climate change in GOULBURN BROKEN

Climate change is one of the most important challenges facing us today. Without action to reduce greenhouse gas emissions and prepare for a changing climate, the direct and indirect impacts will have major adverse effects on the environment, our society and our economy.

Without effective global action to reduce greenhouse gas emissions, by the end of the 21st century concentrations of greenhouse gases in the atmosphere are expected to be two or three times higher than pre-industrial levels (280 parts per million).

Because of the inertia in the climate system and the lifetime of greenhouse gases in the atmosphere, past human activities and greenhouse gas emissions are affecting us now, and today's decisions and actions will have impacts far into the future.

We are already committed to global warming of at least 0.6°C (relative to 1990) by 2030. Thereafter, we have a choice – the extent of climate change we experience will depend on emissions we release over the next couple of decades and beyond. A global emissions reduction target of 60% by 2050 still commits us to global warming of at least 2°C from pre-industrial (1750) levels. Beyond 2°C warming, the risk of dangerous and rapid climate change increases significantly and the costs of adaptation also rise.

Over the past 17 years, observations of carbon dioxide concentrations, global mean temperatures and sea level rise have been tracking close to the upper limit of projections from the Intergovernmental Panel on Climate Change (IPCC). While further evidence is required, these reservations suggest that the mid to low range of projections may be less likely than the upper limits of projections.

→ This document is a summary of how the climate of Goulburn Broken is expected to change during the 21st century based on a range of greenhouse gas emissions scenarios.

The climate change projections have been collated by CSIRO on behalf of the Victorian Government. The projections are consistent with the Australian climate change projections released in late 2007, incorporating results from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007). Further information from the Australian Bureau of Meteorology and other peer-reviewed scientific studies have also been included.

This brochure is one of a series of regional climate change profiles that are available online from **www.climatechange.vic.gov.au**

This summary is not intended for impact analysis or developing adaptation responses, which will require more specific information.

→ HOUSEHOLD ENERGY USE

Energy generation and use accounts for around 70% of Victoria's greenhouse gas emissions.

By using less energy you will lower emissions and help to reduce the impacts of climate change.

The Victorian Government's energy saving campaign uses a black balloon to represent greenhouse gas emissions. A balloon holds 50 grams of greenhouse gas and an average Victorian household produces over 12 tonnes or 240,000 black balloons of greenhouse gas emissions each year.

For further information about how you can save energy and reduce greenhouse gas emissions phone 1300 363 744 or visit www.SaveEnergy.vic.gov.au

the Victorian climate change adaptation program

A Victorian Government initiative

Victoria The Place To Be

GOULBURN BROKEN

→ PROFILE

The Goulburn Broken in northern Victoria is part of the Murray Darling Basin. It covers just over 10% of the state and is home to 181,000 people. The major rural towns and cities in the region include Shepparton, Mooroopna, Benalla, Seymour, Kyabram, Cobram, Yarrawonga, Numurkah, Nathalia, Mansfield, and Yea.

The region is regarded by many as the food bowl of the Murray Darling Basin. The main primary industries are horticulture, dairy, cropping, viticulture, wool, forestry and grazing of both sheep and cattle. The region also supports a large fruit and vegetable food processing industry centred on Shepparton. The production and processing of timber is also an important regional employer. Tourism is increasingly significant to the region. In the southern areas, easy access from Melbourne provides numerous options for tourism and recreational activities. In the northern areas, the Murray River remains a strong tourist attraction.

The region comprises nine different bioregions* where 30% of native vegetation cover remains. 28% of the region is public land that is managed according to reservation types and supports some of Victoria's most valuable National and State Parks, alpine resorts and forest industries. There are three declared Heritage Rivers (the Goulburn below Eildon, the Big and the Howqua Rivers). Significant native species include the nationally listed Leadbeaters Possum, Mountain Pygmy-Possum, Striped Legless-Lizard and Spot-tail Quoll.

*http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html

current climate

Although we can no longer expect that past climate is an adequate guide to the future climate, it is useful to examine the region's historical climate to help understand the spatial variation in temperature and rainfall. It is difficult to describe the 'average' climate, given its variability. However, based on international convention, the average climate described in Figure 1 and Figure 2 is based on the 30 year period from 1961 to 1990.

Summers in the Goulburn Broken region range from warm in the elevated southern region (average daily temperatures less than 25˚C) to hot in the northern areas (more than 30˚C). Winters are milder on the plains but cold in the mountains in the south. Frost is common throughout the region and there is occasionally snow in the mountains above 1000 metres. Annual rainfall averaged across the region is 774 millimetres and occurs mainly in winter and spring. On average there are 112 days each year where at least 1 millimetre of rain falls.

Table 1
Seasonal and annual average temperatures and rainfall in Goulburn Broken (1961 to 1990)

	Average daily temperature (˚C)	Average daily maximum temperature (˚C)	Average daily minimum temperature (˚C)	Average rainfall (mm)
ANNUAL	13.9	20	7.7	774
SPRING	13.3	19.5	7	200
SUMMER	20.1	27.7	12.5	135
AUTUMN	14.4	20.5	8.3	188
WINTER	7.7	12.3	3.1	251

Figure 1
How average annual **temperature** varies across Goulburn Broken (based on average daily temperature between 1961 to 1990)

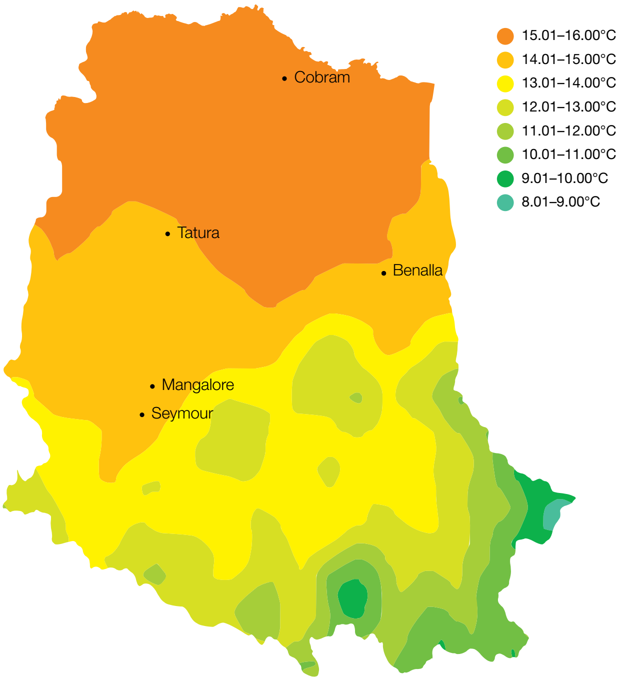
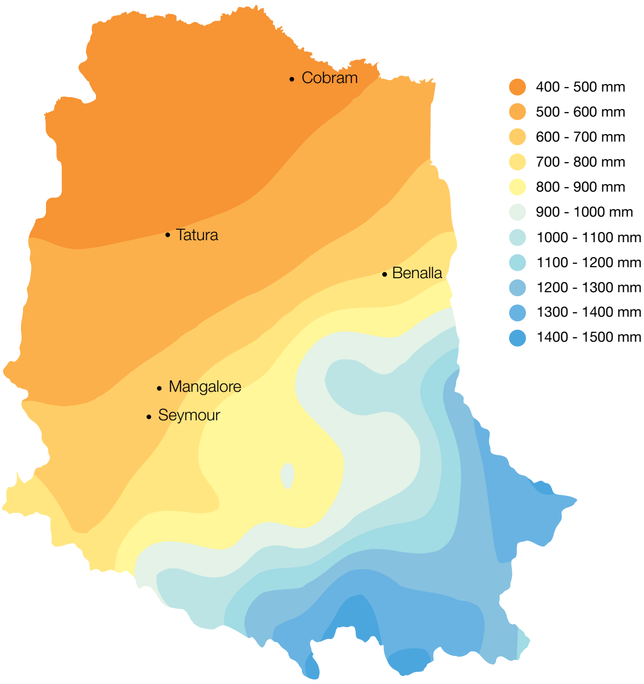


Figure 2
How average annual **rainfall** varies across Goulburn Broken (based on average daily rainfall between 1961 to 1990)



climate trends

During the last decade (1998 to 2007) average annual temperatures in the region were 0.4˚C warmer than the 30 year (1961 to 1990) average. Average daily maximum temperatures increased by 0.6˚C, while the average daily minimum only increased by 0.2˚C. Summer shows the greatest increase in average temperature (0.6˚C), while maximum temperatures increased the most in summer and spring (0.7˚C). Minimum temperatures increased the most in summer (0.5˚C), but showed a small decrease in autumn (0.1˚C). Over this same period, the average annual number of days over 30˚C increased (by 7 days) as did the number of days over 35˚C (by 3 days). During this same period, there were 3 fewer cold nights (minimum temperature below 5˚C) per year.

There has been a decline in the region's rainfall over the past decade. Between 1998 and 2007 the region's average rainfall was 17% below the 1961 to 1990 average. Decreases were greatest in autumn (33%), but rainfall decreased in all seasons. There were 17 fewer rainy days each year on average.

These trends provide a benchmark against which we can measure future climate change. It also allows us to determine whether the trends we have already seen agree with the future direction of climate change.

While the observed warming is likely to be mostly due to increases in greenhouse gas emissions, it is not yet possible to say the same about the observed changes in rainfall. However, because the recent drought has occurred during these periods of increased temperatures, it is possible to say that climate change has exacerbated the impacts of these low rainfall periods.

→ FACT

During the last ice age (20,000 – 100,000 years ago) the global average temperature was only 5ºC cooler than the current global average of 15ºC.

PROJECTING FUTURE CLIMATE

CSIRO and the Australian Bureau of Meteorology have assessed future climate change from the results of 23 global climate models used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007) and different IPCC scenarios for greenhouse gas emissions. The emissions scenarios, which project emissions growth from 1990 to the end of this century, consider a range of assumptions about demographic change, economic growth and technological developments which are likely to influence future emissions. National results were published in *Climate Change in Australia* (2007) www.climatechangeinaustralia.gov.au

Long-term temperature increases depend on how much and how quickly heat trapping greenhouse gases accumulate in the atmosphere and how the climate system responds to the increased concentrations. For this report, three different emissions scenarios have been used to calculate climate projections:

- The **B1** scenario is a lower emissions growth scenario and assumes that there is a rapid shift to less fossil-fuel intensive industries. Under this scenario, it is expected that there will be a weak growth in CO_2 emissions until 2040, and then a decline. CO_2 concentrations approximately double, relative to pre-industrial levels, by 2100. A global temperature increase relative to 1990 of 1.8°C (1.1 to 2.9°C) is likely.
- The **A1B** scenario is a medium emissions growth scenario where there is a balanced use of different energy sources – not just fossil fuels. CO_2 emissions increase moderately until 2030, but decline by the middle of the 21st century. By 2100 a global temperature increase of 2.8°C (1.7 to 4.4°C) is likely.
- The **A1FI** is a higher emissions growth scenario and assumes a continuation of strong economic growth based on continued dependence on fossil fuels. CO_2 concentrations more than triple, relative to pre-industrial levels, by 2100. A global temperature increase of 4.0°C (2.4 to 6.4°C) is likely. This scenario represents the highest level of late 21st century emissions that were thought to be plausible back in 2000. However, recent evidence indicates that CO_2 emissions have been growing at a more rapid rate.

A fourth emissions scenario is shown in Figure 3: the **450** scenario assumes stabilisation of CO_2 concentrations at 450 ppm (approximately double pre-industrial levels) by 2100, requiring a reduction in global emissions of about 50% by 2050 and 70% by 2100.

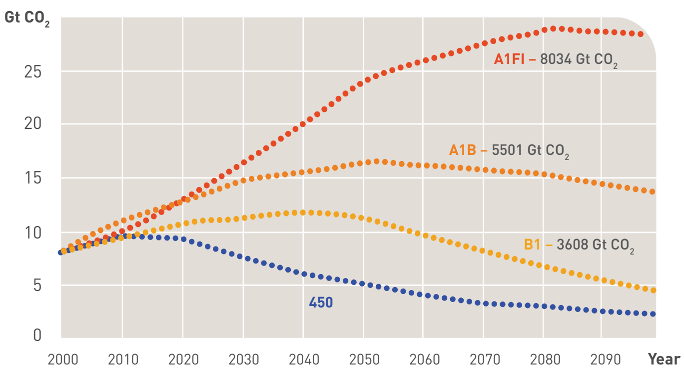


Figure 3
450, B1, A1B and A1FI scenarios showing annual CO_2 emissions out to 2100 in gigatonnes.

→ The projections in this document update those prepared in 2004 by CSIRO for the Victorian Government. While these projections are consistent with earlier work, the new projections indicate a narrower range of warming. This is largely due to improvements in modelling. For rainfall, there is a stronger trend towards precipitation decreases – particularly for annual average rainfall and autumn rainfall.

Projections for 2030 are based on the medium emissions scenario since it is similar to the other scenarios at this time. Beyond 2030, the emission scenarios diverge. Projections for 2070 are given for the lower and higher emissions scenarios. For each emissions scenario, ranges of uncertainty are given, reflecting different results from up to 23 climate models. All projections are relative to a 30-year period centred on 1990.

→ WHAT IS THE IPCC?

In 1988, the United Nations and the World Meteorological Organization set up the Intergovernmental Panel on Climate Change (IPCC), a body comprising governments and many of the world's experts on climate change. The IPCC was established to provide the decision-makers and others interested in climate change with an objective source of information about climate change. The IPCC does not conduct any research nor does it monitor climate related data or parameters.

Its role is to assess the latest scientific, technological and socio-economic peer-reviewed literature relating to the risk of climate change, its observed and potential impacts and options for adaptation and mitigation.

For more information, visit www.ipcc.ch

PROJECTIONS OF FUTURE CLIMATE CHANGE

→ SUMMARY

The future climate of Goulburn Broken is expected to be hotter and drier than it is today.

By 2070, under a higher emissions growth scenario, both temperature and annual rainfall in Tatura would resemble those of present day Naradhan in New South Wales.

By 2070, under a higher emissions growth scenario, Benalla's temperatures would resemble those of present day Hay, while annual rainfall would be similar to present day Rutherglen.

By 2030, average annual temperatures will be around 0.8˚C warmer but the greatest increases are expected in spring and summer (0.9˚C). The number of hot days (days over 30˚C) is also expected to increase. Reductions in the total average annual rainfall of around 3% are expected, with the greatest reductions occurring in spring (7%). Increases in potential evaporation and reductions in relative humidity are expected to contribute to drier conditions. At the same time, small increases (0.6%) in solar radiation are expected. There will be little change in average wind speeds. Projected changes are in comparison with 1990 figures.

By 2070, further increases in temperature are expected even under a lower emissions growth scenario (1.4˚C). Under a higher emissions growth scenario, these increases nearly double (2.7˚C). At the same time, the number of hot days will continue to increase and rainfall totals will continue to drop. With both lower and higher emissions growth warming is likely to be greatest in the summer, while greatest reductions in rainfall are likely to occur in the spring. Conditions will become increasingly drier as potential evaporation continues to increase and relative humidity decreases. Changes in wind speed will continue to be negligible.

Further details of changes in future climate for the region are described in the tables and figures that follow. The projections comprise a central estimate (the median) and a range of uncertainty (10th and 90th percentiles) derived from the various global climate models.

+0.7˚C

Observed increase in average global temperature over the last century

+0.9˚C

Mid-range warming in Goulburn Broken by 2030

Table 2
Summary of projected annual and seasonal climate changes for Goulburn Broken relative to 1990 (80% confidence range)

		EMISSIONS GROWTH SCENARIOS		
		2030	2070	
		MEDIUM EMISSIONS	LOWER EMISSIONS	HIGHER EMISSIONS
ANNUAL	Average temperature	0.9°C (0.6 to 1.2°C)	1.5°C (1.0 to 2.0°C)	2.8°C (1.9 to 3.9°C)
ANNUAL	Average rainfall (%)	-3% (-9% to +1%)	-6% (-14% to +2%)	-10% (-25 to +4%)
ANNUAL	Potential evaporation (%)	3% (1 to 5%)	4% (1 to 8%)	8% (2 to 16%)
ANNUAL	Wind speed (%)	-1% (-6 to +4%)	-1% (-10 to +6%)	-2% (-19 to +12%)
ANNUAL	Relative humidity (%)	-0.7% (-1.5 to -0.1%)	-1.2% (-2.4 to -0.1%)	-2.3% (-4.7 to -0.2%)
ANNUAL	Solar radiation (%)	0.8% (no change to +1.9%)	1.3% (no change to +3.1%)	2.5% (no change to +6%)
SPRING	Average temperature	0.9°C (0.6 to 1.3°C)	1.5°C (1.0 to 2.2°C)	2.9°C (1.9 to 4.3°C)
SPRING	Average rainfall (%)	-7% (-17% to +1%)	-11% (-26% to +2%)	-20% (-44 to +4%)
SPRING	Potential evaporation (%)	2% (-1 to +5%)	3% (-2 to +8%)	6% (-3 to +16%)
SPRING	Wind speed (%)	No change (-8 to +6%)	-1% (-13 to +10%)	-1% (-25 to +20%)
SPRING	Relative humidity (%)	-1.1% (-1.9 to -0.2%)	-1.9% (-3.7 to -0.4%)	-3.7% (-7.2 to -0.7%)
SPRING	Solar radiation (%)	1.1% (0.1 to 2.5%)	1.9% (0.2 to 4.2%)	3.6% (0.3 to 8%)
SUMMER	Average temperature	1.0°C (0.7 to 1.4°C)	1.7°C (1.1 to 2.4°C)	3.2°C (2.1 to 4.6°C)
SUMMER	Average rainfall (%)	-1% (-10 to +9%)	-2% (-17 to +14%)	-4% (-29 to +28%)
SUMMER	Potential evaporation (%))	2% (no change to +5%)	4% (no change to +8%)	7% (no change to +16%)
SUMMER	Wind speed (%)	-1% (-9 to +6%)	-1% (-14 to +9%)	-2% (-27 to +18%)
SUMMER	Relative humidity (%)	-0.6% (-1.8 to +0.4%)	-1% (-3 to +0.7%)	-2% (-5.7 to +1.3%)
SUMMER	Solar radiation (%)	0.4% (-0.6 to +1.5%)	0.6% (-1 to +2.5%)	1.2% (-1.9 to +4.7%)
AUTUMN	Average temperature	0.9°C (0.5 to 1.1°C)	1.4°C (0.9 to 2.1°C)	2.8°C (1.8 to 4°C)
AUTUMN	Average rainfall (%)	-2% (-9 to +6%)	-2% (-14 to +10%)	-5% (-26 to +20%)
AUTUMN	Potential evaporation (%)	4% (2 to 6%)	6% (3 to 11%)	12% (6 to 21%)
AUTUMN	Wind speed (%)	-3% (-10 to +3%)	-4% (-16 to +5%)	-9% (-32 to +11%)
AUTUMN	Relative humidity (%)	-0.5% (-1.6 to +0.5%)	-0.8% (-2.6 to +0.8%)	-1.6% (-5 to +1.5%)
AUTUMN	Solar radiation (%)	0.4% (-0.7 to +1.8%)	0.7% (-1.1 to +2.9%)	1.4% (-2.1 to +5.7%)
WINTER	Average temperature	0.7°C (0.4 to 0.9°C)	1.2°C (0.8 to 1.7°C)	2.2°C (1.5 to 3.3°C)
WINTER	Average rainfall (%)	-4% (-13 to +2%)	-7% (-17 to +3%)	-12% (-30 to +6%)
WINTER	Potential evaporation (%)	9% (-1 to +23%)	14% (-1 to +39%)	28% (-3 to +76%)
WINTER	Wind speed (%)	1% (-5 to +6%)	1% (-9 to +9%)	-2% (-17 to +18%)
WINTER	Relative humidity (%)	-0.5% (-2 to +0.3%)	-0.9% (-2.7 to +0.5%)	-1.7% (-5.2 to +0.9%)
WINTER	Solar radiation (%)	1.9% (-0.2 to +4.6%)	3.2% (-0.4 to +7.6%)	6.2% (-0.7 to +14.7%)

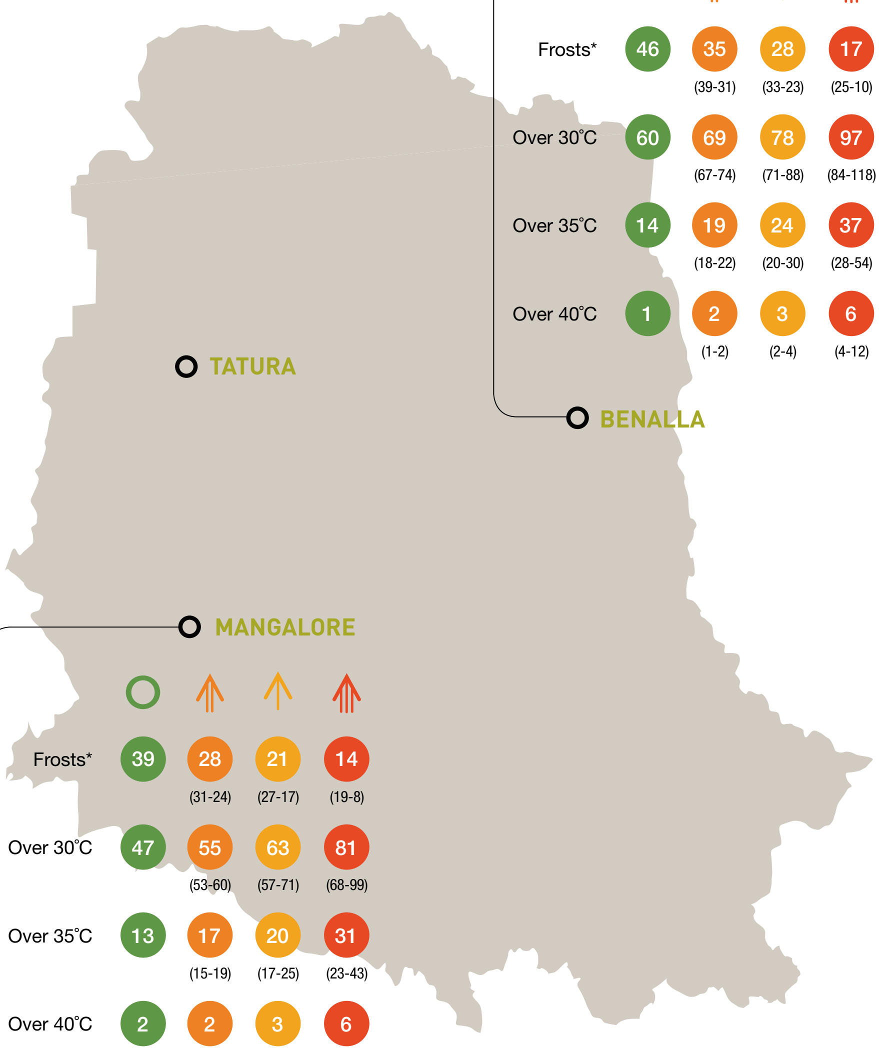
hot & cold

Although average changes in temperature, rainfall and evaporation will have long term consequences for the region, the impacts of climate change are more likely to be felt through extreme events such as the number of hot days, reductions in the number of frosts (**Figure** 4) and changes in daily rainfall patterns (**Table** 3).

Bushfire risk is also expected to increase.

Figure 4
Current and projected average number of hot days and frost days in Benalla and Mangalore per year

- ○ Current
- ↑ 2030 Medium emissions
- ↑ 2070 Lower emissions
- ↑ 2070 Higher emissions
- # Average no. of days
- (# - #) Possible range of no. of days
- * Days where the minimum temperature falls to 2°C or less



BENALLA

	Current	2030 Medium emissions	2070 Lower emissions	2070 Higher emissions
Frosts*	46	35 (39-31)	28 (33-23)	17 (25-10)
Over 30°C	60	69 (67-74)	78 (71-88)	97 (84-118)
Over 35°C	14	19 (18-22)	24 (20-30)	37 (28-54)
Over 40°C	1	2 (1-2)	3 (2-4)	6 (4-12)

MANGALORE

	Current	2030 Medium emissions	2070 Lower emissions	2070 Higher emissions
Frosts*	39	28 (31-24)	21 (27-17)	14 (19-8)
Over 30°C	47	55 (53-60)	63 (57-71)	81 (68-99)
Over 35°C	13	17 (15-19)	20 (17-25)	31 (23-43)
Over 40°C	2	2 (2-3)	3 (3-4)	6 (4-11)

wet & dry

Although average annual and seasonal total rainfall is expected to decline, the intensity of heavy daily rainfall is likely to rise in most seasons (Table 3). However, fewer rain-days are anticipated with more droughts.

Table 3
Projected percentage changes in heavy rainfall intensity (99th percentile) and number of rainy days (>1 mm) for Tatura, Benalla and Mangalore per year relative to 1990 (80% confidence range)

			EMISSIONS GROWTH SCENARIOS		
			2030	2070	
			MEDIUM EMISSIONS	LOWER EMISSIONS	HIGHER EMISSIONS
RAINFALL INTENSITY	Tatura	ANNUAL	0.8% (-7.1 to +14.6%)	2.8% (-11.9 to +24.4%)	5.3% (-23.0 to +47.1%)
		SPRING	0.8% (-13.7 to +14.9%)	2.5% (-22.9 to +24.8%)	4.9% (-44.2 to +48.0%)
		SUMMER	3.0% (-16.6 to +30.9%)	10.0% (-27.6 to +51.5%)	19.3% (-53.4 to +99.6%)
		AUTUMN	2.3% (-6.7 to +25.2%)	7.8% (-11.2 to +42.0%)	15.1% (-21.6 to +81.2%)
		WINTER	0.6% (-20.5 to +22.9%)	2.1% (-34.1 to +38.2%)	4.1% (-65.9 to +73.9%)
	Benalla	ANNUAL	0.9% (-9.0 to +13.5%)	3.2% (-15.0 to +22.4%)	6.1% (-29.0 to +43.4%)
		SPRING	0.5% (-8.5 to +12.9%)	1.7% (-14.2 to +21.5%)	3.3% (-27.4 to +41.6%)
		SUMMER	3.1% (-15.0 to +29.6%)	10.2% (-25.0 to +49.4%)	19.7% (-48.3 to +95.5%)
		AUTUMN	1.8% (-8.0 to +24.5%)	6.0% (-13.3 to +40.8%)	11.6% (-25.7 to +78.8%)
		WINTER	1.0% (-22.6 to +24.1%)	3.5% (-37.7 to +40.1%)	6.7% (-72.8 to +77.5%)
	Mangalore	ANNUAL	1.2% (-7.1 to +15.1%)	3.8% (-11.9 to +25.2%)	7.4% (-22.9 to +48.7%)
		SPRING	0.4% (-16.9 to +17.0%)	1.4% (-28.2 to +28.4%)	2.6% (-54.6 to +54.9%)
		SUMMER	3.2% (-15.2 to +29.0%)	10.5% (-25.3 to +48.3%)	20.4% (-48.9 to +93.4%)
		AUTUMN	2.9% (-9.8 to +26.2%)	9.8% (-16.3 to +43.7%)	18.9% (-31.5 to +84.4%)
		WINTER	1.0% (-19.9 to +23.2%)	3.2% (-33.2 to +38.7%)	6.1% (-64.2 to +74.9%)
NUMBER OF RAINY DAYS	Tatura	ANNUAL	-5% (-17 to -1%)	-9% (-29 to -2%)	-17% (-56 to -3%)
		SPRING	-10% (-27 to -2%)	-16% (-45 to -3%)	-31% (-88 to -6%)
		SUMMER	-3% (-15% to no change)	-5% (-26 to -1%)	-11% (-50 to -1%)
		AUTUMN	-4% (-16 to +2%)	-6% (-26 to +3%)	-12% (-51 to +5%)
		WINTER	-8% (-17% to no change)	-14% (-28 to +1%)	-27% (-54 to +1%)
	Benalla	ANNUAL	-5% (-18 to -1%)	-8% (-30 to -2%)	-16% (-57 to -3%)
		SPRING	-10% (-27 to -2%)	-17% (-45 to -3%)	-33% (-87 to -7%)
		SUMMER	-3% (-15 to +2%)	-5% (-24 to +3%)	-9% (-47 to +6%)
		AUTUMN	-3% (-15 to +1%)	-5% (-25 to +2%)	-10% (-48 to +5%)
		WINTER	-9% (-18 to +1%)	-15% (-31 to +1%)	-28% (-59 to +3%)
	Mangalore	ANNUAL	-5% (-17 to -1%)	-8% (-29 to -2%)	-16% (-56 to -4%)
		SPRING	-10% (-27 to -2%)	-17% (-44 to -4%)	-32% (-86 to -7%)
		SUMMER	-5% (-17% to no change)	-9% (-28 to -1%)	-17% (-54 to -2%)
		AUTUMN	-4% (-16 to +1%)	-7% (-26 to +2%)	-13% (-51 to +4%)
		WINTER	-7% (-14% to no change)	-11% (-24% to no change)	-22% (-47% to no change)

THE IMPACTS OF CLIMATE CHANGE

Changes in climate will have a range of impacts – for example on water resources, bushfire frequency and intensity, primary production and infrastructure. It will also affect the richness of our biodiversity and the health of our landscapes. As well as the direct environmental impacts of climate change it will interact with other drivers of change such as population growth and advancements in technology.

While Victoria already experiences a variable climate, climate change is expected to interact with and enhance this variability. Climate change is likely to have the following impacts on the Goulburn Broken region.

water

Decreases in rainfall and higher evaporation rates will mean less soil moisture and less water for rivers. Our demand for water may also increase as a result of warmer temperatures and as our population grows. Therefore, our need to use water more efficiently will be even greater. Average annual runoff in the Goulburn and Broken rivers is expected to decrease by up to 35% by 2030. By 2070, runoff decreases to both rivers is expected to be between 5% and more than 50%.

Lower flows and higher temperatures may also reduce water quality within the catchment and create a more favourable environment for potentially harmful algal blooms. Greater bushfire activity could temporarily contaminate water catchments with sediments and ash.

farms and primary production

Climate change will have both positive and negative impacts on the types of crops we grow and the productivity of our primary production systems. Higher levels of atmospheric carbon dioxide tend to enhance plant growth and water-use efficiency. However, changes in temperature and rainfall are likely to offset these benefits. Any reduction in rainfall will place most farms under stress, particularly when linked to higher temperatures. For dryland cropping, reductions in rainfall and increases in evaporation directly contribute to reductions in soil moisture. Meanwhile, irrigated agriculture is likely to be affected by tighter constraints on water allocations, possibly resulting in a more developed and competitive water market. In this sense, the unusually hot droughts of recent years may be a sign of things to come.

Some impact studies have already been carried out, and have identified:

- increased heat stress on dairy cattle, reducing milk production unless management measures such as shade sheds and sprinklers are adopted;
- inadequate winter chilling for some fruit trees, which may reduce fruit yield and quality, however, higher temperatures are likely to reduce the risk of damaging winter frosts for other crops;
- in viticulture, higher temperatures are likely to reduce grape quality, but there may be opportunities to shift production to varieties better adapted to warmer conditions.

Other climate change impacts such as heavy rains and winds from storm events will also contribute to crop damage and soil erosion. Indirect impacts due to changes in weeds, pests and international markets may also place farms under stress.

Victorian farmers have developed many useful adaptation skills from managing current climate variability, but they will need to plan for new challenges and opportunities associated with climate change.

biodiversity

The effects of climate change on biodiversity will occur at many different levels – from individuals to ecosystems. Species may alter distribution, abundance, behaviour and the timing of events such as migration or breeding. The most susceptible species will be those with restricted or specialised habitat requirements, poor dispersal abilities or small populations.

Climate change will also have indirect impacts on biodiversity. There may be increased pressure from competitors, predators, parasites, diseases and disturbances (such as bushfire or drought).

It will also influence the composition of ecosystems and their distribution by altering water flows in rivers and wetlands and the occurrence of bushfires, snow and floods. Climate change is likely to amplify existing threats such as habitat loss and invasive species, making their impacts considerably worse.

In addition, projected climate change will place increased stress on marine ecosystems through increased water temperature and acidity.

communities

Climate change has the potential to influence human health from direct effects such as heatwaves, or indirectly – such as bushfires leading to poor air quality and increased respiratory problems. Warmer winters are likely to reduce some cold-related illnesses, but warmer summers are likely to increase the risk of heat-related health problems.

The increased frequency and intensity of heatwaves may cause deaths through heart attack, stroke and heat exhaustion. The most vulnerable are the elderly, people under intense physical stress and those with cardiovascular disease. High temperatures are also linked to:

- increased hospital admissions and deaths (particularly among the elderly) relating to heat stress, sunburn and dehydration;
- more outdoor work-related accidents and reduced productivity;
- buckling of railway lines;
- greater peak electricity demand for air conditioners;
- reduced energy demand for heating in winter.

Changes in the average climate will affect the design and performance of our buildings and infrastructure – including shifting energy use from winter heating to summer cooling. More extreme events such as flash flooding and bushfires will also impact on the built environment and will need to be considered to minimise risk to property. The availability and cost of insurance may also change as a result of extreme events.

Essential infrastructure such as water, power, transport and telecommunications have also been identified as being at high risk at higher levels of projected warming by 2030 without action being taken to prepare for these changes.

alpine

Climate change is expected to result in shorter, drier winters which have significant impacts on Victoria's unique alpine region and the plant and animal species that live there, many of which are already endangered. Species, such as the Mountain Pygmy Possum, which are adapted to the highest elevations and coldest environments will have nowhere to retreat to as the climate warms. Reductions in snow cover, increased risk of bushfires and invasion of weeds and other pests will also have significant impacts.

Previous research by CSIRO in 2005 indicated that compared to the climate of 1979 to 1998, the area with an annual average of at least 60 days snow cover may decrease by between 18% and 60% by around 2020 and by 38% to 96% by 2050.

A low impact scenario (a slow rate of warming and a small increase in precipitation) would have only a minor impact on snow conditions by 2020, reducing the average snow season length by about 5 days. In comparison, a high impact scenario (fast warming and decreased precipitation) is likely to result in the average snow season shortening by 30 to 40 days by 2020. At higher elevations this can represent a reduction in the snow season duration by about 25% but at lower elevations more significant reductions are likely (up to 60%). Impacts on peak snow depth are expected to follow a similar pattern with more moderate impacts expected at higher elevations. There is also a likelihood that maximum snow depth will occur earlier in the season under warmer conditions.

The alpine resorts of Mount Buller, Mount Stirling and Lake Mountain are economic drivers for both surrounding communities and the state as a whole. Previous research by CSIRO indicates that alpine areas are likely to experience shorter snow seasons and decreased natural snow cover, although with snowmaking the alpine resorts will have enough snow for snow activities until at least 2020. Lower elevation resorts like Lake Mountain are particularly vulnerable.

PREPARING FOR CLIMATE CHANGE

The uncertainty over the precise scale and timing of climate change impacts should not be an excuse for postponing action. A precautionary approach is needed. Many of the decisions we make today will affect our vulnerability to climate change. We must start preparing for and adapting to these changes now.

In the context of climate change, adaptation refers to any action, either intentional or otherwise, taken to minimise the adverse effects of climate change or to take advantage of any beneficial effects. Adaptation is the primary means of dealing with the unavoidable impacts of climate change. It is a mechanism used to manage risks, adjust economic activity to reduce vulnerability and to improve business certainty. The Victorian Government is driving adaptation planning that recognises Victoria's specific regional vulnerabilities to climate change, and focuses on early planning to manage risks, avoid future costs and maximise potential benefits. The uncertainty about the nature and magnitude of climate change impacts means that ongoing investment in research will be critical in guiding appropriate and efficient responses. Also, applying policies and principles that help society to become more resilient to the range of future conditions will be increasingly important. Some examples of current adaptation actions in Victoria include:

- supporting a program of research to better understand impacts of climate change, particularly for agriculture and biodiversity;
- incorporating climate change projections into sustainable water planning;
- improving water use efficiency;
- developing a heat wave response plan for Victoria;
- detailed mapping and assessment of potential climate change vulnerabilities along the coast, including the impacts of sea level rise, storm surge, erosion and flooding; and
- reviewing flood and bushfire management plans.

Adapting to climate change will never be a sufficient response on its own. At higher concentrations of greenhouse gases, adaptation becomes more difficult and more expensive. Therefore we will need to continue efforts to achieve deep cuts in greenhouse gas emissions.

The Victorian Government is committed to the challenge of climate change and its responsibility to lead Victorian efforts to reduce our greenhouse emissions by 60% by 2050 compared to 2000 levels.

→ INFO

Want to know more about climate change?

Contact the Department of Sustainability and Environment Customer Service Centre on **136 186** or visit our website at **www.climatechange.vic.gov.au**

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the Victorian climate change adaptation program

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