 – 1.9)	35.2 (12.3 – 73.5)	2.3 (0.1 – 6.7)
Lockhart River Aboriginal Shire	8.4	0	10.3 (2.8 – 18.7)	0.2 (0 – 0.5)	25.4 (13.0 – 46.2)	1.0 (0.2 – 2.8)
Mapoon Aboriginal Shire	36.4	0	23.4 (11.5 – 41.7)	0.3 (0.1 – 0.6)	46.6 (24.5 – 68.0)	1.7 (0.3 – 4.2)
Napranum Aboriginal Shire	43.4	0	16.1 (6.2 – 40.6)	0.4 (0 – 1.2)	29.4 (12.9 – 58.1)	1.5 (0.4 – 3.8)
Northern Peninsula Area Regional	1.0	0	3.2 (0.9 – 5.6)	0 (0 – 0)	9.8 (3.1 – 19.7)	0 (0 – 0)
Pormpuraaw Aboriginal Shire	75.8	0.2	20.8 (3.8 – 59.5)	0.7 (0.1 – 2.0)	41.4 (15.1 – 87.1)	3.2 (0.8 – 7.6)
Torres Shire	4.3	3.7	5.1 (1.9 – 12.6)	0 (0 – 0)	22.4 (8.0 – 53.4)	0 (0 – 0)
Torres Strait Island Regional	0.7	0	10.3 (2.3 – 31.8)	0 (0 – 0)	52.0 (17.5 – 134.9)	0 (0 – 0)
Weipa Town	51.4	0.1	17.7 (6.1 – 44.6)	0.4 (0 – 1.0)	32.0 (12.2 – 62.5)	2.0 (0.8 – 4.0)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 152**: Average number of projected additional days over 35 °C and 40 °C for the Torres and Cape region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Aurukun Shire	58.4	0.1	17.6 (2.9 – 32.0)	0.8 (0 – 1.5)	59.7 (30.1 – 98.6)	8.8 (2.9 – 19.1)
Cook Shire	39.5	0.2	17.2 (5.1 – 31.1)	1.0 (0.3 – 1.9)	58.8 (31.4 – 92.6)	8.8 (3.4 – 19.9)
Kowanyama Aboriginal Shire	88.9	0.6	26.4 (5.5 – 48.2)	2.4 (0.6 – 4.3)	100.4 (49.7 – 166.0)	18.5 (9.1 – 29.2)
Hope Vale Aboriginal Shire	6.9	0.2	14.8 (5.2 – 29.1)	0.7 (-0.1 – 2.3)	80.1 (53.3 – 132.8)	12.8 (1.6 – 41.6)
Lockhart River Aboriginal Shire	8.4	0	12.4 (4.7 – 17.5)	0.3 (0 – 0.8)	54.2 (31.2 – 88.3)	3.8 (0.6 – 14.8)
Mapoon Aboriginal Shire	36.4	0	25.6 (12.5 – 36.2)	0.5 (0.1 – 1.0)	82.0 (54.3 – 124.4)	11.9 (2.9 – 28.7)
Napranum Aboriginal Shire	43.4	0	16.8 (4.4 – 29.6)	0.7 (0.1 – 1.3)	53.5 (27.8 – 85.0)	8.1 (2.6 – 18.2)
Northern Peninsula Area Regional	1.0	0	4.1 (1.3 – 6.5)	0 (0 – 0)	26.8 (14.0 – 48.5)	0.1 (0 – 0.4)
Pormpuraaw Aboriginal Shire	75.8	0.2	20.8 (3.4 – 40.6)	1.1 (0.1 – 2.1)	79.0 (40.3 – 129.7)	11.6 (6.4 – 55.0)
Torres Shire	4.3	3.7	6.2 (2.2 – 11.2)	0 (0 – 0)	65.6 (39.3 – 115.8)	0.2 (0 – 1.0)
Torres Strait Island Regional	0.7	0	11.6 (3.5 – 22.7)	0 (0 – 0)	137.1 (86.1 – 214.9)	0.1 (0 – 0.4)
Weipa Town	51.4	0.1	18.4 (2.8 – 30.7)	0.9 (0.2 – 1.8)	56.7 (31.5 – 90.6)	9.8 (4.7 – 20.3)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

The Torres and Cape region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with a doubling of the days in a year that are under heatwave conditions (Table 153).

By 2070 the average hottest temperature in a heatwave is expected to increase by 0.7-1.9°C (range -0.7-3°C) across the region. Individual heatwaves are likely to last 3 to as much as 14 days longer. The number of days in the year that are heatwave days could increase by more than 3 times.

***Table 153**: Average change in peak temperature, frequency and duration of heatwaves for the Torres and Cape region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Duration ϕ Days	Peak temp* °C	Frequency α %	Duration ϕ Days	Peak temp* °C	Frequency α %	Duration ϕ Days
Aurukun Shire	37.8	1.6	4.3	0.4 (-0.3 – 0.9)	2.2 (1.0 – 4.1)	1.4 (0.2 – 3.1)	1.1 (0.4 – 1.9)	6.9 (2.9 – 14.6)	3.3 (0.9 – 6.3)
Cook Shire	37.3	1.8	4.5	0.4 (-0.1 – 1.0)	2.4 (0.9 – 4.8)	1.1 (0.1 – 2.2)	1.0 (0.2 – 1.9)	8.4 (3.4 – 20.7)	2.9 (1.4 – 6.0)
Kowanyama Aboriginal Shire	39.1	2.0	4.8	0.4 (-0.1 – 0.8)	2.5 (0.9 – 5.2)	1.1 (-0.2 – 2.4)	1.0 (0.4 – 1.6)	7.8 (3.0 – 14.7)	3.0 (0.7 – 6.2)
Hope Vale Aboriginal Shire	36.7	2.2	4.9	0.5 (-0.6 – 2.1)	3.8 (1.2 – 7.0)	1.4 (-0.7 – 3.3)	1.4 (-0.7 – 2.6)	14.6 (3.7 – 33.0)	4.8 (0.2 – 11.3)
Lockhart River Aboriginal Shire	36.1	1.8	4.6	0.3 (-0.3 – 0.8)	3.2 (0.8 – 7.2)	1.2 (0.1 – 2.6)	1.0 (0.2 – 2.1)	13.4 (5.4 – 33.1)	3.3 (1.7 – 7.6)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

The Torres and Cape region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with more than double the days in a year that are under heatwave conditions (Table 154).

By 2070 the average hottest temperatures in a heatwave may have increased by 1.6-3.2°C. Heatwaves are likely to last more than 9 days longer. The number of days in the year that are heatwave days could more than double.

***Table 154**: Average change in peak temperature, frequency and duration of heatwaves for Torres and Cape region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Duration ϕ Days	Peak temp* °C	Frequency α %	Duration ϕ Days	Peak temp* °C	Frequency α %	Duration ϕ Days
Aurukun Shire	37.8	1.6	4.3	0.6 (0.1 – 0.9)	2.6 (1.0 – 3.9)	1.7 (0.8 – 3.1)	2.3 (1.1– 3.7)	21.7 (10.6 – 49)	9.0 (6.3 – 18.0)
Cook Shire	37.3	1.8	4.5	0.6 (0.3 – 1.0)	2.9 (1.3 – 4.7)	1.6 (1.0 – 2.6)	2.1 (1.2 – 3.9)	26.7 (12.7 – 54)	9.7 (5.4 – 25.3)
Kowanyama Aboriginal Shire	39.1	2.0	4.8	0.5 (0.1 – 0.8)	3.0 (1.1 – 4.2)	1.5 (0.8 – 3.0)	1.7 (0.9 – 2.9)	22.4 (10.1 – 46)	9.0 (4.8 – 19.6)
Hope Vale Aboriginal Shire	36.7	2.2	4.9	0.7 (-0.5 – 1.6)	4.4 (1.4 – 8.6)	1.6 (-0.5 – 2.7)	2.7 (0.5– 5.0)	36.7 (24.4 – 54)	22.6 (6.9 – 49.5)
Lockhart River Aboriginal Shire	36.1	1.8	4.6	0.4 (-0.2 – 0.9)	3.9 (1.4 – 6.3)	1.6 (0.5 – 2.8)	2.2 (0.4 – 4.6)	38.9 (24.8 – 61.1)	16.5 (6.3 – 42.9)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Mapoon Aboriginal Shire	37.2	1.5	4.4	0.3 (-0.4 – 0.9)	2.5 (1.0 – 5.4)	1.4 (-0.9 – 3.0)	0.7 (-0.1 – 1.8)	9.2 (3.5 – 18.8)	3.8 (1.4 – 8.2)
Napranum Aboriginal Shire	37.3	1.5	4.3	0.3 (-0.3 – 0.9)	2.5 (1.2 – 4.7)	1.5 (-0.1 – 2.9)	0.9 (0.2 – 1.5)	8.2 (3.0 – 18.9)	3.3 (1.1 – 5.7)
Northern Peninsula Area Regional	34.4	1.5	4.2	0.5 (-0.4 – 1.6)	2.1 (0.3 – 5.0)	1.5 (-1.4 – 2.9)	0.9 (-0.2 – 2.1)	8.4 (2.5 – 20.3)	4.0 (1.8 – 7.8)
Pormpuraaw Aboriginal Shire	38.5	1.9	4.7	0.4 (-0.1 – 0.8)	2.3 (0.7 – 5.1)	1.1 (-0.5 – 2.6)	0.9 (0.4 – 1.6)	7.4 (3.0 – 15.3)	3.2 (0.6 – 6.6)
Torres Shire	34.2	1.8	4.7	0.6 (0 – 1.1)	3.3 (1.3 – 8.8)	1.9 (-0.2 – 3.5)	1.4 (0.9 – 2.1)	14.2 (5.6 – 33.1)	5.6 (2.9 – 13.4)
Torres Strait Island Regional	34.4	2.3	5.4	0.8 (0.2 – 1.7)	6.2 (0.7 – 16.6)	2.2 (-1.3 – 5.4)	1.9 (1.0 – 3.0)	26.1 (13.6 – 51.2)	13.6 (2.2 – 48.1)
Weipa Town	37.7	1.5	4.1	0.3 (-0.4 – 0.9)	2.2 (1.1 – 4.1)	1.6 (0.2 – 3.3)	1.1 (0.5 – 1.9)	7.4 (2.8 – 13.8)	3.8 (1.6 – 6.9)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
[α]Number of heatwave days relative to number of days in year
[ϕ]Average duration in days of all heatwave events in year

Humidity

The Torres and Cape region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 155).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Mapoon Aboriginal Shire	37.2	1.5	4.4	0.5 (-0.2 – 1.1)	3.0 (1.8 – 4.5)	1.7 (0.8 – 2.5)	2.1 (0.1 – 3.7)	26.3 (15.4 – 48)	12.0 (7.0 – 22.4)
Napranum Aboriginal Shire	37.3	1.5	4.3	0.6 (0.1 – 0.9)	2.9 (1.5 – 4.7)	1.6 (0.9 – 3.5)	2.4 (1.0 – 3.7)	26.4 (12.2 – 55)	9.0 (5.8 – 20.7)
Northern Peninsula Area Regional	34.4	1.5	4.2	0.6 (-0.6 – 2.0)	2.4 (0.6 – 3.9)	1.8 (-0.6 – 3.1)	1.9 (0 – 3.4)	28.1 (16.1 – 51.8)	12.5 (7.5 – 24.2)
Pormpuraaw Aboriginal Shire	38.5	1.9	4.7	0.4 (0.1 – 0.7)	2.8 (1.0 – 3.9)	1.5 (0.6 – 2.6)	1.6 (0.9 – 3.0)	22.4 (10.4 – 48.3)	9.1 (6.0 – 19.8)
Torres Shire	34.2	1.8	4.7	0.7 (0.1 – 1.2)	4.0 (1.6 – 7.2)	2.2 (0.9 – 3.9)	2.6 (1.7 – 3.6)	38.8 (26.5 – 62)	26.9 (9.6 – 57.5)
Torres Strait Island Regional	34.4	2.3	5.4	0.8 (0.2 – 1.3)	7.6 (3.1 – 15.0)	2.1 (-1.3 – 4.3)	3.2 (2.1 – 4.1)	52.3 (42.9 – 67.0)	72.2 (31.0 – 135.3)
Weipa Town	37.7	1.5	4.1	0.6 (0.1 – 1.1)	2.8 (1.4 – 4.3)	1.5 (0.8 – 2.4)	2.7 (1.5 – 3.6)	22.9 (11.1 – 47)	9.4 (6.0 – 16.1)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
[α]Number of heatwave days relative to number of days in year
[ϕ]Average duration in days of all heatwave events in year

Humidity

The Torres and Cape region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 156).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 155**: Average change in humidity for the summer months in Torres and Cape under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Aurukun Shire	89.4	-0.8 (-4.0 – 0.6)	-0.9 (-3.7 – 0.7)
Cook Shire	88.2	-0.9 (-4.7 – 0.9)	-1.0 (-5.3 – 0.8)
Kowanyama Aboriginal Shire	87.3	-0.8 (-5.3 – 1.5)	-0.9 (-5.5 – 0.8)
Hope Vale Aboriginal Shire	89.3	-0.2 (-1.8 – 0.6)	-0.1 (-1.7 – 0.8)
Lockhart River Aboriginal Shire	90.9	-0.5 (-2.5 – 0.4)	-0.7 (-3.2 – 0.2)
Mapoon Aboriginal Shire	87.1	-0.5 (-2.1 – 0.4)	-0.7 (-1.9 – 0.3)
Napranum Aboriginal Shire	89.5	-0.8 (-3.4 – 0.6)	-0.9 (-3.3 – 0.6)
Northern Peninsula Area Regional	88.5	-0.4 (-1.6 – 0.3)	-0.6 (-2.7 – 0.1)
Pormpuraaw Aboriginal Shire	87.8	-0.8 (-4.8 – 1.3)	-1.0 (-4.8 – 0.9)
Torres Shire	85.8	-0.2 (-1.1 – 0.5)	-0.3 (-1.3 – 0.2)
Torres Strait Island Regional	80.9	0 (-0.5 – 0.7)	0.1 (-0.4 – 0.6)
Weipa Town	89.9	-0.7 (-3.1 – 0.5)	-0.8 (-2.7 – 0.7)

Fire weather

Uncertain changes to fire frequency

Dry-season bushfires are common in the region. The projected changes in rainfall are not expected to significantly change fire occurrence. When and where fire does occur, there is high confidence that fire behaviour will be more extreme.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 156**: Average change in humidity for the summer months in Torres and Cape under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Aurukun Shire	89.4	-0.7 (-2.2 – 0.1)	-0.9 (-3.0 – 0.8)
Cook Shire	88.2	-0.9 (-3.0 – 0.3)	-1.0 (-3.7 – 1.0)
Kowanyama Aboriginal Shire	87.3	-0.6 (-2.8 – 0.7)	-0.6 (-3.8 – 1.4)
Hope Vale Aboriginal Shire	89.3	-0.1 (-1.0 – 0.5)	-0.2 (-2.2 – 0.9)
Lockhart River Aboriginal Shire	90.9	-0.7 (-1.9 – 0.3)	-0.8 (-2.6 – 0.2)
Mapoon Aboriginal Shire	87.1	-0.5 (-1.2 – 0.1)	-0.6 (-1.7 – 0.1)
Napranum Aboriginal Shire	89.5	-0.7 (-2.0 – 0)	-0.9 (-2.9 – 0.5)
Northern Peninsula Area Regional	88.5	-0.4 (-1.3 – 0.1)	-0.7 (-2.5 – 0.2)
Pormpuraaw Aboriginal Shire	87.8	-0.7 (-2.6 – 0.6)	-0.8 (-3.4 – 1.2)
Torres Shire	85.8	-0.2 (-0.8 – 0.4)	-0.3 (-1.1 – 0.4)
Torres Strait Island Regional	80.9	0 (-0.6 – 0.8)	0.2 (-0.3 – 0.8)
Weipa Town	89.9	-0.6 (-1.5 – 0.1)	-0.8 (-2.3 – 0.3)

Fire weather

Uncertain changes to fire frequency

Dry-season bushfires are common in the region. The projected changes in rainfall are not expected to significantly change fire occurrence. When and where fire does occur, there is high confidence that fire behaviour will be more extreme.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 157**: Average change in seasonal count of days in each level of fire risk in Torres and Cape region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Aurukun Shire	89.9	23.4	0	5.4 (-0.1 – 21.9)	3.2 (-0.5 – 14.1)	0 (0 – 0.1)	5.1 (-2.2 – 26.1)	3.0 (-1.7 – 15.3)	0 (0 – 0.1)
Cook Shire	64.2	14.1	0	6.1 (0.5 – 23.4)	2.5 (-0.3 – 10.1)	0 (0 – 0.1)	6.5 (0.8 – 29.4)	3.2 (0.1 – 11.7)	0.1 (0 – 0.2)
Kowanyama Aboriginal Shire	98.6	46.2	0.1	6.0 (-3.6 – 20.1)	5.7 (-1.4 – 24.2)	0.1 (-0.1 – 0.5)	6.5 (-0.1 – 20.5)	7.0 (0.3 – 30.9)	0.2 (-0.1 – 0.7)
Hope Vale Aboriginal Shire	0.4	0	0	0.3 (-0.3 – 1.1)	0 (0 – 0)	0 (0 – 0)	0.3 (-0.4 – 0.8)	0 (0 – 0)	0 (0 – 0)
Lockhart River Aboriginal Shire	6.8	0.1	0	1.5 (-0.6 – 6.0)	1.1 (0 – 0.3)	0 (0 – 0)	1.4 (-0.7 – 6.8)	0.1 (-0.1 – 0.3)	0 (0 – 0)
Mapoon Aboriginal Shire	53.1	2.8	0	6.5 (0.2 – 21.5)	0.7 (-0.6 – 3.1)	0 (0 – 0)	4.8 (-2.6 – 20.4)	0.7 (-0.1 – 2.6)	0 (0 – 0))
Napranum Aboriginal Shire	70.3	7.9	0	6.0 (-2.2 – 24.6)	1.6 (-1.1 – 8.4)	0 (0 – 0)	4.6 (-4.3 – 24.3)	1.6 (-0.7 – 6.7)	0 (0 – 0)
Northern Peninsula Area	18.0	0.2	0	1.9 (-1.6 – 11.9)	0.1 (-0.2 – 0.5)	0 (0 – 0)	1.9 (-2.1 – 8.7)	0.1 (0 – 0.3)	0 (0 – 0)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 158**: Average change in seasonal count of days in each level of fire risk in Torres and Cape region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Aurukun Shire	89.9	23.4	0	3.6 (-3.9– 13.7)	3.2 (-2.5– 10.9)	0 (0 – 0.1)	5.8 (-3.1 – 25.0)	4.4 (-2.3 – 13.8)	0.1 (0 – .2)
Cook Shire	64.2	14.1	0	4.7 (-2.5 – 17.1)	2.5 (-0.6 – 6.4)	0 (0 – 0.1)	7.4 (-2.8 – 24.8)	4.3 (-0.8 – 8.8)	0.1 (0 – 0.2)
Kowanyama Aboriginal Shire	98.6	46.2	0.1	3.1 (-5.8 – 11.4)	4.9 (-2.4 – 18.5)	0.1 (-0.1 – 0.2)	6.0 (-3.3 – 17.7)	7.9 (-2.1 – 20.7)	0.2 (-0.1 – 0.4)
Hope Vale Aboriginal Shire	0.4	0	0	0.2 (-0.3 – 0.8)	0 (0 – 0)	0 (0 – 0)	0.6 (-0.4 – 1.7)	0 (0 – 0)	0 (0 – 0)
Lockhart River Aboriginal Shire	6.8	0.1	0	1.5 (-0.6 – 3.7)	0.1 (0 – 0.3)	0 (0 – 0)	1.6 (-2.2 – 5.8)	0.1 (-0.1 – 0.3)	0 (0 – 0)
Mapoon Aboriginal Shire	53.1	2.8	0	4.3 (-4.4 – 14.6)	0.8 (-0.1 – 1.6	0 (0 – 0)	4.9 (-4.1 – 24.8)	1.5 (-0.2 – 3.4)	0 (0 – 0)
Napranum Aboriginal Shire	70.3	7.9	0	3.9 (-6.4 – 16.5)	2.0 (-0.2 – 4.9)	0 (0 – 0)	3.9 (-6.0 – 24.4)	3.2 (-0.3 – 8.0)	0 (0 – 0)
Northern Peninsula Area	18.0	0.2	0	2.1 (-2.9 – 6.5)	0.2 (0 – 0.3)	0 (0 – 0)	3.2 (-4.9 – 11.8)	0.3 (0 – 0.6)	0 (0 – 0)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Pormpuraaw Aboriginal Shire	99.2	41.5	0.1	5.3 (-2.9 – 21.2)	4.7 (-1.0 – 21.0)	0.1 (0 – 0.3)	6.4 (0.5 – 24.5)	5.5 (-1.1 – 26.8)	0.1 (0 – 0.5)
Torres Shire	1.8	0	0	0.28 (-0.4 – 1.5)	0 (0 – 0)	0 (0 – 0)	0.4 (-0.2 – 1.3)	0 (0 – 0)	0 (0 – 0)
Torres Strait Island Regional	0	0	0	0 (0 – 0)	0 (0 – 0)	0 (0 – 0)	0 (0 – 0.1)	0 (0 – 0)	0 (0 – 0)
Weipa Town	79.6	11.1	0	6.0 (-1.0 – 24.1)	2.0 (-1.6 – 9.1)	0 (0 – 0.1)	3.6 (-6.7 – 21.7)	2.1 (-1.1 – 8.4)	0 (0 – 0.1)

Rainfall

More intense downpours

Rainfall is likely to be influenced by high natural variability in the next few decades. While annual totals show little change, the intensity of rainfall events is likely to increase.

***Table 159**: Average change in precipitation for Torres and Cape under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Aurukun Shire	5.6	-0.4 (-1.5 – 0.8)	-0.2 (-1.5 – 0.6)
Cook Shire	4.5	-0.3 (-0.8 – 0.1)	-0.2 (-0.9 – 0.2)
Kowanyama Aboriginal Shire	4.8	-0.3 (-1.4 – 0.7)	-0.2 (-1.4 – 0.3)
Hope Vale Aboriginal Shire	8.7	-0.2 (-1.4 – 1.4)	-0.1 (-1.2 – 0.7)
Lockhart River Aboriginal Shire	5.9	-0.3 (-0.7 – 0.5)	-0.1 (-0.8 – 0.8)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Pormpuraaw Aboriginal Shire	99.2	41.5	0.1	3.0 (-5.1 – 13.2)	4.7 (-1.0 – 21.0)	0.1 (0 – 0.3)	6.8 (-2.3 – 21.5)	6.5 (-2.6 – 19.4)	0.2 (0 – 0.4)
Torres Shire	1.8	0	0	0.4 (-0.5 – 1.0)	0 (0 – 0)	0 (0 – 0)	0.7 (-0.5 – 1.6)	0 (0 – 0)	0 (0 – 0)
Torres Strait Island Regional	0	0	0	0 (0 – 0)	0 (0 – 0)	0 (0 – 0)	0 (0 – 0.1)	0 (0 – 0)	0 (0 – 0)
Weipa Town	79.6	11.1	0	3.7 (-4.8 – 13.6)	2.4 (-1.3 – 6.6)	0 (0 – 0.1)	2.8 (-7.0 – 22.6)	3.9 (-0.9 – 10.5)	0 (0 – 0)

Rainfall

More intense downpours

Rainfall is likely to be influenced by high natural variability in the next few decades. While annual totals show little change, the intensity of rainfall events is likely to increase.

***Table 160**: Average change in precipitation for Torres and Cape under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Aurukun Shire	5.6	-0.4 (-0.9 – 0.1)	-0.2 (-1.5 – 0.5)
Cook Shire	4.5	-0.2 (-0.5 – 0)	-0.2 (-0.7 – 0.1)
Kowanyama Aboriginal Shire	4.8	-0.3 (-0.9 – 0.3)	0 (-1.2 – 0.8)
Hope Vale Aboriginal Shire	8.7	-0.2 (-0.9 – 0.2)	0 (-1.5 – 1.9)
Lockhart River Aboriginal Shire	5.9	-0.2 (-0.6 – 0.6)	-0.1 (-0.8 – 0.9)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)			
Mapoon Aboriginal Shire	5.7	-0.5 (-1.7 – 0.8)	-0.4 (-1.7 – 0.8)
Napranum Aboriginal Shire	5.4	-0.4 (-1.3 – 0.7)	-0.4 (-1.3 – 0.6)
Northern Peninsula Area Regional	6.3	-0.4 (-1.6 – 0.3)	-0.5 (-1.5 – 0.6)
Pormpuraaw Aboriginal Shire	5.1	-0.3 (-1.3 – 0.7)	-0.2 (-1.4 – 0.4)
Torres Shire	5.8	-0.3 (-1.0 – 0.3)	-0.3 (-1.1 – 0.5)
Torres Strait Island Regional	4.3	-0.1 (-0.6 – 0.5)	-0.2 (-1.0 – 0.5)
Weipa Town	6.0	-0.4 (-1.7 – 1.0)	-0.4 (-1.7 – 0.8)

Tropical cyclones

Less frequent but more intense tropical cyclones

Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.

Sea level

Sea level will continue to rise

Sea levels will continue to rise at an accelerating rate and is projected to rise by as much as 0.65 m above present-day levels by 2100 (Table 161).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)			
Mapoon Aboriginal Shire	5.7	-0.6 (-1.2 – 0.2)	-0.3 (-1.8 – 0.7)
Napranum Aboriginal Shire	5.4	-0.5 (-0.9 – 0.1)	-0.3 (-1.3 – 0.4)
Northern Peninsula Area Regional	6.3	-0.6 (-1.2 – 0.3)	-0.5 (-1.7 – 0.6)
Pormpuraaw Aboriginal Shire	5.1	-0.3 (-0.9 – 0.3)	-0.2 (-1.3 – 0.6)
Torres Shire	5.8	-0.3 (-0.9 – 0.3)	-0.4 (-1.1 – 0.4)
Torres Strait Island Regional	4.3	-0.1 (-0.7 – 0.4)	-0.3 (-0.9 – 0.2)
Weipa Town	6.0	-0.6 (-1.3 – 0.1)	-0.3 (-1.7 – 0.8)

Tropical cyclones

Less frequent but more intense tropical cyclones

Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.

Sea level

Sea level will continue to rise

Sea levels will continue to rise at an accelerating rate and is projected to rise by as much as 0.88 m above present-day levels by 2100 (Table 162).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 161: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for the Torres and Cape region under a moderate emissions scenario. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Weipa*		Torres Strait^ϕ		Lockhart River^∝	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allow ance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allow ance	Sea-level rise (relative to average 1986-2005) RCP4.5	Allow ance
2030 (m)	0.11 (07-0.16)	0.12	0.12 (08-0.17)	0.12	0.13 (09-0.17)	0.14
2050 (m)	0.21 (0.13-0.29)	0.22	0.22 (0.15-0.30)	0.23	0.23 (0.16-0.31)	0.26
2070 (m)	0.32 (0.20-0.45)	0.34	0.34 (0.22-0.46)	0.35	0.35 (0.23-0.48)	0.40
2090 (m)	0.44 (0.27-0.63)	0.48	0.46 (0.28-0.64)	0.51	0.47 (0.30-0.65)	0.58
Rate of change by 2100 (mm/year)	6 (3.1-9)	N/A	5.9 (3.0-8.8)	N/A	6.0 (3.2-8.9)	N/A

* Projections for Cook Shire, Pormpuraaw Aboriginal Shire are very similar to those for Weipa
ϕ Projections for the northern Peninsula Area are very similar to those for Torres Strait
∝ Projections for Hope Vale are very similar to those for Lockhart Shire

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More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 162: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time for Torres and Cape region under a high emissions scenario. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Weipa*		Torres Strait^ϕ		Lockhart River^∝	
	Sea-level rise (relative to average 1986-2005) RCP8.5	Allow ance	Sea-level rise (relative to average 1986-2005) RCP8.5	Allow ance	Sea-level rise (relative to average 1986-2005) RCP8.5	Allow ance
2030 (m)	0.12 (07-0.16)	0.12	0.13 (08-0.17)	0.13	0.13 (09-0.18)	0.14
2050 (m)	0.24 (0.16-0.33)	0.25	0.25 (0.17-0.34)	0.26	0.26 (0.18-0.35)	0.26
2070 (m)	0.40 (0.27-0.55)	0.43	0.42 (0.29-0.56)	0.45	0.43 (0.30-0.58)	0.40
2090 (m)	0.61 (0.40-0.84)	0.67	0.63 (0.42-0.86)	0.71	0.65 (0.44-0.88)	0.58
Rate of change by 2100 (mm/year)	11.4 (7.0-15.9)	N/A	11.3(7.2-16.2)	N/A	11.5 (7.3-16.4)	N/A

* Projections for Cook Shire, Pormpuraaw Aboriginal Shire are very similar to those for Weipa
ϕ Projections for the northern Peninsula Area are very similar to those for Torres Strait
∝ Projections for Hope Vale are very similar to those for Lockhart Shire

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More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

4.13 Townsville

How will climate change affect the Townsville Region?

Townsville is the main urban centre and Charters Towers is the main regional centre of this area. It includes the local government councils of Burdekin Shire, Cassowary Coast Regional, Charters Towers Regional, Flinders Shire, Hinchinbrook Shire, Palm Island Aboriginal Shire, Richmond Shire and Townsville City.

4.13.1 Current climate

The HHS region's eastern parts experience a tropical climate characterised by relatively high temperatures throughout the year, pronounced wet and dry seasons and high-intensity tropical storms. High summer temperatures generally peak in January and are usually accompanied by high humidity. To the west, the region has a semi-arid climate with hot humid summers and dry warm winters.

The average annual temperature is 23-25 °C, with the warmer averages in the western parts of the region. The summer average temperature is 28-30 °C, and winter average 18-19 °C.

Annual and seasonal average rainfall amounts are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns such as the El Niño–Southern Oscillation. In the east of the region, annual average rainfall is 661 mm, occurring predominantly between November and April, and mainly in the form of short duration, intense tropical storms which can cause flooding. The region is occasionally affected by tropical cyclones, flooding, storm tide inundation and strong winds.

In the west, annual average rainfall is 453 mm, with most rain falling during the summer wet season (October–March) either as thunderstorms or rain depressions.

The region's annual average potential evaporation is more than twice the annual average rainfall in the east and as much as four times the annual average rainfall in the west, which contributes to the depletion of soil moisture.

4.13.2 Climate projections

This section provides plausible scenarios of the future climate for the Townsville region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.

Future scenario 2 assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
Temperature Maximum, minimum, and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking. Temperature is variable across the region and the magnitude of increases in temperature depend on the locality. In the near future (2030), the annually averaged maximum temperature for the Townsville region is projected to increase by at least 0.1 °C, and as much as 2.0 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.5 °C warmer on average (Table 163). By 2070, the average maximum daily temperatures are expected to increase by at least 0.6 °C, and as much as 2.9 °C above the recent climate (1986–2005) (Table 163). Nights are projected to also be at least 0.9 °C warmer and as much as 2.6 °C warmer.	**Temperature** Maximum, minimum, and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1. Temperature is variable across the region and the magnitude of increases in temperature depend on the locality. By 2030, annual average maximum temperatures for the Townsville region for this high emissions scenario are projected to increase by as much as 1.1 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.5 – 1.5 °C warmer on average (Table 164). By 2070, the projected increase in average maximum daily temperatures across the region is at least 1.3 °C, with some models showing as much as 3.9 °C above the recent climate (1986–2005) (Table 164). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Table 163: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the Townsville region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Burdekin Shire	19.4	28.1	0.8 (0.5 – 1.3)	0.9 (0.5 – 1.4)	1.6 (1.1 – 2.2)	1.6 (0.9 – 2.3)
Cassowary Coast Regional	20.4	26.9	0.8 (0.5 – 1.2)	0.8 (0.5 – 1.1)	1.5 (1.0 – 2.1)	1.6 (1.0 – 2.1)
Charters Towers Regional	17.2	28.1	0.9 (0.5 – 1.3)	1.0 (0.4 – 2.0)	1.7 (1.2 – 2.3)	1.9 (0.8 – 2.9)
Flinders Shire	17.6	30	0.9 (0.5 – 1.4)	1.0 (0.2 – 1.8)	1.8 (1.2 – 2.5)	1.9 (0.7 – 2.7)
Hinchinbrook Shire	19.8	27.3	0.8 (0.5 – 1.2)	0.8 (0.5 – 1.2)	1.5 (1.1 – 2.1)	1.6 (1.0 – 2.2)
Palm Island Aboriginal Shire	23.6	25.5	0.7 (0.5 – 1.1)	0.6 (0.3 – 1.1)	1.4 (0.9 – 1.9)	1.3 (0.8 – 1.7)
Richmond Shire	19.1	31.7	1.0 (0.5 – 1.5)	1.0 (0.1 – 1.9)	1.9 (1.2 – 2.6)	1.9 (0.6 – 2.7)
Townsville City	19.4	27.4	0.8 (0.5 – 1.2)	0.9 (0.5 – 1.3)	1.6 (1.1– 2.2)	1.6 (0.9 – 2.2)

Hotter and more frequent hot days

There is likely to be an extra 15 to over 50 days over 35 °C across the region by 2070. Some parts will experience just a few additional days over 40 °C, while other parts such as Flinders Shire and Richmond Shire can expect a large increase (Table 165).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 164: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario RCP8.5 for the Townsville region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Burdekin Shire	19.4	28.1	0.9 (0.5 – 1.2)	0.9 (0.4 – 1.6)	2.7 (2.0 – 3.5)	2.6 (1.7 – 3.4)
Cassowary Coast Regional	20.4	26.9	0.8 (0.5 – 1.1)	0.9 (0.5 – 1.2)	2.4 (1.9 – 3.2)	2.6 (2.0 – 3.3)
Charters Towers Regional	17.2	28.1	1.0 (0.6 – 1.3)	1.1 (0.2 – 2.1)	2.8 (2.2 – 3.7)	2.9 (1.5 – 3.8)
Flinders Shire	17.6	30	1.0 (0.5 – 1.4)	1.1 (0.1 – 1.9)	3.0 (2.1 – 3.9)	2.8 (1.3 – 3.9)
Hinchinbrook Shire	19.8	27.3	0.8 (0.5 – 1.1)	0.9 (0.5 – 1.2)	2.5 (1.9 – 3.3)	2.7 (2.0 – 3.4)
Palm Island Aboriginal Shire	23.6	25.5	0.8 (0.5 – 1.0)	0.7 (0.4 – 1.0)	2.2 (1.7 – 2.9)	2.1 (1.6 – 2.7)
Richmond Shire	19.1	31.7	1.1 (0.5 – 1.5)	1.0 (0 – 1.8)	3.2 (2.1 – 4.1)	2.8 (1.1 – 3.7)
Townsville City	19.4	27.4	0.9 (0.5 – 1.2)	0.9 (0.5 – 1.5)	2.6 (2.0 – 3.4)	2.6 (1.8 – 3.3)

Many more hot days and an increase in very hot days.

There is likely to be an extra 40 to over 100 days over 35 °C across the region by 2070. In the Shire of Richmond, more than half the days in a year could be over 35 °C. Some parts will experience just a handful additional days over 40 °C, while other parts such as Flinders Shire, Richmond Shire and Palm Island Aboriginal Shire might expect more than 30 extra days over 40 °C (Table 166).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 165**: Average number of projected additional days over 35 °C and 40 °C for the Townsville region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Burdekin Shire	13.8	0.3	9.8 (2.1 – 20.2)	0.7 (0.2 – 1.7)	46.2 (18.7 – 74.3)	8.6 (1.6 – 24.0)
Cassowary Coast Regional	2.7	0	5.1 (0.8 – 8.8)	0.2 (-0.1 – 0.5)	15.9 (4.4 – 29.7)	0.4 (0 – 0.6)
Charters Towers Regional	42.0	1.4	16.0 (3.4 – 30.3)	1.6 (0.2 – 3.1)	31.5 (7.9 – 49.8)	4.7 (1.3 – 8.9)
Flinders Shire	92.9	8.2	22.3 (1.5 – 42.0)	6.8 (1.0 – 11.5)	40.9 (9.3 – 63.5)	16.9 (5.2 – 29.0)
Hinchinbrook Shire	5.2	0.1	5.5 (0.6 – 10.2)	0.2 (-0.1 -0.7)	15.5 (4.2 – 34.7)	0.6 (-0.1 – 1.7)
Palm Island Aboriginal Shire	3.0	0.1	17.7 (1.6 – 27.5)	0.8 (-0.1 – 2.0)	51.9 (9.4 – 88.0)	4.8 (0.1 – 14.7)
Richmond Shire	139.6	21.4	23.7 (-3.2 – 45.1)	13.7 (0.3 – 24.1)	46.1 (8.2 – 84.6)	30.4 (7.3 – 52.8)
Townsville City	5.8	0.2	6.7 (0.7 – 14.4)	0.4 (0– 1.3)	17.4 (3.0 – 30.8)	1.2 (-0.2 – 3.2

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 166**: Projected average number of additional days over 35 °C and 40 °C for the Townsville region for a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Burdekin Shire	13.8	0.3	10.4 (1.5 – 17.8)	0.7 (0.1 – 1.4)	46.2 (18.7 – 74.3)	8.6 (1.6 – 24.0)
Cassowary Coast Regional	2.7	0	5.8 (0.2 – 11.5)	0.1 (-0.1 – 0.5)	43.9 (23.9 – 73.8)	2.4 (0.2 – 5.5)
Charters Towers Regional	42.0	1.4	17.1 (1.0 – 33.2)	1.9 (0.2 – 2.8)	50 (15.8 – 71.4)	12.5 (3.3 – 21.9)
Flinders Shire	92.9	8.2	23.4 (-0.3 – 45.3)	7.6 (1.4 – 13.9)	60.5 (16.7 – 87.6)	31.6 (11.5 – 51.1)
Hinchinbrook Shire	5.2	0.1	6.2 (0.1 – 14.3)	0.3 (-0.1 – .0)	39.0 (22.2 – 77.2)	2.9 (0.1 – 12.0)
Palm Island Aboriginal Shire	3.0	0.1	19.6 (3.3 – 40.7)	0.7 (0 – 1.7)	106.5 (68.0 – 146.7)	31.4 (1.7 – 69.8)
Richmond Shire	139.6	21.4	23.7 (-10.4 – 7.3)	14.9 (2.8 – 7.6)	73.4 (28.5 – 122.0)	47.5 (13.7 – 76.2)
Townsville City	5.8	0.2	7.2 (0.8 – 12.2)	0.4 (-0.2 – 1.0)	39.5 (15.8 – 65.9)	5.9 (0.5 – 20.1)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
The Townsville region will experience an increase in length, peak temperatures and frequency of heatwaves. By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with a doubling of the days in a year that are under heatwave conditions (Table 167). By 2070 the average hottest temperature in a heatwave is expected to increase by 0.8-2.2 °C across the region although some models show a small decrease up to 3.9 °C. Individual heatwaves are likely to last a few days longer, although the models suggest a significantly greater increase in duration in some parts. The number of days in the year that are heatwave days would more than double (Table 167).	**The Townsville region will experience an increase in length, peak temperatures and frequency of heatwaves.** By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with a doubling of the days in a year that are under heatwave conditions (Table 168). By 2070 the average hottest temperatures in a heatwave may have increased by 1.7-4.5 °C. Heatwaves are likely to last from 5 to 40 days longer. The number of days in the year that are heatwave days would more than double (Table 168).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 167**: Average change in peak temperature, frequency and duration of heatwaves for the Townsville region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days
Burdekin Shire	36.8	2.5	4.9	0.9 (-0.5 – 2.4)	2.1 (0.1 – 4.4)	1.0 (0 – 2.4)	1.6 (-0.3 – 3.9)	6.2 (1.7 – 12.9)	2.0 (0.4 – 3.8))
Cassowary Coast Regional	35.5	1.8	4.4	0.4 (-0.5 – 1.4)	2.3 (0.9 – 3.7)	0.9 (0 – 1.8)	0.8 (-0.6 – 1.5)	9.1 (2.2 – 17.7)	3.2 (0.9 – 5.5)
Charters Towers Regional	38.5	2.4	4.5	0.5 (-0.4 – 1.7)	2.0 (0.3 – 3.8)	0.6 (-0.4 – 1.2)	1.4 (0 – 2.5)	6.3 (1.8 – 11.5)	1.8 (0.8 – 2.8
Flinders Shire	40.6	2.7	4.5	0.4 (-0.2 – 1.1)	2.2 (0.3 – 4.1)	0.5 (0 – 0.9)	1.3 (0.3 – 2.3)	6.5 (1.6 – 11.0)	1.6 (0.7 – 2.3)
Hinchinbrook Shire	36.1	2.1	4.6	0.3 (-0.8 – 1.0)	1.9 (0.8 – 3.4)	0.7 (0.1 – 2.3)	0.8 (-0.7 – 2.3)	7.8 (2.2 – 17.0)	2.3 (0.5 – 4.1)
Palm Island Aboriginal Shire	35.8	2.7	5.3	1.0 (-0.6 – 2.4)	5.4 (0.6 – 9.0)	3.5 (-0.1 – 10.1)	2.2 (-0.4 – 4.2)	16.0 (4.9 – 25.5)	13.2 (2.4 – 27.3)
Richmond Shire	42.0	2.8	4.7	0.5 (-0.1 – 1.1)	2.5 (-0.3 – 4.7)	0.7 (0.1 – 1.5)	1.2 (-0.1 – 2.5)	6.9 (1.3 – 12.5)	2.0 (1.1 – 2.9)
Townsville City	35.9	2.4	5.0	0.7 (-0.4 – 2.2)	2.1 (0.2 – 4.3)	0.9 (0 – 2.0)	1.4 (-0.6 – 3.3)	6.6 (1.9 – 13.2)	2.3 (0.5 – 4.3)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
$^{\alpha}$Number of heatwave days relative to number of days in year
$^{\phi}$Average duration in days of all heatwave events in year

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 168**: Average change in peak temperature, frequency and duration of heatwaves for the Townsville region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days
Burdekin Shire	36.8	2.5	4.9	0.8 (-0.1 – 1.6)	2.3 (0 – 4.6)	0.8 (-0.7 – 2.3)	3.1 (1.2 – 6.2)	20.2 (9.6 – 38.1)	7.2 (2.6 – 16.7)
Cassowary Coast Regional	35.5	1.8	4.4	0.2 (-0.8 – 0.8)	2.7 (0.8 – 5.8)	0.9 (0.1 – 1.8)	1.7 (0.3 – 2.5)	26.4 (15.7 – 40.3)	12.4 (3.6 – 23.5)
Charters Towers Regional	38.5	2.4	4.5	0.8 (-0.3 – 1.3)	2.4 (0.2 – 4.7)	0.8 (-0.7 – 1.6)	2.4 (0.5 – 4.1)	17.4 (6.7 – 31.1)	5.5 (2.4 – 12.2)
Flinders Shire	40.6	2.7	4.5	0.6 (0.1 – 1.2)	2.5 (0.2 – 4.9)	0.6 (-0.2 – 1.5)	2.1 (0.9– 3.0)	15.3 (5.9 – 25.9)	4.4 (1.9 – 8.7)
Hinchinbrook Shire	36.1	2.1	4.6	0.4 (-0.5 – 1.2)	2.5 (0.4 – 5.8)	0.8 (-0.2 – 1.7)	1.7 (0.2 – 3.8)	25.3 (14.1 – 41.4)	9.9 (3.1 – 22.2)
Palm Island Aboriginal Shire	35.8	2.7	5.3	0.8 (-0.6 – 2.0)	6.7 (1.5 – 12.1)	3.9 (-0.1 – 9.8)	4.5 (2.1 – 6.5)	31.3 (21.7 – 41.8)	40.3 (22.8 – 62.1)
Richmond Shire	42.0	2.8	4.7	0.6 (0 – 1.2)	2.9 (0.3 – 5.8)	0.9 (0.4 – 1.6)	2.1 (0.8 – 3.2)	14.7 (4.9 – 23.2)	4.9 (2.3 – 9.4)
Townsville City	35.9	2.4	5.0	0.7 (-0.5 – 1.5)	2.4 (0.2 – 4.6)	0.8 (-0.6 – 2.2)	2.8 (0.6 – 6.1)	20.5 (1.0 – 36.7)	7.6 (2.5 – 16.1)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
$^{\alpha}$Number of heatwave days relative to number of days in year
$^{\phi}$Average duration in days of all heatwave events in year

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Humidity

The Townsville region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 169).

***Table 169**: Average change in humidity for the summer months in Townsville under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Burdekin Shire	86.8	-0.6 (-4.2 – 1.5)	-1.7 (-4.5 – 1.2)
Cassowary Coast Regional	91.9	-0.2 (-1.0 – 0.2)	-0.3 (-1.3 – 0.1)
Charters Towers Regional	81.1	-1.7 (-7.7 – 1.6)	-1.7 (-8.4 – 1.4)
Flinders Shire	70.6	-1.8 (-10.4 – 2.6)	-1.6 (-10.5 – 3.6)
Hinchinbrook Shire	91.6	-0.4 (-2.0 – 0.5)	-0.6 (-2.5 – 0.6)
Palm Island Aboriginal Shire	81.3	0.1 (-0.2 – 0.7)	0.2 (-0.4 – 0.6)
Richmond Shire	69.8	-1.4 (-10.7 – 3.8)	-1.0 (-10.7 – 4.6)
Townsville City	88.2	-0.6 (-3.5 – 1.0)	-0.7 (-4.5 – 1.1)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Humidity

The Townsville region can expect a slight decrease in humidity during summer.

In this scenario, humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 170).

***Table 170**: Average change in humidity for the summer months in Townsville under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Burdekin Shire	86.8	-0.3 (-4.0 – 1.2)	-0.7 (-4.6 – 1.3)
Cassowary Coast Regional	91.9	-0.2 (-0.9 – 0.4)	-0.4 (-1.6 – 0.1)
Charters Towers Regional	81.1	-1.3 (-7.2 – 2.1)	-1.7 (-7.6 – 1.9)
Flinders Shire	70.6	-1.2 (-8.7 – 2.8)	-0.7 (-8.2 – 4.8)
Hinchinbrook Shire	91.6	-0.4 (-2.1 – 0.5)	-0.8 (-3.6 – 0.3)
Palm Island Aboriginal Shire	81.3	0.1 (-0.4 – 0.6)	0.4 (-0.3 – 0.9)
Richmond Shire	69.8	-0.7 (-8.3 – 3.5)	0.2 (-8.0 – 6.6)
Townsville City	88.2	-0.4 (-3.6 – 1.1)	-0.8 (-4.2 – 1.1)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Fire weather

Uncertain changes or harsher fire weather

Bushfires in the region are driven by fuel availability, which varies mainly with rainfall. Changes in future rainfall the main driver to changes in any change in fire frequency. When and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 171).

***Table 171**: Average change in seasonal count of days in each level of fire risk in Townsville region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Burdekin Shire	36.3	2.9	0	6.1 (-3.8 – 22.7)	1.0 (-0.6– 4.0)	0 (-0.1 – 0.2)	9.1 (-2.5 – 30.6)	1.9 (-0.5 – 5.6)	0 (0 – 0.1)
Cassowary Coast Regional	0	0	0	0 (-0.1 – 0.2)	0 (0 – 0)	0 (0 – 0)	0 (0 – 0.2)	0 (0 – 0)	0 (0 – 0)
Charters Towers Regional	74.0	27.5	0.3	6.7 (-5.1 – 24.7)	7.4 (-1.8 – 23.6)	0.2 (0 – 0.6)	9.1 (-1.5 – 30.5)	12.8 (-1.7 – 31.6)	0.4 (-0.2 – 1.3)
Flinders Shire	111.7	70.9	3.9	2.2 (-12.5 – 14.2)	11.3 (-3.7 – 33.4)	1.6 (-0.1 – 5.0)	2.2 (-9.4 – 16.5)	16.5 (-3.9 – 41.4)	3.7 (-0.4 – 8.6)
Hinchinbrook Shire	1.3	0.1	0	0.5 (-0.6 – 3.7)	0 (-0.1– 0.4)	0 (0 – 0)	0.8 (-0.6 – 3.4)	0 (-0.1 – 0.2)	0 (0 – 0)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Fire weather

Uncertain changes or harsher fire weather

Bushfires in the region are driven by fuel availability, which varies mainly with rainfall. Changes in future rainfall the main driver to changes in any change in fire frequency. When and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 172).

***Table 172**: Average change in seasonal count of days in each level of fire risk in Townsville region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Burdekin Shire	36.3	2.9	0	4.8 (-1.2 – 24.3)	0.9 (-0.3– 3.3)	0 (-0.1 – 0.1)	13.1 (-4.2 – 30.6)	2.7 (0.1 – 6.9)	0 (-0.1 – 0.1)
Cassowary Coast Regional	0	0	0	0 (-0.1 – 0.2)	0 (0 – 0)	0 (0 – 0)	0 (-0.1 – 0.1)	0 (0 – 0)	0 (0 – 0)
Charters Towers Regional	74.0	27.5	0.3	5.8 (-8.3 – 30.3)	5.4 (-1.6 – 22.0)	0.2 (-0.1 – 0.8)	9.9 (-8.4 – 28.5)	14.8 (-4.1 – 32.2)	0.6 (-0.1 – 1.9)
Flinders Shire	111.7	70.9	3.9	1.6 (-21.0 – 12.8)	7.2 (-3.3 – 29.4)	1.3 (-0.5 – 5.1)	2.4 (-25.4 – 18.6)	15.9 (-7.2 – 37.2)	4.4 (-0.1 – 11.0)
Hinchinbrook Shire	1.3	0.1	0	0.5 (-0.6 – 2.2)	0 (-0.1 – 0.1)	0 (0 – 0)	1.2 (-0.4 – 3.9)	0 (-0.1 – 0.2)	0 (0 – 0)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Palm Island Aboriginal Shire	0	0	0	0 (-0.1 – 0.1)	0 (0 – 0)	0 (0 – 0)	0.1 (0 – 0.2)	0 (0 – 0)	0 (0 – 0)
Richmond Shire	123.9	94.9	9.0	-1.1 (-9.7 – 14.0)	8.8 (-6.3 – 30.2)	2.9 (-1.2 – 9.3)	-2.8 (-16.5 – 17.3)	13.0 (-7.0 – 35.6)	5.9 (-1.0 – 13.7)
Townsville City	16.0	0.7	0	4.0 (-1.7 – 14.2)	0.3 (-0.2 – 1.2)	0 (-0.1 – 0.1)	5.7 (-2.1 – 19.8)	0.4 (-0.2 – 1.5)	0 (0 – 0)

Rainfall

More intense downpours

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades. In 2070, rainfall changes continue to show a large amount of variability, with the possibility of a drier or wetter climate. However, there may be slight declines in spring rainfall by the end of the century for eastern parts, while winter and spring rainfall declines are possible towards the end of the century for the west. The intensity of heavy rainfall events is likely to increase.

***Table 173**: Average change in precipitation for Townsville under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Burdekin Shire	5.7	-0.1 (-1.2 – 0.7)	-0.2 (-1.3 – 0.3)
Cassowary Coast Regional	10.6	-0.4 (-1.3 – 0.5)	-0.4 (-1.9 – 0.3)
Charters Towers Regional	2.5	-0.1 (-0.6 – 0.3)	-0.2 (-0.6 – 0.1)
Flinders Shire	1.7	-0.1 (-0.4 – 0.2)	0 (-0.4 – 0.2)
Hinchinbrook Shire	8.6	-0.3 (-1.1 – 0.5)	-0.4 (-1.8 – 0.2)
Palm Island Aboriginal Shire	5.0	-0.1 (-0.9 – 0.8)	-0.2 (-1.1 – 0.5)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Palm Island Aboriginal Shire	0	0		0 (-0.1 – 0.1)	0 (0 – 0)	0 (0 – 0)	0.1 (-0.1 – 0.2)	0 (0 – 0)	0 (0 – 0)
Richmond Shire	123.9	94.9	9.0	-2.6 (-17.9 – 8.1)	5.6 (-7.3 – 26.6)	2.3 (-0.8 – 7.7)	-5.4 (-19.8 – 4.0)	12.5 (-1.5 – 35.6)	6.6 (-0.8 – 15.0)
Townsville City	16.0	0.7	0	2.7 (-1.0 – 13.8)	0.2 (-0.1 – 0.9)	0 (-0.1 – 0)	8.6 (-2.0 – 27.1)	0.6 (0 – 1.5)	0 (-0.1 – 0.1)

Rainfall

More intense downpours

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades. In 2070, rainfall changes continue to show a large amount of variability, with the possibility of a drier or wetter climate. However, there may be slight declines in spring rainfall by the end of the century for eastern parts, while winter and spring rainfall declines are possible towards the end of the century for the west. The intensity of heavy rainfall events is likely to increase.

***Table 174**: Average change in precipitation for Townsville under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Burdekin Shire	5.7	-0.1 (-1.3 – 0.6)	-0.1 (-1.2 – 0.8)
Cassowary Coast Regional	10.6	-0.3 (-1.5 – 0.3)	-0.5 (-1.9 – 0.8)
Charters Towers Regional	2.5	-0.1 (-0.6 – 0.2)	-0.1 (-0.4 – 0.4)
Flinders Shire	1.7	0 (-0.4 – 0.2)	0.1 (-0.2 – 0.5)
Hinchinbrook Shire	8.6	-0.3 (-1.7 – 0.1)	-0.4 (-1.8 – 0.7)
Palm Island Aboriginal Shire	5.0	-0.2 (-1.2 – 0.1)	-0.2 (-1.2 – 0.4)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)			
Richmond Shire	1.9	0 (-0.4 – 0.3)	0 (-0.3 – 0.4)
Townsville City	5.9	-0.2 (-1.3 – 0.6)	-0.2 (-1.5 – 0.4)

Cyclones

Less frequent but more intense cyclones

Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.

Sea levels

Sea levels will continue to rise

Sea levels will continue to rise at an accelerating rate and is projected to rise by as much as 0.65 m above present-day levels by 2100.

Table 175: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time under RCP4.5 for Townsville. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Townsville*	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.13 (09-0.17)	0.14
2050 (m)	0.23 (0.16-0.31)	0.25
2070 (m)	0.35 (0.23-0.47)	0.38
2090 (m)	0.47 (0.30-0.65)	0.54
Rate of change by 2100 (mm/year)	5.9 (3.1-8.7)	N/A

*Sea-level rise projection values for Palm Island, Cassowary Coast and Hinchinbrook are almost identical to those for Townsville

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)			
Richmond Shire	1.9	0 (-0.3 – 0.4)	0.2 (-0.1 – 0.7)
Townsville City	5.9	-0.2 (-1.4 – 0.2)	-0.2 (-1.5 – 0.9)

Cyclones

Less frequent but more intense cyclones

Tropical cyclones are projected to become less frequent, but those that do occur are expected to be more intense.

Sea levels

Sea levels will continue to rise

Sea levels will continue to rise at an accelerating rate and is projected to rise by as much as 0.87 m above present-day levels by 2100.

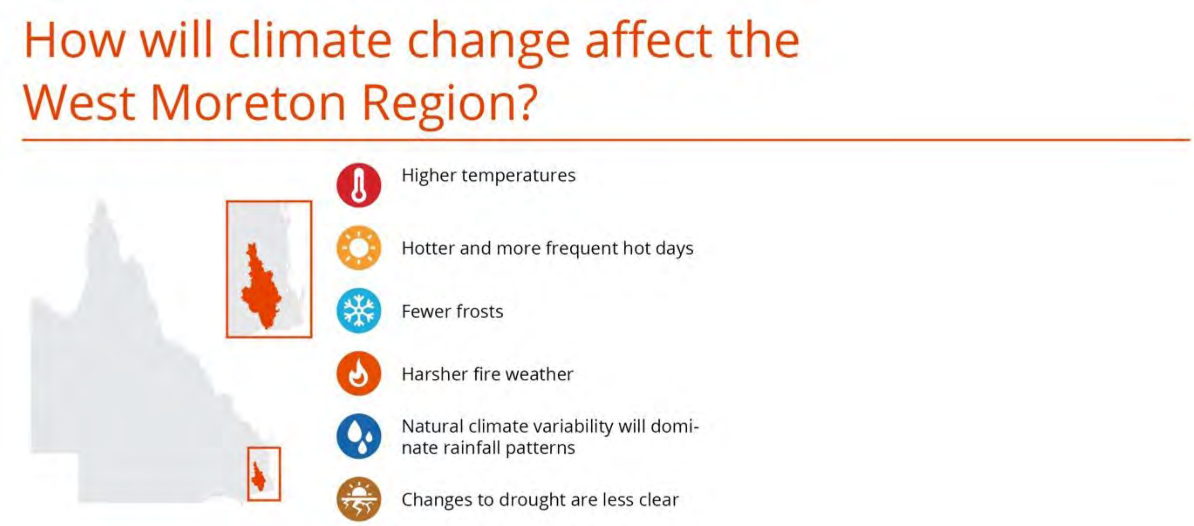
Table 176: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time under RCP8.5 for Townsville. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Townsville*	
	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance
2030 (m)	0.13 (09-0.18)	0.14
2050 (m)	0.26 (0.18-0.35)	0.28
2070 (m)	0.43 (0.30-0.57)	0.48
2090 (m)	0.64 (0.44-0.87)	0.75
Rate of change by 2100 (mm/year)	11.4 (7.4-16.1)	N/A

*Sea-level rise projection values for Palm Island, Cassowary Coast and Hinchinbrook are almost identical to those for Townsville

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)
More frequent sea-level extremes Higher sea levels will increase the risks of coastal hazards such as storm tide inundation. **Warmer and more acidic ocean** Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.	**More frequent sea-level extremes** Higher sea levels will increase the risks of coastal hazards such as storm tide inundation. **Warmer and more acidic ocean** Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

4.14 West Moreton



The West Moreton HHS region is in southeast Queensland and includes the local government councils of Somerset, parts of Scenic Rim, Ipswich City, Brisbane City and Lockyer Valley Regional.

4.14.1 Current climate

Southeast Queensland has a sub-tropical climate influenced by tropical systems from the north and fluctuations in the high-pressure ridge to the south. The average daily maximum temperature in summer (Dec – Feb) range from 28.7 °C (Scenic Rim) to 29.4 °C (Ipswich) with winter maximums averaging 19.5 to 20.3 °C. Overnight average minimum temperature in summer range from 18.6 °C (Scenic Rim) to 19.5 °C (Ipswich), with winter minimums falling to 10 to 10.6 °C.

Annual and seasonal average rainfalls are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño– Southern Oscillation. Most rainfall occurs in summer and autumn (388 mm and 295 mm per year, respectively).

The area experiences high relative humidity (%), with the annual average across the region over 80%. Spring has the lowest average humidity (82 % in Ipswich, 84% in Scenic Rim), and winter the highest (89 % in Ipswich, 91% in Somerset).

The region's annual average potential evaporation is almost 50% greater than the annual average rainfall, which contributes to the depletion of soil moisture.

4.14.2 Climate projections

This section provides plausible scenarios of the future climate for the West Moreton region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking.

In the near future (2030), the annually averaged maximum temperature for the West Moreton region is projected to increase by at least 0.6 °C, and as much as 1.8 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.2 °C warmer on average (Table 177).

By 2070, the average maximum daily temperatures are expected to increase by at least 1.1 °C, and as much as 3.4 °C above the recent climate (1986–2005) (Table 177). Nights are projected to also be at least 1.2 °C warmer and as much as 2.3 °C warmer.

***Table 177:** Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario RCP4.5 for the West Moreton region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Ipswich City Council	15.0	25.3	0.9 (0.5 – 1.2)	1.0 (0.6 – 1.7)	2.0 (1.1 – 2.3)	2.0 (1.1 – 3.2)
Scenic Rim Shire	14.3	24.6	0.9 (0.6 – 1.2)	1.0 (0.6 – 1.7)	1.7 (1.2 – 2.2)	2.1 (1.2 – 3.2)
Somerset Shire	14.4	24.8	0.9 (0.5 – 1.2)	1.0 (0.6 – 1.7)	1.7 (1.2– 2.3)	2.1 (1.2 – 3.2)
Brisbane City	16.5	24.8	0.9 (0.6 – 1.2)	1.0 (0.6 – 1.2)	0.9 (1.2 – 2.2)	0.9 (1.1 – 2.5)
Lockyer Valley Regional	14.1	24.8	0.9 (0.6 – 1.2)	1.1 (0.6 – 1.8)	1.7 (1.2 – 2.3)	2.1 (1.2 – 3.4)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1.

By 2030, annual average maximum temperatures for the West Moreton region for this high emissions scenario are projected to increase by at least 0.4 °C, and as much as 1.8 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.6 – 1.3 °C warmer on average (Table 178).

By 2070, the projected increase in average maximum daily temperatures across the region is at least 2.0 °C, with some models showing as much as 4.4 °C above the recent climate (1986–2005) (Table 178). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

***Table 178:** Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions RCP8.5 scenario for the West Moreton region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Ipswich City Council	15.0	25.3	0.9 (0.6 – 1.2)	0.9 (0.5 – 1.7)	2.9 (2.1 – 3.8)	3.1 (2.0 – 4.3)
Scenic Rim Shire	14.3	24.6	0.9 (0.6 – 1.3)	1.0 (0.5 – 1.7)	2.9 (2.1 – 3.7)	3.2 (2.2 – 4.4)
Somerset Shire	14.4	24.8	0.9 (0.6 – 1.3)	1.0 (0.4 – 1.6)	2.9 (2.2 – 3.8)	3.2 (2.1 – 4.4)
Brisbane City	16.5	24.8	0.9 (0.6 – 1.2)	0.9 (0.6 – 1.2)	2.8 (2.1 – 3.7)	2.8 (2.0 – 3.7)
Lockyer Valley Regional	14.1	24.8	1.0 (0.6 – 1.3)	1.0 (0.5 – 1.8)	2.9 (2.2 – 3.8)	3.2 (2.1 – 4.4)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Hotter and more frequent hot days

There is likely to be a small increase in the number of days over 35 °C across the region by 2070. Days over 40 °C show a modest increase (Table 179).

***Table 179**: Average number of projected additional days over 35 °C and 40 °C for the West Moreton region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		***Increase*** in mean annual number of days for 2030		***Increase*** in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Ipswich City Council	9	0.2	6.0 (0 – 13.0)	0.3 (-0.1 – 0.6)	15.6 (5.2 – 24.2)	1.0 (0.1 – 2.7)
Scenic Rim Shire	4.5	0.9	3.7 (0.1 – 8.9)	0.1 (0 – 0.3)	9.4 (2.5 – 15.9)	0.5 (0 – 1.2)
Somerset Shire	6.3	0.1	4.5 (0.1 – 9.9)	0.2 (0 – 0.6)	11.9 (4.4 – 18.8)	0.7 (0 – 1.9)
Brisbane City	2.1	0	1.7 (0 – 3.7)	0.1 (0 – 0.1)	5.4 (2.1 – 8.0)	0.2 (0.1 – 0.6)
Lockyer Valley Regional	9.1	0.3	6.1 (1.0 – 13.3)	0.4 (-0.1 – 1.0)	14.4 (3.7 – 24.7)	1.1 (0.1 – 3.1)

The West Moreton region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with a doubling of the days in a year that are under heatwave conditions (Table 181).

By 2070 the average hottest temperature in a heatwave is expected to increase by 0.5-2.8°C (range 0.5-2.8°C) across the region. Individual heatwaves are likely to last 1-2 days longer. The number of days in the year that are heatwave days could increase fourfold.

Many more hot days and an increase in very hot days

For this high emissions scenario, by 2070 there is likely to be about three times as many days over 35 °C. There will be 1-2 extra days over 40 °C by 2070 (Table 180).

***Table 180**: Average number of projected additional days over 35 °C and 40 °C for the West Moreton region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		***Increase*** in mean annual number of days for 2030		***Increase*** in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Ipswich City Council	9	0.2	5.7 (0 – 14.0)	0.4 (-0.1 – 1.1)	30.3 (8.5 – 59.2)	2.0 (0.4 –3.8)
Scenic Rim Shire	4.5	0.1	3.3 (0.1 – 7.2)	0.2 (0 – 0.6)	18.7 (4.8 – 36.3)	1.2 (4.96 – 307)
Somerset Shire	6.3	0.1	4.0 (-0.4 – 9.5)	0.3 (-0– 0.2)	23.9 (7.6 – 45.5)	1.6 (0.2 – 3.5)
Brisbane City	2.1	0	1.7 (-0.4 – 5.0)	0.1 (0 – 0.2)	13.75 (3.9 – 29.6)	0.4 (0.1 –0.9)
Lockyer Valley Regional	9.1	0.3	5.4 (0 – 11.4)	0.4 (-0.1 – 1.2)	26.4 (9.8 – 47.0)	2.5 (0.4 – 5.4)

The West Moreton region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with a doubling of the days in a year that are under heatwave conditions (Table 182).

By 2070 the average hottest temperatures in a heatwave may have increased by 2.3°C. Heatwaves are likely to last 3 days longer. The number of days in the year that are heatwave days could increase sevenfold.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 181**: Average change in peak temperature, frequency and duration of heatwaves for the West Moreton region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days
Ipswich City Council	36.3	2.3	4.5	0.4 (-0.6 – 1.0)	2.1 (0.6 – 4.8)	0.5 (-1.3 – 1.9)	1.5 (0.5 – 2.4)	5.8 (1.9 – 9.3)	1.2 (-0.8 – 2.0)
Scenic Rim Shire	34.8	2.3	4.6	0.5 (-0.69 – 1.71)	2.3 (0.6 – 4.6)	0.5 (-1.2 – 1.9)	1.6 (0.5 – 2.8))	6.0 (2.3 – 9.2)	1.1 (-0.8 – 1.9)
Somerset Shire	35.7	2.3	4.5	0.5 (-0.8 – 1.6)	2 (0.4 – 4.2)	0.4 (-0.9 – 1.9)	1.5 (0.6 – 2.3)	5.5 (1.7 – 9)	1 (-0.6 – 1.8)
Brisbane City	33.9	2.2	4.5	0.5 (0.1 – 1.1)	2.2 (0.3 – 4.4)	0.8 (-0.8 – 2.1)	1.5 (0.7 – 2.4)	6.6 (2.3 – 10.5)	1.7 (0.1 – 2.7)
Lockyer Valley Regional	36.3	2.4	4.6	0.6 (-1.0 – 1.4)	2.2 (0.9 – 4.7)	0.5 (-1.4 – 1.9)	1.6 (0.3 – 2.6)	5.8 (2.3 – 9.7)	1.0 (-1.1 – 1.8)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
$^{\alpha}$Number of heatwave days relative to number of days in year
$^{\phi}$Average duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost is projected by the end of the century.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 182**: Average change in peak temperature, frequency and duration of heatwaves for the West Moreton region under a high emissions scenario RCP48.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days	Peak temp* °C	Frequency $^{\alpha}$ %	Duration$^{\phi}$ Days
Ipswich City Council	36.3	2.3	4.5	0.3 (-1.0 – 1.2)	2.1 (0.7 – 4.8)	0.3 (-1.8 – 1.5)	2.2 (0.7 – 4.0)	15.0 (6.0 – 27)	3.6 (0.8 – 8)
Scenic Rim Shire	34.8	2.3	4.6	0.3 (-1.1 – 1.4)	2.2 (0.9 – 5.2)	0.3 (-1.8 – 1.7)	2.3 (0.6 – 4.1)	15.2 (5.4 – 27.6)	3.6 (1 – 8.1)
Somerset Shire	35.7	2.3	4.5	0.3 (-0.9 – 1.5)	2 (0.5 – 4.9)	0.3 (-1.4 – 1.7)	2.3 (0.7– 3.8)	14.5 (5.8 – 26.3)	3.4 (0.9 – 7.9)
Brisbane City	33.9	2.2	4.5	0.4 (-0.3 – 1.3)	2.5 (0.9 – 5.6)	0.6 (-1.0 – 2.3)	2.3 (1.4 – 3.5)	17.0 (8.6 – 28.5)	5.5 (2.2 – 11.1)
Lockyer Valley Regional	36.3	2.4	4.6	0.3 (-0.8 – 1.3)	2.1 (0.8 – 5.0)	0.3 (-1.6 – 1.7)	2.3 (0.8 – 4.1)	14.7 (5.8 – 26.5)	3.3 (0.7 – 7.3)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
$^{\alpha}$Number of heatwave days relative to number of days in year
$^{\phi}$Average duration in days of all heatwave events in year

Frost days

A substantial decrease in the frequency of days with a risk of a frost days is projected by the end of the century.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Humidity

The West Moreton region can expect a slight decrease in humidity during summer

In this scenario, relative humidity changes little with projections ranging from a small decrease to a slight increase in the upper limits of the models (Table 183).

Table 183*: Average change in relative humidity for the summer months in West Moreton under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	**Relative humidity %** Historical annual average (1986-2005)	**Relative humidity %** Change in mean annual relative humidity 2030	**Relative humidity %** Change in mean annual relative humidity 2070
Ipswich City Council	85.5	-0.9 (-6.6 – 1.7)	-1.3 (-6.1 – 0.5)
Scenic Rim Shire	87.2	-1.0 (-6.2 – 1.2)	-1.2 (-5.7 – 0.5)
Somerset Shire	87.3	-1 (-6.2 – 1.3)	-1.3 (-5.7 – 0.9)
Brisbane City	84.1	-0.4 (-3.9 – 1.0)	-0.7 (-4.3 – 0.4)
Lockyer Valley Regional	85.8	-1.2 (-7.1 – 1.2)	-1.4 (-6.4 – 0.9)

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 185).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Humidity

The West Moreton region can expect a slight decrease in humidity during summer

In this scenario, relative humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 184).

Table 184*: Average change in relative humidity for the summer months in West Moreton under a moderate emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	**Relative humidity %** Historical annual average (1986-2005)	**Relative humidity %** Change in mean annual relative humidity 2030	**Relative humidity %** Change in mean annual relative humidity 2070
Ipswich City Council	85.5	0.2 (-3.4 – 2.6)	-1.53 (-5.66 – 0.67)
Scenic Rim Shire	87.2	0.1 (-3.5 – 2.6)	-0.7 (-4.4 – 2.1)
Somerset Shire	87.3	0.1 (-2.8 – 1.8)	-1.0 (-4.8 – 1.5)
Brisbane City	84.1	0.3 (-1.8 – 2.0)	-0.3 (-3.3 – 1.2)
Lockyer Valley Regional	85.8	0.1 (-3.4 – 2.2)	-0.9 (-5.0 – 2.0)

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 186).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 185**: Average change in seasonal count of days in each level of fire risk in West Moreton region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Ipswich City Council	8.3	1	0	4.7 (-0.4 – 16.8)	0.6 (-0.1– 2.3)	0 (0 – 0)	9.1 (-0.1 – 33.7)	1.5 (-0.1 – 5)	0 (0 – 0.3)
Scenic Rim Shire	5.6	0.6	0	3.3 (-0.3 – 11)	0.5 (-0.2 – 1.8)	0 (0 – 0)	6.3 (-0.2 – 16)	1.2 (0– 4.4)	0 (0 – 0.2)
Somerset Shire	7.6	0.9	0	3.2 (-0.4 – 11.7)	0.5 (-0.2 – 2.8)	0 (0 – 0)	6 (-0.3 – 21.9)	1.4 (0 – 5.5)	0 (0 – 0.2)
Brisbane City	0.8	0.1	0	0.4 (-0.2 – 2.0)	0.1 (-0.1– 0.3)	0 (0 – 0)	1.0 (0 – 5.1)	0.2 (0 – 0.6)	0 (0 – 0)
Lockyer Valley Regional	13.1	1.5	0	5.6 (-0.6 – 18.3)	1.2 (0– 4.8)	0 (0 – 0.1)	9.9 (-0.6 – 33.6)	2.7 (-0.1 – 9.5)	0.1 (0 – 0.4)

Rainfall

Natural climate variability will dominate rainfall patterns.

High climate variability is likely to remain the major factor influencing rainfall changes in the next few decades. By 2070, projections of total rainfall show little change or a decrease, particularly in winter and spring. Rainfall is naturally highly variable and this will continue to be a major factor in the next decade. However, the intensity of heavy rainfall events is likely to increase.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 186**: Average change in seasonal count of days in each level of fire risk in West Moreton region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Ipswich City Council	8.3	1	0	1 (-6.8 – 10.5)	0.2 (-2.1– 1.7)	0 (0 – 0.1)	9.5 (0 2– 29.3)	1.6 (0 – 4.5)	0.1 (0 – 0.2)
Scenic Rim Shire	5.6	0.6	0	0.7 (-5.3 – 8.4)	0.2 (-1.2 – 1.3)	0 (0 – 0)	6.6 (0.4 – 20.7)	1.3 (0.1 – 3.5)	0.1 (0 – 0.2)
Somerset Shire	7.6	0.9	0	0.4 (-7.3 – 7.1)	0.2 (-1.6 – 1.4)	0 (0 – 0)	6.8 (0.1 – 18.5)	6.8 (0.1 – 5.1)	0 (0 – 0.2)
Brisbane City	0.8	0.1	0	-0.1 (-2.1 – 1.2)	0 (-0.3– 0.1)	0 (0 – 0)	1.1 (0 1– 4.1)	0.2 (0 – 0.5)	0 (0 – 0.1)
Lockyer Valley Regional	13.1	1.5	0	1.5 (-7.2 – 12.6)	0.5 (-2.3– 2.7)	0 (0 – 0.1)	10.2 (0 – 30.2)	3.2 (0.2 – 9.1)	0.1 (0 – 0.4)

Rainfall

Natural climate variability will dominate rainfall patterns.

High climate variability is likely to remain the major factor influencing rainfall changes in the next few decades. By 2070, projections of total rainfall show little change or a decrease, particularly in winter and spring. Rainfall is naturally highly variable and this will continue to be a major factor in the next decade. However, the intensity of heavy rainfall events is likely to increase.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 187**: Average change in precipitation for West Moreton under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Ipswich City Council	4.3	-0 (-0.4 – 0.5)	-0.1 (-0.7 – 0.3)
Scenic Rim Shire	4.0	-0.1 (-0.5 – 0.5)	-01 (-0.6 – 0.3)
Somerset Shire	3.7	-0.1 (-0.5 – 0.5)	-0.1 (-0.4 – 0.5)
Brisbane City	5.1	-0 (-0.6 – 0.9)	-0.1 (-0.7 – 0.4)
Lockyer Valley Regional	3.5	-0.1 (-0.6 – 0.4)	-0.1 (-0.6 – 0.1)

Changes to drought are less clear

By late this century, it is likely that eastern parts of the region will experience more time in drought.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

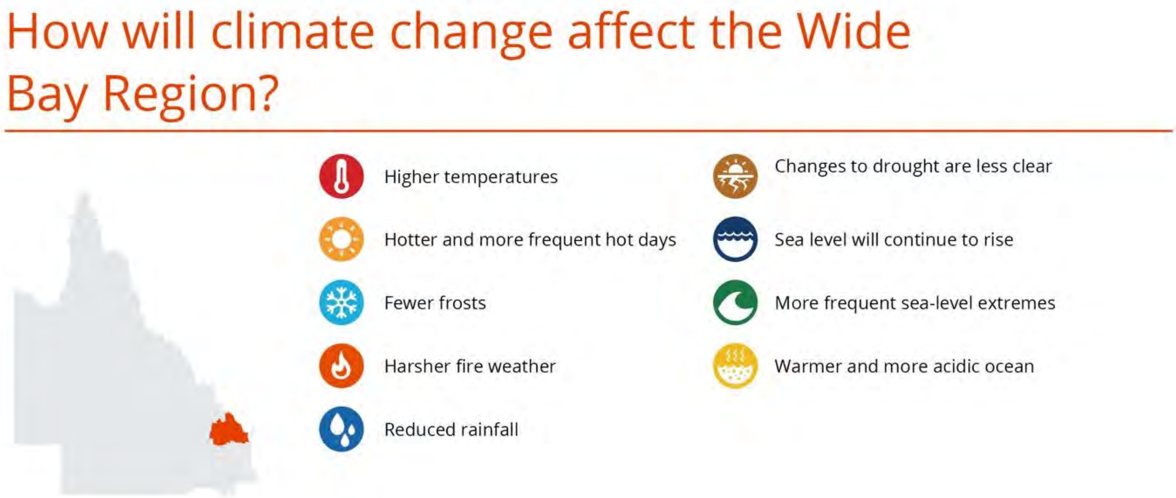
***Table 188**: Average change in precipitation for West Moreton under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Ipswich City Council	4.3	0.1 (-0.3 – 0.4)	-0.1 (-0.5 – 0.7)
Scenic Rim Shire	4.0	0 (-0.4 – 0.3)	0 (-0.4 – 0.5)
Somerset Shire	3.7	0 (-0.4 – 0.5)	0 (-0.4 – 0.7)
Brisbane City	5.1	0.1 (-0.7 – 0.6)	0 (-0.6 – 1.1)
Lockyer Valley Regional	3.5	0 (-0.4 – 0.2)	0 (-0.5 – 0.4)

Changes to drought are less clear

By late this century, under a high emissions scenario, it is likely that eastern parts of the region will experience more time in drought.

4.15 Wide Bay



The Wide Bay HHS region lies on the south coast of Queensland and includes the local government councils of North Burnett Regional, Gladstone Regional, Bundaberg Regional and Fraser Coast.

4.15.1 Current climate

The Wide Bay HHS region experiences a sub-tropical climate with warm wet summers and mild winters.

The average annual temperature is 20 °C. The summer average temperature is 25 °C, autumn 21 °C, winter 15 °C and spring 21 °C.

Annual and seasonal average rainfall are variable, affected by local factors such as topography and vegetation, and broader scale weather patterns, such as the El Niño–Southern Oscillation.

Annual average rainfall is 774 mm, with most occurring during the summer months.

The region's annual average potential evaporation is approximately twice the average mean rainfall, which contributes to the depletion of soil moisture.

5.15.2 Climate projections

This section provides plausible scenarios of the future climate for the Wide Bay region based on two scenarios of the future. In the following, the scenarios are presented in two columns.

> **Future scenario 1** assumes global policies successfully reduce greenhouse gas emissions. By 2100, global temperature increases over pre-industrial levels are projected to reach between 1.1 °C and 2.6 °C in this scenario. In climate modelling terms, the changes outlined in the first column are based on RCP4.5.
>
> **Future scenario 2** assumes poor to no uptake of global policies to reduce greenhouse gas emissions. In fact, actions to reduce emissions across the globe make this scenario increasingly unlikely. However, from a risk evaluation perspective, this scenario may be regarded as "worst case". In climate modelling terms, the changes outlined in the second column are based on RCP8.5.

In the near future (2030), there is little difference in the temperature changes expected for the low and high emissions scenarios. Indeed, because the scenarios incorporate natural variability, sometimes the warming will appear to be slightly more in the lower emissions scenario.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise, but at a slower rate than they are currently tracking.

In the near future (2030), the annually averaged maximum temperature for the Wide Bay region is projected to increase by at least 0.3 °C, and as much as 1.8 °C above the recent climate (1986–2005). Nighttime minima may become 0.5 – 1.3 °C warmer on average (Table 191).

By 2070, the average maximum daily temperatures are expected to increase by at least 1.0 °C, and as much as 3.5 °C above the recent climate (1986–2005) (Table 191). Nights are projected to also be at least 1.1 °C warmer and as much as 2.34 °C warmer.

Table 189: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a moderate emissions scenario for the Wide Bay region. The range in the brackets below the average is the 10th and 90th percentile of modelled values. Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Bundaberg Regional	16.7	26.1	0.9 (0.5 – 1.2)	0.9 (0.4 – 1.8)	1.7 (1.2 – 2.3)	1.8 (1.1 – 3.0)
Fraser Coast Regional	17.2	25.8	0.9 (0.5 – 1.2)	0.9 (0.4 – 1.5)	1.7 (1.1 – 2.3)	1.8 (1.1 – 2.7)
Gladstone Regional	17.1	26.3	0.9 (0.5 – 1.2)	0.9 (0.5 – 1.7)	1.7 (1.1– 2.3)	1.8 (1.1 – 3.0)
North Burnett Regional	15.0	26.7	0.9 (0.5 – 1.3)	1.0 (0.3 – 1.8)	1.8 (1.2– 2.4)	2.1 (1.0 – 3.5)

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Temperature

Maximum, minimum and average temperatures are projected to continue to rise at a faster rate than for Future scenario 1.

By 2030, annual average maximum temperatures for the Wide Bay region for this high emissions scenario are projected to increase by at least 0.4 °C, and as much as 1.9 °C above the recent climate (1986–2005). Nighttime minima are expected to be 0.5 – 1.3 °C warmer on average (Table 192).

By 2070, the projected increase in average maximum daily temperatures across the region is at least 1.9 °C, with some models showing as much as 4.1 °C above the recent climate (1986–2005) (Table 192). Nighttime minima are likely to experience a similar level of increase as daytime maxima.

Table 190: *Recent (averaged across 1986–2005) maximum and minimum temperatures (°C) and average projected increase in those temperatures in 2030 and 2070 under a high emissions scenario for the Wide Bay region. The range in the brackets below the average is the 10th and 90th percentile of modelled values). Maximum/minimum temperature is the highest/lowest temperature on each day.*

Local government area	Recent temperatures (1986-2005) °C		Mean projected increase in temperatures by 2030 °C		Mean projected increase in temperatures by 2070 °C	
	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)	Min. (night time)	Max. (day time)
Bundaberg Regional	16.7	26.1	0.9 (0.6 – 1.3)	0.9 (0.5 – 1.7)	2.8 (2.1 – 3.7)	2.9 (2.0 – 3.7)
Fraser Coast Regional	17.2	25.8	0.9 (0.5 – 1.3)	0.9 (0.6 – 1.4)	2.8 (2.1 – 3.7)	2.9 (2.1 – 3.6)
Gladstone Regional	17.1	26.3	0.9 (0.6 – 1.3)	0.9 (0.5 – 1.8)	2.8 (2.1 – 3.7)	2.8 (1.9 – 3.7)
North Burnett Regional	15.0	26.7	1.0 (0.6 – 1.3)	1.0 (0.4 – 1.9)	3.0 (2.2 – 3.9)	3.1 (1.9 – 4.1)

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Hotter and more frequent hot days

There is likely to be an extra 5 to 20 days over 35 °C across the region by 2070 depending on locality. Days over 40 °C show a modest increase (Table 191).

Table 191*: Average number of projected additional days over 35 °C and 40 °C for the Wide Bay region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Bundaberg Regional	2.8	0	2.5 (-0.4 – 7.4)	0.1 (0 – 0.2)	7.1 (2.1 – 16.5)	0.1 (0 – 0.3)
Fraser Coast Regional	20.6	17.1	3.0 (-0.4 – 8.9)	0.1 (0 – 0.2)	8.2 (2.9 – 16.5)	0.2 (0 – 0.5)
Gladstone Regional	2.1	0.1	2.2 (0.1 – 5.6)	0.1 (0 – 0.4)	5.8 (2.2 – 11.7)	0.3 (0 – 0.8)
North Burnett Regional	14.9	0.4	8.4 (0.2 – 20.9)	0.5 (-0 .3 – 1.2)	20.8 (5.8 – 42.6)	1.8 (0.4 – 5.8)

The Wide Bay region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little longer with almost twice the number of days in a year that are under heatwave conditions (Table 193).

By 2070 the average hottest temperature in a heatwave is expected to increase by 0.8-1.2°C (range 0.2-2.9°C) across the region. Individual heatwaves are likely to last 1-2 days longer. The number of days in the year that are heatwave days are likely to more than double.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Many more hot days and an increase in very hot days

For this high emissions scenario, by 2070 there is likely to be an extra 16 to 34 days over 35 °C depending on locality. There may be an 1 to 4 extra days over 40 °C by 2070 (Table 192).

Table 192*: Average number of projected additional days over 35 °C and 40 °C for the Wide Bay region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical mean annual number of days (1986-2005)		*Increase* in mean annual number of days for 2030		*Increase* in mean annual number of days for 2070	
	>35°C	>40°C	>35°C	>40°C	>35°C	>40°C
Bundaberg Regional	2.8	0	2.3 (0.3 – 5.7)	0 (0 – 0.1)	16.6 (6.7 – 26.3)	0.2 (0 –0.4)
Fraser Coast Regional	20.6	17.1	2.6 (-0.3– 6.7)	0.1 (0 – 0.2)	19.3 (7.3 – 33.9)	0.3 (0 – 0.6)
Gladstone Regional	2.1	0.1	1.9 (0.6 – .6)	0.1 (0 – 0.2)	13.8 (4.7 – 23.9)	0.6 (0 – 1.9)
North Burnett Regional	6.3	0.1	8.4 (2.5 – 21.0)	0.5 (-0.2 – 1.4)	33.8 (11.9 – 52.5)	4.1 (1.0 – 10.1)

The Wide Bay region will experience an increase in length, peak temperatures and frequency of heatwaves.

By 2030 the average hottest temperature in a heatwave will likely be a little hotter and last a little bit longer with almost twice the number of days in a year that are under heatwave conditions (Table 194).

By 2070 the average hottest temperatures in a heatwave may have increased by 1.5 - 2.1°C (range 0.7-3.6°C). Heatwaves are likely to last 3 to 6 days longer. The number of days in the year that are heatwave days could increase by seven or eight times.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 193**: Average change in peak temperature, frequency and duration of heatwaves for the Wide Bay region under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Duration ϕ Days	Peak temp* °C	Frequency α %	Duration ϕ Days	Peak temp* °C	Frequency α %	Duration ϕ Days
Bundaberg Regional	34.6	2.3	4.6	0.2 (-0.6 – 1.1)	1.9 (0.3 – 5.1)	0.7 (-0.1 – 2.4)	0.8 (0.2 – 1.6)	5.8 (2.1 – 10)	1.7 (0.5 – 3.4)
Fraser Coast Regional	34.6	2.2	4.5	0.3 (-0.5 – 1.3)	2.1 (0.2 – 4.7)	0.8 (-0.4 – 2.4)	1.0 (0.4 – 2.1)	6.5 (2.4 – 10.2)	2.0 (0.5 – 3.2)
Gladstone Regional	34.2	2.2	4.6	0.3 (-0.6 – 1.8)	1.9 (0.2 – 4.4)	0.8 (-0.1 – 2.1)	1.0 (0.3 – 2.1)	5.9 (2.5 – 10.6)	1.8 (0.7 – 3.7)
North Burnett Regional	37.2	2.5	4.8	0.3 (-0.7 – 1.8)	2 (0.2 – 4.7)	0.6 (-0.5 – 1.9)	1.2 (0.1 – 2.9)	5.8 (2.0 – 11.0)	1.2 (-0.4 – 2.5)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year

Humidity

The Wide Bay region can expect a slight decrease in relative humidity during summer.

In this scenario, relative humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 195).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 194**: Average change in peak temperature, frequency and duration of heatwaves for the Wide Bay region under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local govt area	Historical annual average (1986-2005)			*Change* in mean annual heatwave conditions 2030			*Change* in mean annual heatwave conditions 2070		
	Peak temp* °C	Frequency α %	Duration ϕ Days	Peak temp* °C	Frequency α %	Duration ϕ Days	Peak temp* °C	Frequency α %	Duration ϕ Days
Bundaberg Regional	34.6	2.3	4.6	0.2 (-0.6 – 0.7)	2.0 (0.6 – 4.0)	0.6 (-0.6 – 1.8)	1.5 (0.7 – 2.0)	17.1 (6.7 – 29.6)	5.4 (1.6 – 11.7)
Fraser Coast Regional	34.6	2.2	4.5	0.3 (-0.6 – 1.0)	2.3 (0.6 – 5.0)	0.3 (-1.8 – 1.7)	1.6 (0.8 – 2.3)	18.2 (7.8 – 30.8)	6.3 (2 – 13.8)
Gladstone Regional	34.2	2.2	4.6	0.4 (-0.3 – 0.9)	2.1 (0.6 – 4.2)	0.7 (-0.2 – 2.1)	1.9 (1.0– 3.0)	17.6 (7.2 – 30.3)	5.8 (2.1 – 12.2)
North Burnett Regional	37.2	2.5	4.8	0.3 (-1.2 – 1.3)	2.1 (0.8 – 4.3)	0.4 (-1.3 – 1.3)	2.1 (0.9– 3.6)	14.8 (7.0 – 25.9)	3.4 (1.5 – 6.7)

*Peak temperature is maximum temperature (in ˚C) of the hottest day of the hottest heatwave.
αNumber of heatwave days relative to number of days in year
ϕAverage duration in days of all heatwave events in year

Humidity

The Wide Bay region can expect a slight decrease in relative humidity during summer.

In this scenario, relative humidity changes little with projections ranging from a slight decrease to a small increase in the upper limits of the models (Table 196).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 195**: Average change in humidity for the summer months in the Wide Bay region under a moderate emissions scenario RCP 4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Bundaberg Regional	86.6	-0.9 (-8.5 – 2.6)	-1.1 (-6.6 – 1.0)
Fraser Coast Regional	87.2	-0.8 (-7.4 – 2.3)	-0.9 (-5.7 – 1.0)
Gladstone Regional	86.2	-1 (-7.8 – 1.9)	-1.1 (-5.9 – 0.4)
North Burnett Regional	81.3	-1.1 (-8.0 – 2.6)	-1.6 (-7.5 – 1.1)

Fewer frosts

A substantial decrease in the frequency of frost risk days is projected by the end of the century.

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 197).

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 196**: Average change in humidity for the summer months in the Wide Bay under a high emissions scenario RCP 8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Relative humidity %	Relative humidity %	Relative humidity %
	Historical annual average (1986-2005)	Change in mean annual relative humidity 2030	Change in mean annual relative humidity 2070
Bundaberg Regional	86.6	-0.1 (-5.3 – 2.3)	-1.53 (-6.1 – 2.9)
Fraser Coast Regional	87.2	0.1 (-4.1 – 2.3)	-0.5 (-4.9 – 2.4)
Gladstone Regional	86.2	-0.3 (-5.5 – 1.5)	-0.7 (-5.3 – 2.4)
North Burnett Regional	81.3	-0.3 (-5.1 – 1.8)	-0.8 (-6.4 – 2.8)

Fewer frosts

A substantial decrease in the frequency of frost risk days is projected by the end of the century.

Fire weather

Climate change will result in harsher fire weather.

Climate change will result in harsher fire weather and when and where fire does occur, there is high confidence that fire behaviour will be more extreme (Table 198).

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

***Table 197**: Average change in seasonal count of days in each level of fire risk in Wide Bay region for a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Bundaberg Regional	6.7	0.3	0	3.3 (-0.5 – 16.2)	0.1 (-0.4–0.9)	0 (0 – 0)	6.5 (-0.2 – 30.3)	0.4 (0 – 1.6)	0 (0 – 0)
Fraser Coast Regional	3.6	0.2	0	1.9 (-0.4 – 8.8)	0.1 (-0.2 – 0.6)	0 (0 – 0)	3.6 (-0.2 – 15.7)	0.3 (0– 1.2)	0 (0 – 0)
Gladstone Regional	7.5	0.3	0	3.6 (-0.3 – 15.8)	0.1 (-0.2 – 1.0)	0 (0 – 0)	7.0 (0.2 – 29.6)	0.4 (0 – 1.6)	0 (0 – 0.1)
North Burnett Regional	35.4	3.5	0	8.5 (-0.6 – 30.5)	2.2 (-0.7 – 9.7)	0 (-0.1 – 0.1)	14.2 (-0.3 – 44.9)	6.0 (0.1 – 25.1)	0.1 (0 – 0.3)

Rainfall

Reduced rainfall

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

Rainfall projections for 2070 show little change or a decrease, particularly in winter and spring; but there is high variability in the projection outputs.

The intensity of heavy rainfall events is expected to increase.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

***Table 198**: Average change in seasonal count of days in each level of fire risk in Wide Bay region for a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local gov't area	Historical annual average (1986-2005)			*Change* in average annual fire risk 2030			*Change* in average annual fire risk 2070		
	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days	High fire risk days	Very high fire risk days	Severe fire risk days
Bundaberg Regional	6.7	0.3	0	1.6 (-0.4 – 12.1)	0.2 (-0.5–0.9)	0 (0 – 0)	7.7 (0.4–24.7)	0.5 (0.1 – 1.3)	0 (0 – 0)
Fraser Coast Regional	3.6	0.2	0	0.7 (-0.7 – 5.8)	0.1 (-0.3 – 0.5)	0 (0 – 0)	4.4 (0.2 – 11.6)	0.3 (0 – 0.9)	0 (0 – 0)
Gladstone Regional	7.5	0.3	0	2.5 (-0.5 – 15.5)	0.2 (-0.3 – 0.8)	0 (0 – 0)	8.5 (0.2 – 28)	0.5 (0 – 1.2)	0 (0 – 0.1)
North Burnett Regional	35.4	3.5	0	4.7 (-4.4 – 26.3)	0.2 (-1.6 – 1.4)	0 (0 – 0.1)	15.8 (0.8 – 43.5)	7.5 (0.6 – 18.8)	0.1 (0 – 0.3)

Rainfall

Natural climate variability will dominate rainfall patterns

High natural variability is likely to remain the major factor influencing rainfall changes in the next few decades.

Rainfall projections for 2070 show little change or a decrease, particularly in winter and spring; but there is high variability in the projection outputs.

The intensity of heavy rainfall events is expected to increase.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)

Changes to drought are less clear

Projecting changes in the frequency and duration of drought is difficult. By late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

Table 199: *Average change in precipitation for Wide Bay under a moderate emissions scenario RCP4.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Bundaberg Regional	4.6	0 (-0.6 – 0.7)	-0.1 (-0.9 – 0.2)
Fraser Coast Regional	5.1	0 (-0.6 – 0.6)	-01 (-0.6 – 0.3)
Gladstone Regional	4.4	0 (-0.7 – 0.6)	-0.1 (-0.9 – 0.4)
North Burnett Regional	2.7	-0.1 (-0.3 – 0.3)	-0.1 (-0.7 – 0.1)

Sea level will continue to rise

Sea level is projected to rise by 0.5m above present-day levels by 2100 (Table 201).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Changes to drought are less clear

Projecting changes in the frequency and duration of drought is difficult. By late this century, under a high emissions scenario, it is likely that the region will experience more time in drought.

Table 200: *Average change in precipitation for Wide Bay under a high emissions scenario RCP8.5. The range in the brackets below the average is the 10th and 90th percentile of modelled values.*

Local government area	Historical annual average precipitation per day (1986-2005)	Change in annual average precipitation per day 2030	Change in annual average precipitation per day 2070
	mm/day	mm/day	mm/day
Bundaberg Regional	4.6	0 (-0.6 – 0.6)	0 (-0.7 – 0.9)
Fraser Coast Regional	5.1	-0.1 (-0.8 – 0.3)	0 (-0.7 – 1.1)
Gladstone Regional	4.4	0 (-0.7 – 0.6)	-0.1 (-0.8 – 0.8)
North Burnett Regional	2.7	0 (-0.4 – 0.3)	0.1 (-0.5 – 0.4)

Sea level will continue to rise

Sea level is projected to rise by 0.8m above present-day levels by 2100 (Table 202).

More frequent sea-level extremes

Higher sea levels will increase the risks of coastal hazards such as storm tide inundation.

Warmer and more acidic ocean

Sea surface temperature has risen significantly across the globe over recent decades and warming is projected to continue. The ocean will become more acidic due to dissolved carbon dioxide, with acidification proportional to emissions growth.

Future scenario 1: Climate in coming decades if global greenhouse gas emissions slow and concentration in atmosphere stabilises (RCP4.5)	Future scenario 2: Climate in coming decades if global greenhouse gas emissions continue to rise and concentration in atmosphere increases largely unabated (RCP8.5)

Table 201: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time under RCP4.5 for the Wide Bay region. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Bundaberg*	
	Sea-level rise (relative to average 1986-2005) RCP4.5	Allowance
2030 (m)	0.13 (09-0.18)	0.14
2050 (m)	0.24 (0.16-0.31)	0.26
2070 (m)	0.35 (0.23-0.47)	0.41
2090 (m)	0.47 (0.30-0.65)	0.60
Rate of change by 2100 (mm/year)	5.9 (3.2-8.7)	N/A

*Sea-level rise projection values for Fraser Coast and Gladstone are almost identical to those for Bundaberg.

Table 202: *Mean sea-level rise (relative to average sea level between 1986-2005) for a given point in time under RCP8.5 for the Wide Bay region. All units in metres except rate of change (mm/year). There is a 66% probability that the observed sea-level rise will lie within the range shown in brackets. Allowance is the amount defences will need to be raised in order to provide the same level of protection as is experienced today.*

Year	Bundaberg	
	Sea-level rise (relative to average 1986-2005) RCP8.5	Allowance
2030 (m)	0.13 (09-0.18)	0.14
2050 (m)	0.27 (0.19-0.35)	0.29
2070 (m)	0.44 (0.31-0.58)	0.52
2090 (m)	0.65 (0.45-0.87)	0.85
Rate of change by 2100 (mm/year)	11.4 (7.5-16.1)	N/A

*Sea-level rise projection values for Fraser Coast and Gladstone are almost identical to those for Bundaberg.

5. Climate change risks and opportunities specific to HHSs

Climate change will impact on HHSs and the broader community in a number of ways. For HHSs these is likely to include:

- direct effects on the planning and operation of HHSs, through impacts on estate management (e.g. excessively hot buildings, overheating equipment) and human resources (e.g. staff unable to work in very hot conditions).
- changes in the demands on HHS (e.g. increased admissions)
- indirect impacts (e.g. power cuts due to excessive demand on the electricity supply caused by increased use of air conditioning throughout the community in hot conditions).

In thinking about risks to your HHS consider how climate change may challenge your past experience and knowledge of planning for and assessing risk. For example, climate change may impact on the useful life of assets (Figure 11), create impacts external to the HHS which in turn impacts on HHS operations (e.g. increased wildlife around rural roads during drought causing more accidents, decreased availability of fresh food, increased cost of supplies) or require you to plan for flooding in buildings where it has not occurred in the past. Increased numbers of extreme weather events may mean considering how to operate more frequently in recovery mode.

Table 203 provides some examples to help prompt your thinking about the risks and opportunities to your HHS from climate change. Some risks may be considered currently as part of your general contingency planning – you may need to think about how to manage the impacts if they occur much more frequently than at present. And some impacts may be entirely new to some areas – for example expansion into new areas of the present-day range of some diseases, more southerly tracks of tropical cyclones. Working through the Guidelines you will assess the level of risk (and any opportunities) and whether you need to consider action to build the resilience of your HHS to manage the impacts.

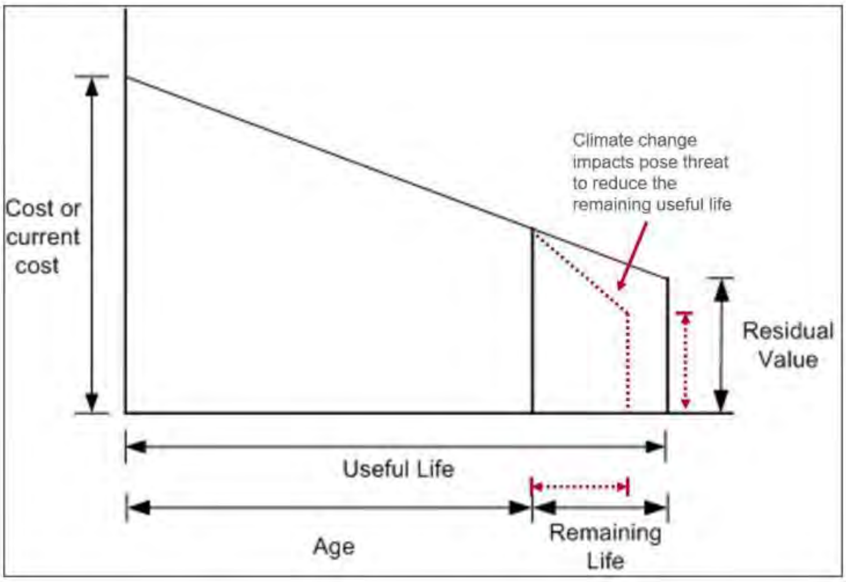


Figure 11: *Schematic diagram showing the implication of climate change for asset management. Red dotted lines show potential reduction of useful life and residual value of assets because of climate change. Adapted from IPWEA (2018).*

Table 203: Summary of examples of possible risks to HHSs under climate change

Category	Risks/opportunities	Examples
Community health	Increased health risks	• Health outcomes for vulnerable patients (e.g. suffering heart and respiratory conditions) compromised by exposure to hotter conditions • Increased mental health problems resulting from increasing climate change pressures on business and properties e.g. increased severity and duration of drought, increased threat of sea-level rise on properties, increased frequency of extreme events • Increase in respiratory related illnesses (e.g. cardiovascular diseases, chronic obstructive pulmonary disease and asthma) due to increased pollution (e.g. dust in dry conditions, increased smoke from bush fires)
	Increased exposure to diseases	• Increased exposure to and risk of infection with arboviruses and other vector-borne diseases (e.g. malaria, dengue, yellow fever, Zika, Ross River fever, borreliosis, tick-borne encephalitis, typhus, leishmaniasis, filariasis and Chagas disease) within the community as control measures fail to halt migration of disease vectors to new areas as a result of changing climate condition. • Increase in disease outbreaks during climate extreme events (e.g. waterborne disease and infection during flooding – typhoid) cryptosporidiosis, campylobacter, leptospirosis). • Increase in food-borne diseases, diarrhoea and gastroenteritis (e.g. salmonella, campylobacter, cholera • Increased risk of outbreaks of harmful algal blooms in public water bodies (lakes, rivers) • Increase in risk of infection and parasitic conditions due to warmer, moister conditions • Ponding of water can increase disease risks, particularly from vector-borne diseases when combined with warmer temperatures
	Increased risk of injury	• Increase in physical injuries during climate extreme events
	Opportunity: Decrease in some health conditions	• Decrease in cold weather-related health issues • Decreased risk of infection and parasitic conditions in drier conditions
	Increased exposure to unfavourable weather conditions for vulnerable community members	• Increased exposure to disease and vectors of populations with compromised immunity • Malnutrition due to decreasing food security or availability (e.g. crop failure, reduced nutrition)
Financial and economic	Disruption to utilities (e.g. electricity)	• Increase in electricity costs with increased demand for cooling technologies (e.g. air-conditioning, refrigeration) • Costs from damage to equipment and perishables

		from power failure (from both high-demand blackouts and transmission failures) • Increased costs from failure of communications systems
	Changes in staffing needs and demands	• Additional staffing requirements to meet increased volume of climate-related patient admissions (above requirements for predicted population increases) e.g. for increased heat stress presentations, new disease outbreaks • New expertise in staffing required to treat new types of admissions (e.g. new disease loads) • Costs of employing additional staff to meet increased admissions as a consequence of shifts in vulnerable populations • Costs of employing additional staff as a consequence of likely decrease in staff availability from fatigue, heat stress, increasing admissions and stress • Increased demand on maintenance staffing to tend to aging infrastructure and equipment
	Increased/decreased service demands	• Increased Emergency Department presentations • Costs associated with providing additional waste services in hotter conditions • Higher costs associated with increased service demands, increased maintenance, temporary staffing, staff recruitment, building retrofit or repairs • Decreases in local populations due to climate conditions (e.g. drought) may mean cuts to funding
	Increased cost of supplies	• Increased cost of fresh and perishable food stuffs and supplies due to crop failure • Increased costs from failure of access and transport infrastructure • Increased cost of utilities as they respond to climate change e.g. increased cost of water supply and sewerage due to increased maintenance and need to upgrade infrastructure (e.g., installation of larger capacity storm drains)
	Increased costs of maintenance and repairs	• More frequent need to repair external equipment and plant due to increased operating temperatures • Increased maintenance costs with increased building and equipment degradation (e.g. foundations cracking, paint deteriorating, mould growth etc.) • Increased costs with increased maintenance requirements (e.g. deterioration of assets under hotter or wetter conditions, machinery or electrical breakdowns due to hotter operating conditions, increased need for drain and gutter clearance to avoid water overflow in intense rainfall periods, preparation for storms or intense rainfall conditions)

Buildings and Infrastructure	Buildings/Infrastructure no longer fit for purpose	• Buildings or facilities, particularly older buildings, become hot and unsafe for patients and staff due to design unsuitability for higher temperatures • Insecurity of water supply (failure to meet demand) • Increased demand on chilled water equipment • Plant design based on climate zone using historical data • Generator capacity does not include support of air-conditioning during power outages • Groundwater becomes too hot to be treated by existing water processing equipment
	Damage to or degradation of buildings and infrastructure	• Buildings degrade rapidly and must be replaced or refurbished sooner than expected end of design life (e.g. fading, drying, cracking and perishing of plastic fixtures in hotter conditions, water damage from more intense rainfall events) • If conditions become drier, reduced soil moisture and reduced humidity can cause cracking and subsidence in buildings. • Frequent, high intensity rainfall can impact building foundations through scouring and water logging and may lead to the increased formation of mould where small leaks penetrate the roof structure. • Damage to underground services (e.g. plant machinery, car parking) during flooding requires more frequent repair or replacement • Erosion (storm surge) can undermine the foundations of buildings (rendering them unsafe or requiring significant repairs), damage or undermine access roads or paths or create unsafe areas within property grounds. • Impacts to equipment from more frequent power cuts (from both high demand blackouts and transmission failures) • Damage to outdoor equipment from extreme exposure • Damage to communications systems • Damage to access and transport infrastructure
	Opportunity: New builds can increase energy efficiency by adopting adaptation measures	• Incorporation of renewable energy back-up power sources can be used to reduce energy costs • Incorporation of passive cooling elements can reduce energy costs
Administration and service	Staffing needs change	• Increased staff absences due to more frequent impacts of extreme events on people and property • Change in expertise demands on staff to meet new types of admissions; new appointments may be required • Local climate conditions (both climate and economic) make retaining staff to live in remote areas more challenging

	Increased admissions	• Increased pressure on community service organisations (e.g. responding to multiple extreme events, increasing risks to vulnerable people) • Increase in cases attending hospital and health services • Increased disease and injury presentations with increased extreme events • Increased incidence of extremes (droughts/floods) may increase presentations of mental health cases
	Adequacy of facilities to meet service demand	• Increased ambulance arrivals need to be accommodated (ramping) • Overcrowded emergency department (e.g. on extremely hot days) • Interruption to service more frequent if increased maintenance or repair required • Reduced capacity of small HHS centres to support vulnerable clients under severe conditions
	Changes in health and safety profiles	• Unsafe working conditions due to extreme heat require changes in rostering or timing of some work (particularly outdoor work) • Increased health and safety risks from external changes as a result of climate factors e.g. increased wildlife on roads during drought in rural districts pose hazard to staff traveling between centres and clients • Increased risk of food or medicine spoilage requires new procedures for handling and storage of perishables
	Changes in emergency management needs	• Increased risk of patient evacuation and need for dedicated alternative care centres as a result of multiple and ongoing extreme events will require new evacuation procedures and care models
	Increased pressure on waste services	• Need for more frequent waste disposal to reduce pest, disease and nuisance risk from waste holding in warmer or wetter conditions
	Increased demand for maintenance and repairs	• Failure of external equipment and plant due to higher operating temperatures • Increased maintenance costs with increased building and equipment degradation (e.g. building cracking, paint deteriorating, mould growth etc.) • Increased maintenance requirements (e.g. deterioration of assets under hotter or wetter conditions, machinery or electrical breakdowns due to hotter operating conditions, drain and gutter clearance to avoid water overflow in intense rainfall periods, preparation for storms or intense rainfall conditions) • Maintenance demands may increase because of greater use of equipment (e.g. cooling technologies heavily relied on in hotter conditions).

Access and supply	Interruption to supply chains	• More frequent power outages as a result of hot weather or flooding cause services to be closed or more frequent reliance on back-up power • Reduced availability of some foods or medicines due to interruptions to production and supply chains • Increased risk of poor water supply quality over extended parts of the year
	Access to facilities interrupted	• Access to facilities lost or limited more frequently with increased flooding; inundation requires increased capacity to store supplies • Inability to dispose of waste because of reduced access to, or closure of, disposal facilities. • During a flood, hospital staff may face restricted access due to road closures and infrastructure damage, impacting their ability to reach the facility and provide care.
	Increased admissions change supply needs	• Changes in the type and volume of patient admissions require holding of additional supplies.

Transition risks

Policy and regulatory changes including those that cap emissions and impose a price on emissions and increasing trend of litigation action for non-compliance with environment or emissions legislation can increase operating costs and affect critical operations of the HHSs. Some of these possible transition risks and possible opportunities are outlined in Table 204.

Table 204: *Summary of examples of possible transition risks and opportunities for HHSs under climate change*

Category	Risks/opportunities	Examples
Policy and Legal	**Risk:** Emissions reduction targets (and associated policies / regulations).	Australia has committed to achieve a 43% reduction in emissions below 2005 levels by 2030 and net zero by 2050. These legislated targets are augmented with state-specific targets and sectoral policies, such as Renewable Energy Target and Safeguard Mechanism. This might impact HHSs where they are expected to reduce their own emissions.
	Risk: Enhanced climate-related financial risk disclosure (reporting) obligations.	The Commonwealth Treasury released a paper revealing Australia's plan to implement the International Sustainability Standards Board (ISSB)-aligned mandatory sustainability disclosure standards (IFRS S1 and IFRS S2) (IFRS 2023), with a focus initially on climate-related disclosure, on 1 January 2025. This will initially be applicable to the biggest listed and unlisted companies and financial institutions, with others being added over time.

Reputation and Resilience	**Risk/opportunity: Perceived adequacy of climate action by stakeholders with increasing climate concern.**	**More instances of stakeholders and community concern. There is expected to be an increase in the popularity of purpose-driven workforces, whereby organisations including HHSs may see improved attraction and retention of talent where climate action by the organisation aligns with that expected of the workforce.**
Market	**Opportunity**: Increased access to capital and subsidies (e.g. green finance, favourable tax treatment of decarbonisation and resilience measures).	Perceived to have a lower risk profile, healthcare providers taking action on climate risks are negotiating more affordable insurance premiums and securing full reimbursement of property and casualty insurance claims (MarshMcLennan, 2022).
Technology	**Opportunity**: Reduced price of clean energy technologies such as electric vehicles (EV).	The Commonwealth government is investing in the development of charging networks (ARENA, 2023) and reducing taxes on EV purchases by raising the luxury car threshold for low emissions vehicles (ATO 2024). All states offer reduced or free registrations fees and stamp duty for EVs. VIC (2024), QLD (2022), TAS (2020) and SA (2024) have also set targets to transition their fleets to EVs to supply the second-hand car market with more EVs.

6. Potential adaptation options

There are many management options that an HHS might consider to reduce climate change risks. The available options will change depending on when risks are identified or considered (e.g. at the planning stage of a major project, or as part of a review of existing facilities). Moving early to consider your adaptation options should give you more choice and more flexibility.

Adaptation measures will need to be assessed with respect to the circumstances of individual HHSs: factors such as budget, culture and risk appetite. Following the Guidelines will support that decision-making process. Here we provide some examples of adaptation options that might be considered. These are arranged in broad categories:

- Planning
- Building design, construction and engineering
- Operations and maintenance

***Table 204**: Summary of examples of adaptation options for HHSs*

Broad categories	Examples of adaptation actions
Planning	• Avoid building in areas at risk in the future (e.g. at risk of inundation from sea-level rise, areas of high fire danger) • Consider a decentralised approach to HHS development to avoid site specific impacts • Plan for raised development sites in the future. For example, ensure that future additions or replacement structures can be installed above flooding or inundation levels. • Adopt more resilient and adaptive building types, e.g. incorporating passive cooling design • Map and model disease and health trends related to climate • Build relationships with community service organisations to understand impacts on vulnerable community members and inform planners of likely changes in demands on the HHS • Consider population movements and growth linked to climate change and the resulting geographic changes in demand for HHSs • Recognise future training and capacity needs and consider how HHSs might meet these needs • Monitor staff levels and demands to understand present-day relationship with weather variations (e.g. hot weather coincides with holiday periods) • Build a better understanding of supply chains to identify climate vulnerabilities, look for diversity in supply sources • Replace old and obsolete equipment with energy efficient alternatives (e.g. air-conditioners, refrigeration) so increased usage can be offset by reduced running costs • Review telecommunications and consider if alternative channels are needed as back-up during outages • Model costs of maintenance, repairs, utilities and services under climate change for budget purposes
Building design, construction and engineering	• Prioritise risks to existing structures; design and construct protection from heat e.g. shade areas, water features, plantings • Look at retrofit options that will reduce maintenance or repair needs (e.g. UV stable materials, upgraded waste-water systems) • Relocate essential infrastructure (e.g. electrical plant, elevators) to low climate risk locations (e.g. above flooding risk areas) • Assess use of low maintenance building materials and design • Install alternative energy sources (e.g. solar panels) to provide back-up and cost savings

	• Raise (essential) external services including sewage pumping stations, and associated electricity supply, to levels above future flood levels, accounting for climate change amplification over the life of the service (100 years +) • Identify any contaminated sites in areas at future flood risk and establish clean-up procedures or implement options that reduce potential for leakage during flood events • Increase capacity of storm water management systems by adopting water sensitive urban design principles such as development of onsite stormwater detention • Consider additional storage and reuse of runoff. Implement water efficiency measures e.g. water tanks, water efficient shower heads etc. • Incorporate green infrastructure to reduce heat (e.g. trees, green roofs) • Incorporate passive cooling measures in new building designs e.g. choice of construction materials, landscaping and orientation. Modify or assess current standards that have been developed on historical data, and that may not consider future conditions to achieve target passive cooling or energy efficiencies • Retrofit existing buildings with measures to achieve passive cooling and increased energy efficiency e.g. fitting double or triple glazed windows on west- and north-facing walls of facilities, passive cooling in landscape design • Ensure vulnerable electrical equipment is adequately insulated from heat or installed in appropriate locations e.g. away from a western facing walls or areas with poor circulation
Operations and service	• Provide staff training in design and maintenance of landscaping for shading and passive cooling using drought tolerant species. • Limit outdoor work by operations and maintenance staff in severe heat conditions, automate systems wherever possible • Develop guidelines to promote healthy working (e.g. regular hydration) • Identify and control any activities that may create sparks during fire weather • Re-locate any on-site sewerage facilities at risk of inundation from rising seas • Increase monitoring of buildings and infrastructure for signs of corrosion, damage, cracking etc. • Consult with energy providers around vulnerabilities and security of supply. • Discuss future needs and expectations with tertiary training, certification and audit organisations • Consider staffing policies and procedures to ensure adequate breaks and self-care are implemented • Increase frequency of maintenance and monitoring of essential equipment to avoid unplanned outages • Review existing and implement new food handling and storage procedures • Regularly review staffing levels and expertise to ensure these remain fit for purpose as the types and volumes of admissions change. Recruit new expertise if necessary • Develop a register of locally qualified people who could be hired as temporary staff during periods of high demand • Ensure staff are aware of the challenges faced by the HHS under climate change. Deliver annual briefings, ensure staff receive training to cope with changing patterns and volumes of admissions. • Implement new transport and storage conditions for transporting perishables.

7. Summary of risks and responses to address specific climate change variables

Table 205: *Summary of examples of risks to HHSs associated with climate change variables, and possible adaptation options*

Climate change variable	**Risks to HHS that may arise due to the projected changes**	**Potential responses (adaptation)**
Increased temperatures (warmer winters, hotter summers, warmer daily averages, warmer overnight temperatures)	Increased demand for services to treat heat related illnesses and mental health issues Demand for new services (e.g. new disease treatment) Increased maintenance as infrastructure experiences faster deterioration Unsuitable working conditions (internal and external) Equipment failure requires more frequent repair Food spoilage Structural impacts on older buildings (e.g. cracking) Increased staff absences and staffing shortfalls Impacts to water quality and water supply Power outages mean loss of air-conditioning	Develop green infrastructure (trees, green roof and vertical gardening in buildings) to reduce heat island effects Incorporate passive cooling features in new building design (e.g. double-glazed windows, orientation) Retrofit structures to cool (e.g. insulation, shading) Change how buildings are used (e.g. patient waiting area in cool refuge) New food handling and storage policies Increase pool of staff to allow for more absences Change work times to avoid heat of day where possible (especially outdoor activities) Introduce innovative cooling structures such as water features Increase water quality monitoring Increase generator capacity to support air cooling technologies
Hotter, more frequent and longer heatwaves	More heat related illness and deaths; increased admissions and demand for services Unsuitable working conditions (internal and external) Equipment failure (overheating) Loss of power (regional load shedding or failure of electricity network)	Model admission patterns related to heat and ensure staffing arrangements suit Review operating temperatures of equipment (e.g. air-conditioning) to ensure continued operation in heatwaves Install supplementary power generation that can be used as back-up or primary supply Reschedule non-essential outdoor work

Climate change variable	Risks to HHS that may arise due to the projected changes	Potential responses (adaptation)
		Review procedures for responding to extreme heat weather warnings
Worsening fire weather conditions	Increased respiratory illness increases demand for services Interruption to power supply Interruption to supply chain Impacts to water supply	Contingency planning Additional supply storage Additional on-site water treatment Supplementary and on-site power generation
Likelihood of more frequent and/or intense droughts, reduced soil moisture	Soil movement causes structural damage to buildings and infrastructure Damage to critical infrastructure Increasing service demands Food scarcity and increased costs due to reduced failed agricultural production (local or regional) Reduced water quality and volumes Increased wildlife movement increase safety risk for staff services rural and remote areas	Install system redundancies Screen new builds and new build areas for long term stability Assess opportunities for fresh food services and local farming Look at opportunities to recycle water Increase on -site treatment and storage capacities Assess opportunities for water demand reduction Increased staff training and awareness of driving safety
Increased seasonal rainfall, more intense rainfall events	Stormwater systems overflow causing localised flooding of facilities or blocking access to facilities Water ponding increases risk of disease, increasing admissions On-site flooding (e.g. car park, grounds) Offsite flooding limits emergency access Reduction of capability to deliver services Access to HHS facilities cut temporarily or for moderate periods Increased accident and injury admissions	Increase capacity of storm water management Incorporate stormwater systems that allow rapid dispersal of water in new builds or in landscaping Increase maintenance regime Look at onsite storage, detention and treatment capacities Consider alternative access options Monitor/review admissions associated with intense rainfall events to understand risk exposure Consider stormwater management (increased capacity) in new builds or refurbishment

Inundation, flooding, erosion due to increased sea levels and storm surge	Interruption to supply chain Damage to buildings Interruption to services Evacuation of patients Loss of access Interruption to communications Interruption to power supply Impacts to water supply and water quality Reduction in services Damage to buildings and infrastructure through erosion or undermining Loss of access and disruption to service	Ensure emergency planning is fit for purpose under changing risk of inundation – including evacuation triggers and procedures. Ensure staff receive ample opportunity to learn and practice emergency procedures Avoid construction in areas at risk Adopt more resilient and adaptive building types Locate critical infrastructure above flood levels (e.g. electricity and plant equipment) Limit or prohibit rebuilding of damaged structures in areas at high or increasing risk Locate critical patient services above flood level Additional supply storage Flood proofing of facilities not able to be moved On-site power options Avoid construction in areas at risk Raise floor levels Locate critical infrastructure above and remote from expected flooding levels Limit or prohibit rebuilding of damaged structures in areas at high or increasing risk Construct protective structures Communication backups Provide on-site staff housing facilities Secure telehealth facilities

More intense storms/cyclones	Staff shortages Damage to property Loss of access Interruption to supply chain Loss of power and/or telecommunications Loss of water supply	Ensure emergency planning is fit for purpose under changing risk of severe cyclones – including evacuation triggers and procedures. Ensure staff receive ample opportunity to learn and practice emergency procedures Consider if ngineering/building standards of new builds are adequate for more intense storms Review if existing facilities would meet need in a severe storm Install back-up power supplies adequate to meet needs Additional supply storage to allow holding of additional supplies Ensure adequate water storage could meet needs in loss of access to mains water Increased maintenance/repair/renewal to maintain building integrity
Increased occurrence of coincident or multiple events (e.g. heatwave followed by fire; riverine and overland flooding combined with storm surge)	Increased pressure on emergency response and hazard planning Increased demand for services Reduced opportunity to repair damage to assets Prolonged interruption to supplies, access, utilities	Review emergency management plans (including evacuation plans) annually to ensure they remain fit for purpose in a changing climate Regularly review supply chains to ensure adequate stocks of essential supplies are held on site during at-risk periods (e.g. storm season) Regularly review staff training procedures and staff roles in emergencies to ensure they remain fit for purpose Regularly undertake staff training to cope with complex emergencies, including full-scale drills; ensure staff are clear about their roles

8. Taking a pathways approach to adaptation

8.1 What is an adaptation pathway?

Decisions about what adaptation action to take might be best undertaken in sequence as the risks from climate change become more severe and, hopefully, as the uncertainties reduce. However, it is important that the decision-making sequence is built in a systematic forward-looking manner rather than undertaken incrementally in response to the changing climate. We call the outcome from such systematic adaptation planning an 'adaptation pathway'.

A pathways approach to adaptation planning is about keeping options open and so avoiding path dependency and lock-in (i.e. committing to a course of action that ultimately proves to be inappropriate and/or cost ineffective). It provides structure and guidance to help incorporate flexibility into adaptation planning. It can reduce unnecessary expenditure, preventing organisations from being locked into actions that may not be the best solutions for what is a long-term problem. Under the approach, rather than determining a final outcome or decision at an early stage, decision makers are able to build a strategy that will follow changing circumstances over time. The approach acknowledges that while not all decisions can be made now, they can be planned, prioritised and prepared for. It is a useful approach for dealing with uncertainty, especially in cases where the uncertainty may reduce over time, for example with improvements in estimates of future local sea-level rise.

- More information on building adaptation pathways can be found on CoastAdapt https://coastadapt.com.au/pathways-approach and https://coastadapt.com.au/how-to-pages/applying-pathways-approach.

8.2 Thresholds and trigger points

An important component of building an adaptation pathway is determining what event will require a particular decision to be made, or cause a particular adaptation action to be implemented, and how that fits in with the whole adaptation strategy. Generally, adaptation actions are not triggered by reaching a particular point in time, but by the occurrence of an event. Rather than saying, for example, that a decision whether to build a sea wall will be made in 2040, in an adaptation pathway it might be the frequency of flooding (say, three times a year) that triggers the decision-making process. At that point, a range of options will be considered that include building a sea wall. These trigger points (and the options to be considered at each trigger point) are decided in advance, when the adaptation pathway is constructed, and may be decided on through community consultation (for example, to understand the community's appetite for risk).

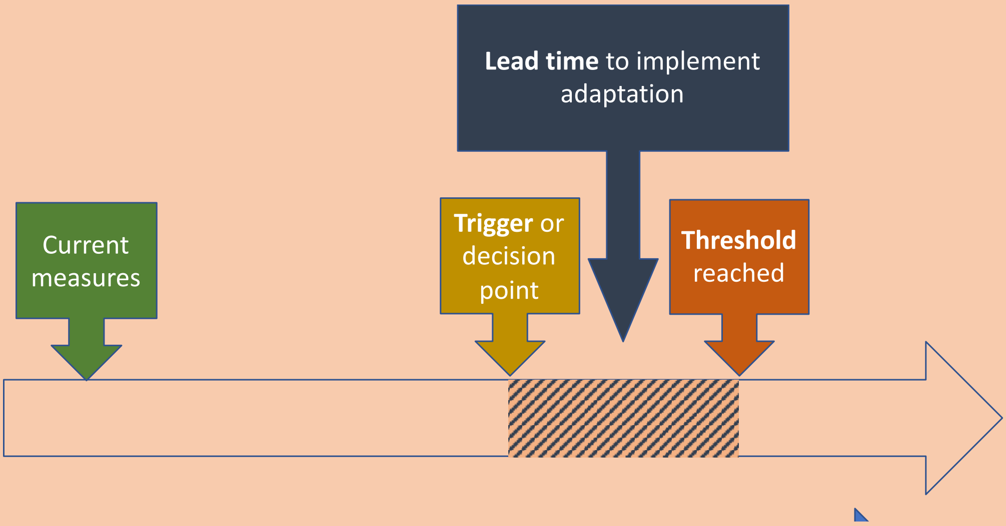
Once options have been identified, it is possible to develop a 'map', or pathway, of how the different options fit together (the order of implementation), and to identify trigger points that require a decision to be made (see Box 3) in order to avoid a critical threshold being reached.

Box 3: Thresholds, lead times and triggers explained.

A **threshold** is the condition under which an asset or process can no longer achieve its desired objectives because of changing environmental conditions.

In setting thresholds which will require new adaptation responses, it is necessary to consider **lead times** to adopting a new response e.g. time to design and construction major infrastructure.

Triggers or **decision points** indicate when you need to make a decision to avoid reaching a threshold.



9. Case studies and examples

9.1 The Spaulding Rehabilitation Hospital

The Spaulding Rehabilitation Hospital was constructed on a waterfront site in Charleston, Massachusetts (Figure 12). The property is at current sea level and already at risk from severe storms and storm surge.

Given the nature of the site, it was essential that the Hospital be constructed with a resilient design philosophy. The design brief included the need to:

- protect patients and employees from the effects of extreme weather and long-term climate change,
- maintain basic building systems and services for a period of at least four days from the onset of an emergency,
- integrate an alternative or backup in the event of system failure, and
- maintain this degree of resiliency over the lifetime of the building (approximately 80 years).

In meeting this brief the building design included the following measures:

1. Building the ground floor at 30 inches above the 500-year flood line. This elevated the building out of significant danger of flooding from sea-level rise for most of its projected life (80 years). The height also accounted for connections to surrounding streets.
2. Locating all critical mechanical and electrical equipment on the roof.
3. Installing a heat and power plant on the roof to supplement power from the grid under normal conditions as well as provide emergency power during an extreme climate event.
4. Waterproofing fuel and fire pumps located in the basement and at ground level.
5. Elevating all vents above 500-year flood levels.
6. Relocating critical patient services above ground level (except food services).
7. Providing secure storage for a four-day supply of linen, food etc.
8. Triple glazed, key-openable windows.
9. Extensive granite and landscape berms to absorb and deflect incoming waves.
10. A drainage network that allows floodwaters to dissipate quickly if flooding occurred and green roofs to help reduce stormwater discharge during heavy rainfalls.

Risk appetite

The hospital has a limited tolerance for disruption of services and impacts on patients who are in a weakened condition. Evacuating the hospital would be complex and undesirable.

Information used to support the decision

The design process considered:

- Climate change including sea-level rise, expected future frequency and intensity of rainfall over the short- and medium-term, and expected future duration and intensity of heat waves.
- Case studies of the experiences of health care facilities under extreme weather conditions (e.g. Hurricane Katrina) and of the experiences of contractors' in post-disaster restoration.
- A review of infrastructure dependencies, principally those of utilities and transportation systems.

Figure 12: *The Spaulding Rehabilitation Hospital was built on an exposed site but includes design features to reduce the risk from flooding and heat.*

Table 206: *The identified climate risks and adaptation options adopted in the design of the hospital.*

Climate hazard	Potential impacts/consequences	Adaptation adopted
Extreme temperature (heatwaves)	• Health impacts • Equipment failure	• Triple glazed windows to exclude heat and retain cooling • Windows that can be opened for cooling if air-conditioning fails
Inundation from sea-level rise	• Flooding of building lower levels • Need to evacuate patients	• Building ground floor above 500-year flood level • Location of vital equipment on roof/higher floors • Capacity to keep patients in place for 4 days • Waterproofing equipment in the basement
Storm surge	• Property damage	• Granite berms to dissipate wave energy

Cost

The measures to improve resilience against future flooding collectively added between 0.3 and 0.5 percent to the initial cost of construction. This was easily offset by energy savings obtained through design features.

Key lessons

This case study is an example of planning for a major infrastructure development where the goal is that the asset be adapted to climate change for its design life of 80 years. It demonstrates that even at a high-risk location, adaptation options may reduce the risks. The project looked at the costs of additional measures and found them to be minimal compared to the avoided risks. Additional costs were also offset by power savings generated through design measures.

9.2 Darling Downs Hospital and Health Service (DDHHS) First Pass Climate Change Risk Screening

What triggered the risk assessment?

Darling Downs Hospital and Health Service took a pro-active response in acknowledging climate change and its potential impacts to its business (i.e. delivery of health services) and to business continuity. This ensures that its Board is well-placed in a rapidly changing legal environment and in considering the long-term sustainability of its operations.

How it was done?

Two workshops were held with key management and projects personnel from the DDHHS Infrastructure Division and from the DDHHS Rural & Aged Care Division. Additional targeted discussions to cover other operational areas were held to ensure that the first-pass screening covered the broad range of activities undertaken by DDHHS.

Participants were provided with an overview of the climate of the region and how it was projected to change into the future under various climate change scenarios. Participants were also taken through the approach to be followed in the risk screening process.

The groups held a facilitated discussion which took them through various steps for each climate hazard. The discussion questions were as follows:

- Have the hazards occurred before in the DDHHS region and, if so, what aspects of the business was affected?
- Have management plans or activities to address the threat had been implemented?
- Is existing management working? (This question enables identification of residual risk)
- Are the identified risks likely to change in the future (20, 50 years)? Is the change likely to reduce or increase exposure?
- Are any identified changes likely to be problematic? Are there are any specific locations, facilities or operational activities where the change is likely to occur, and where the risk should therefore be considered a priority?

What were the major findings?

A number of climate related risks to the organisation, its facilities and staff were identified and recommendations were made about adaptation responses to these risks. Some actions were recommended as immediate priorities and others were longer term. In some cases, a more detailed risk assessment was recommended to underpin determination of appropriate management actions.

How is it being used?

The risk assessment outcomes have been considered by executive management and the board and are now a consideration of various planning and management process of the DDHHS. The organisation actively considers the implications of a changing climate to its business and is in a good position to take further detailed steps in the future as necessary.

Figure 13: *Darling Downs Hospital in Toowoomba. Source: Ourtoowoomba - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=4680361*

9.3 The South West Hospital and Health Service Climate Change Roadmap

Climate projections for the South West Hospital and Health Service (SW HHS) region:

- Higher mean temperatures
- Higher and more frequent hot days and heatwaves
- Harsher fire weather
- More intense downpours
- Fewer frost events

Following a high-level climate risk assessment, the SW HHS identified two strategic risks:

1) Increase intensity and frequency of extreme weather climate will impact public health, services, workforce, supply chain and infrastructure.
2) Risks to operations from changing regulatory compliance and litigation requirements associated with policy and regulatory change.

SW HHS's response include the following:

1. Near-term work
    - Estimation of total emissions to understand carbon footprint
    - Setting reduction targets
    - Completion of a detailed climate risk assessment
    - Develop a Sustainability Strategy
    - Establishment of a Climate Risk Management Committee.
2. Mid-term work
    - Introduction of sustainable procurement policies
    - Development of a renewable energy procurement policy
    - Implementation of staff climate risk training
    - Promotion of telemedicine and remote healthcare services to reduce emissions
    - Collaborate with other regional partners on climate planning
    - Retro-fit existing facilities and design new facilities for climate resilience .
3. Long-term work
    - Encourage suppliers to provide low carbon alternatives
    - Review adaptation plan.

Link to the SW HHS's Sustainability Action Plan 2024 - 2027.

9.4 Other case studies and examples

After recording breaking rains major medical centre's hazard mitigation plan improves – Following catastrophic floods that closed a major medical facility, a plan for resilience was developed.

- https://toolkit.climate.gov/case-studies/after-record-breaking-rains-major-medical-centers-hazard-mitigation-plan-improves

Bracing for heat – Strategies taken in Minnesota to help protect people in both rural and urban settings from extreme heat health effects.

- https://toolkit.climate.gov/case-studies/bracing-heat

Global, Green and Healthy Hospitals – A collection of case studies from members.

- https://www.greenhospitals.net/case-studies/

Health care facilities maintain indoor air quality through smoke and wildfires – Hospital deploys air-scrubbers to keep hospital open during heavy smoke.

- https://toolkit.climate.gov/case-studies/health-care-facilities-maintain-indoor-air-quality-through-smoke-and-wildfires

Robust Hospitals in a Changing Climate (UK) – Description of a research project to design retrofit options for NHS buildings.

- https://www.youtube.com/watch?v=GvNjVQQmXLU

10. Where to find further information

Recent climate change
State of the Climate 2024 Report

- http://www.bom.gov.au/state-of-the-climate/

What is climate change?
CoastAdapt

- www.coastadapt.com.au

Australian Academy of Science

- https://www.science.org.au/learning/general-audience/science-booklets-0/science-climate-change

Climate change in Australia

- www.climatechangeinaustralia.gov.au

What is adaptation?
CoastAdapt

- www.coastadapt.com.au

Climate projections
Climate change in Australia

- www.climatechangeinaustralia.gov.au

Queensland Future Climate Dashboard

- https://www.longpaddock.qld.gov.au/qld-future-climate/

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