4. Climate change

4.1 What is climate change?

It is important to understand the difference between weather, climate, climate variability and climate change. The following definitions have been sourced from the CSIRO.[7]

Weather is the day-by-day variation in temperature, wind and rainfall. Weather usually changes from hour to hour and from town to town.

Climate is more stable and refers to the average weather conditions over at least a 30 year period (i.e. long term average).

Climate variability and climate change are different aspects of climate.

Climate variability refers to the year-to-year variations around the average weather conditions. For example not all consecutive summers will be identical - some summers will be cooler and some will be hotter than the long term average. Seasonal climate variability is a key feature in the West Gippsland region.

Climate change refers to any long-term trends or change in average weather conditions over many decades.

Consideration of both the shorter term variability and longer term change in climate is important. When climate change is superimposed on natural climate variability, it leads to a change in the frequency, intensity and duration of extreme weather events, such as droughts, heavy rainfall, fire weather, heat waves, hail storms and flooding.[7]

4.1.1 What is causing the climate to change?

The scientific basis for climate change is that changes in the earth's atmosphere, due to the increased emission of carbon dioxide and other greenhouse gases (including methane and nitrous oxide), are trapping heat and increasing temperatures. This is altering global weather patterns and climate. Climate change can occur due to a combination of natural and human induced causes.

With greenhouse gas emissions continuing to increase, the Bureau of Meteorology expects the warming trend of the past century to accelerate throughout this century. It also expects changes to rainfall patterns and to the frequency of extreme weather events like cyclones and droughts.

The future climate will depend on whether the world manages to slow or even reduce greenhouse gas emissions. Since greenhouse gases have a long lifetime in the atmosphere, any change in emissions will have a delayed effect on atmospheric concentrations, so these concentrations are expected to increase, leading to further warming and climate change for many decades.

4.2 What is climate change adaptation?

Given the uncertainty around the climate and other socio-economic variables in the future, keeping as many management options open as possible is vital.[8] Climate change adaptation focuses on improving the ability of a system or people to adjust to climate change (including climate variability and extremes), to reduce potential damage, to take advantage of opportunities, or to cope with the consequences.

In this way adaptation may accommodate the medium and long term impacts of climate change, such as sea level rise, increases in temperature and changing rainfall patterns. Examples of options for adaptation in natural resource management include:

Supporting the protection of core habitat areas of native habitat in good condition

- Enhance the condition of remnant vegetation, to conserve biodiversity and maintain ecological integrity.
- Identify and protect refugia.
- Develop buffers around rainforest remnants.
- Enhance riparian vegetation and support stream-bank protection.
- Preserve genetic diversity by conserving habitat over a gradient of climatic zones.

Building resilient landscapes and seascapes

- Build connectivity, especially between representative habitats, providing avenues for species migration.
- Promote a multi-purpose, landscape mosaic to improve the functionality of natural and production focused ecosystems.
- Limit impediments to make space for the migration of coasts, rivers and coastal wetlands; and consider land swaps or offsets.
- Introduce genetics from drier, hotter areas.

Removing or minimising existing stressors

- Manage invasive plants and animals, and diseases; including surveillance and prompt responses to incursions.
- Monitor the impacts of existing water allocations and factor climate change into water resource and salinity planning.
- Develop alternative water sources to reduce the pressure on stressed water assets.

Promoting best management practices on farms and in forests

- Manage soils to reduce erosion and nutrient loss risks on farms and in forests (e.g. revegetate gully heads, maintain optimal soil cover, and manage run-off).
- Manage grazing to protect vulnerable areas (e.g. remnant vegetation and riparian areas).
- Promote water use efficiency.

Adopting engineering solutions to protect key natural assets

- Manipulate hydrology of wetlands to maintain ecological processes.
- Manage the delivery of environmental flow allocations in response to changing conditions and understandings.
- Consider levees to protect key natural assets, if long-term protection is possible and has net benefits.

Adaptive management and effective monitoring

- Monitor the implications of new policies and emerging land and other resource uses, including changes in agriculture.
- Practice active adaptive management in the implementation and evaluation of NRM actions.
- Understand how, and why, landscapes are changing.

Promoting integrated catchment management and inter-agency collaboration

- Integrate adaptation to climate change into natural resource management planning across all sectors of government.
- Prepare for more frequent bushfires and explore strategies that minimise risks to vulnerable assets.
- Conduct targeted education and awareness programs that promote understanding of climate change impacts, options and trends.

4.3 What is climate change mitigation?

Climate change mitigation involves direct actions to reduce the rate of release to the atmosphere of greenhouse gases (e.g. emission reductions) and/or increasing the sequestration of carbon through activities such as revegetation and soil storage.

Capture of greenhouse gases, such as carbon dioxide, can occur at the point of emission (e.g. from power plants) or through natural processes (such as photosynthesis), which remove carbon dioxide from the earth's atmosphere and which can be enhanced by appropriate management practices. Native vegetation, aquatic ecosystems and agricultural land are important to climate change mitigation. Firstly because of the significance of their carbon stock, and secondly because their exchange of greenhouse gases between the atmosphere and soils and vegetation can go both ways. Many human activities such as logging, fuel reduction burning, grazing of livestock or cultivation, influence the exchange of greenhouse gases with the atmosphere and ultimately the overall regional carbon footprint.

In West Gippsland there are a range of activities, such as investment in renewable energy sources or transition away from high emission farming systems, which will decrease regional carbon emissions. The main focus of the Strategy however will be on sequestration activities that have the ability to increase carbon storage in plants and soils, whilst protecting the values of priority regional assets including waterways, wetlands, terrestrial habitat, coastal ecosystems and agricultural land.

Carbon sequestration is the general term used for the capture and long-term storage of carbon dioxide in the various carbon pools in vegetation, soils and living organisms. These options are outlined in Table 1.

Table 1: Carbon sequestration options for natural assets

Asset type	Carbon sequestration options
Native vegetation (terrestrial)	Biodiverse plantings Natural regeneration Farm forestry, including woodlots and plantations
Waterways	Riparian plantings Natural regeneration
Wetlands	Grazing control promoting reestablishment of natural wetland vegetation Buffer plantings Natural regeneration
Coastal ecosystems	Blue carbon through protection and enhancement of saltmarsh, mangrove and seagrass habitats
Soils	Changed land use (e.g. cropping to grazing) 'Improved' cropping systems (e.g. no-till) Changed management of grazing land

These options are further discussed below:

Biodiverse plantings
Biodiverse plantings typically involve establishment of indigenous vegetation through tube stock or direct seeding methods on a range of sites from 'greenfield' to areas with scattered remnants. In recent years there has been a focus on re-establishing the vegetation that occurred prior to clearing, in the form of ecological vegetation classes (EVCs), for which detailed prescriptions exist. These types of plantings have been generally proven to be most beneficial for fauna and maintenance of local ecological processes, however, the degree of site modification plays a key role in what will succeed best in certain locations.

Natural regeneration
Natural regeneration means allowing or assisting the bush to grow back by itself. Generally it is the most effective and most economical way to expand patches of native vegetation and improve their condition. Where existing native seed sources exist, grazing by introduced species, especially sheep, cattle, rabbits and native species, especially kangaroos and wallabies is the key inhibitor of natural regeneration. Existing weed loads, also play a role in reducing the potential of areas to naturally regenerate.

Farm forestry
Farm forestry involves incorporation of commercial tree growing into farming systems. It can take many forms, including timber belts, alleys and widespread tree plantings. Farm forestry can provide farmers with an alternative source of income, through the sale of wood products such as sawlogs, firewood and bioenergy. It can improve agricultural production by providing shelter for stock and crops and can provide substantial environmental benefits such as salinity control.

Riparian plantings
Riparian plantings are essentially a subset of biodiverse plantings associated with waterway restoration. Located in the most fertile parts of the landscape with high moisture availability, riparian areas usually offer excellent conditions for tree growth and carbon sequestration. Extensive river restoration works have been undertaken along the region's waterways as the result of work by the WGCMA, Landcare and the previous River Improvement Trusts.

Blue carbon

Vegetated coastal habitats (saltmarsh, mangroves, and seagrass meadows), collectively known as 'blue carbon' habitats, together sequester nearly equivalent quantities of organic carbon (Corg) as their terrestrial counterparts, in spite of their comparatively limited biomass (0.05% of terrestrial plant biomass).

West Gippsland contains significant areas of habitat suitable for the conservation and sequestration of 'blue carbon'. In many cases these habitat areas are in good condition and therefore the protection of these ecosystems, and their carbon stores, should be a high priority. Research undertaken by Deakin University in 2014 reported that these features make vegetated coastal habitats ideal candidates for carbon offset programs and nature-based climate mitigation initiatives.[9] Wetlands (which include alpine peatland, freshwater wetland and coastal wetlands) are also thought to be significant carbon sinks.[10] However further work is required to better understand the effects of wetting and drying cycles on the capture and retention of carbon in these ecosystems.

A preliminary assessment of the potential of 'Blue Carbon' for the West Gippsland region was completed in 2014 with the following recommendations to maximize carbon stocks within vegetated coastal habitats.[9]

- Prioritise "Blue Carbon" hotspots for conservation.
- Produce updated seagrass distribution maps.
- Focus revegetation projects on saltmarsh ecosystems and/or estuarine environments closer to fluvial inputs.
- Restore natural hydrology to enhance carbon sequestration in vegetated coastal habitats.
- Investigate the drivers of sea urchin barrens within Nooramunga Marine and Coastal Park and their potential impacts on blue carbon stocks in the absence of management intervention.
- Research into the distribution and carbon storage potential of wetland ecosystems in West Gippsland.

It is not clear how 'blue carbon' would be assessed under the current ERF approved methods, although work is underway to develop and approve an appropriate method.

Grazing management

Grazing of agricultural land by sheep and cattle is a prominent land use in the West Gippsland region. The timing and intensity of grazing, together with factors such as fertiliser application and management of soil nutrients can influence pasture groundcover and soil carbon levels. Changes in grazing management in areas associated with remnant vegetation, riparian areas and wetlands can be an important mechanism in allowing natural regeneration in areas with important biodiversity values, in addition to increasing carbon sequestration.

Mitigation options are also considered within the context set by the Australian Government in outlining the Principles that should underpin regional planning for climate change, including:

- identifying priority landscapes for carbon plantings,
- identifying strategies to build landscape integrity,
- guiding adaptation and mitigation actions to address climate change impacts on natural ecosystems,
- avoiding adverse impacts associated with carbon in the landscape.

Section 6 highlights how these principles have been considered in the identification of complementary adaptation and mitigation responses across the relevant planning areas.

4.4 Regional climate vulnerability and future projections

4.4.1 Regional overview

The West Gippsland catchment region is determined by the WGCMA boundary. It extends from Warragul and San Remo in the west, to the Gippsland Lakes in the east, and from the Great Dividing Range in the north to Wilsons Promontory in the south (Figure 5).

The West Gippsland region is characterised by a variety of soil types. Soils are moderately well structured across the region and support a range of agricultural enterprises and natural ecosystems.

The eastern highlands, Strzelecki Ranges and the western half of the region receive high rainfall, have deep soils and support extensive areas of native forest. The plains in the east of the region are in the rain shadow of the highlands, where the remaining native vegetation is mainly woodland, grassy woodland, heathland and riparian complexes in low-lying areas.

The region is home to a wide range of terrestrial, marine and aquatic flora and fauna species, many of which are threatened. For example, 69 fauna and flora species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and 141 of Victoria's 601 threatened species formally listed under the *Flora and Fauna Guarantee Act 1988* (FFG Act) are located within the region. There is a high representation of endangered, rare and vulnerable ecological vegetation classes across the region. Historic wide-scale clearing that opened up the region for settlement, agriculture and industry has resulted in a considerable loss of native vegetation throughout the landscape.

There is a diversity of marine environments in the region ranging from open coasts, sandy beaches, bays, inlets and estuaries.[11]

Figure 5: West Gippsland Catchment Management Authority region

4.4.2 Current climate conditions and climate variability

The West Gippsland region currently has maximum temperatures and minimum rainfall in summer. The region has mild to warm summers with average maximum temperatures around 21 to 23˚C near the coast and elevated areas, and 23 to 25˚C further inland. In winter, average maximum temperatures are mostly around 12 to 14˚C, but drop to less than 10˚C in the mountains. Frosts are rare near the coast, but do occur further inland.[12]

West Gippsland is Victoria's wettest region, with an annual rainfall average of 926 millimetres. However, there is substantial variation across the region (Figure 6). The southern flanks of the Great Dividing Range, the Strzelecki Ranges and the south western part of the region receive high rainfalls of 1000 to over 1600 millimetres a year, falling as snow on the higher peaks of the Great Dividing Range in winter. Annual average rainfall decreases to less than 600 millimetres in the east as a result of a rain shadow effect from Wilson's Promontory and the Strzelecki Ranges.[12]

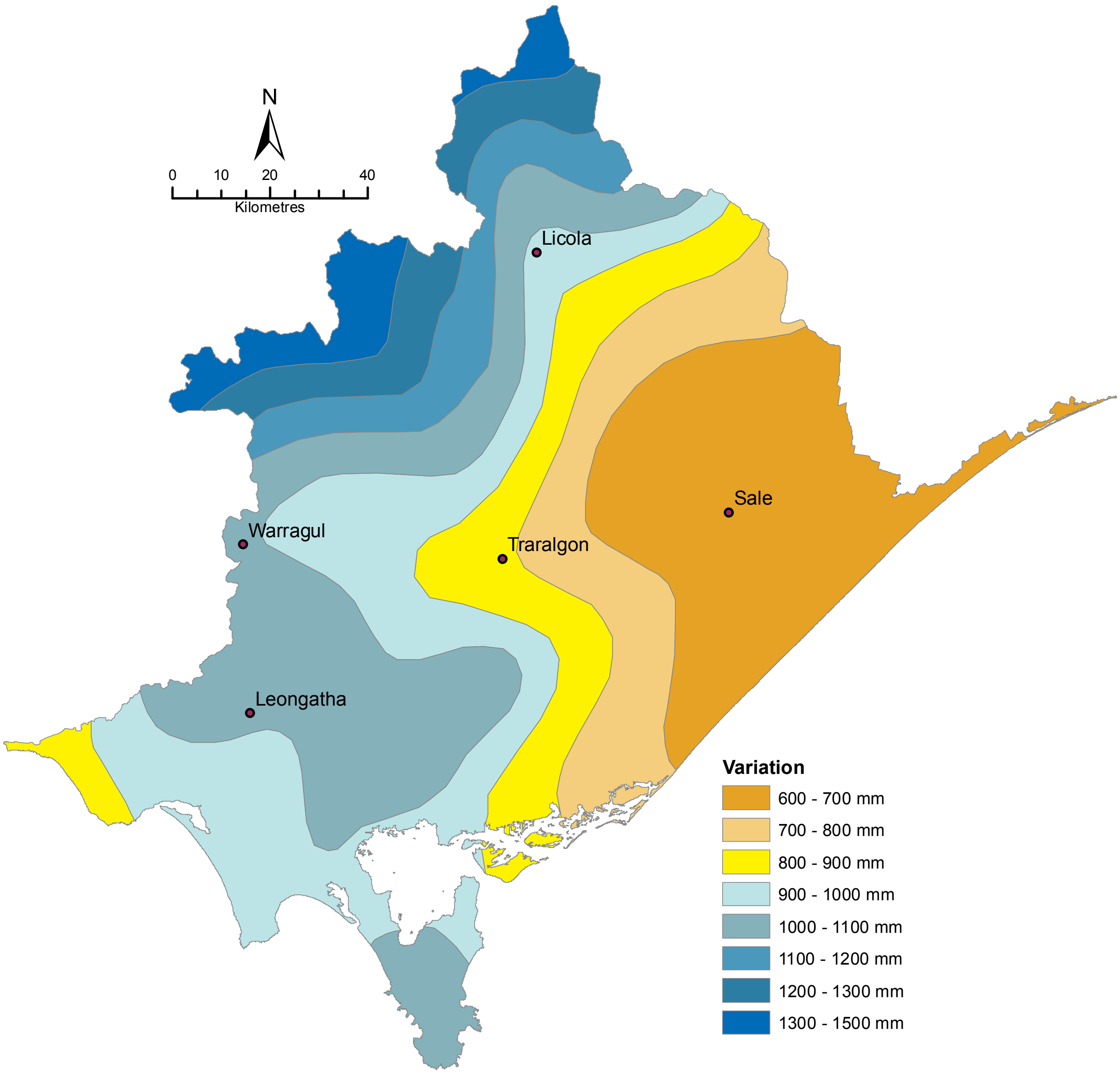

Figure 6: How average annual rainfall varies across the region (based on 1961-1990 average)[12]

Low pressure systems off the east coast can be responsible for extremely heavy rainfall events in the east of the region.[13] Although they can occur at any time of the year, east coast lows are more common during autumn and winter with a maximum frequency in June.

Rainfall variability gives rise to dry and wet periods and influence the frequency of flood and fire that have an effect on land management and the health of natural assets in the region.

Sea level rise is variable due to factors including prevailing winds, the changing strength of ocean currents, and gravitational pull of the polar ice-sheets. Rising sea levels in the region are observed through storm surges and coastal flooding; coastal erosion and shoreline retreat; increasing salinity of coastal waterways and inundation of low-lying coastal areas.

Understanding the current and past climate patterns within the region helps us to start thinking about potential future changes to climate and climate variability.

4.4.3 Future climate projections

Future climate projections provided by the CSIRO and Bureau of Meteorology are based on the outputs of global climate models, which are supplemented by additional regional modelling and/or statistical downscaling to represent finer, regional scale patterns. The projections are based on four Representative Concentration Pathways (RCPs), three emissions scenarios (low, intermediate and high), and 20-year time increments correlating to the years 2030, 2050, 2070 and 2090. The projections indicate that the future climate in the West Gippsland region is likely to have the following characteristics.[14]

Temperature

- Average daily minimum and maximum temperatures are predicted to increase, with an increase in the temperature reached on the hottest days, an increase in the frequency of very hot days and duration of warm spells.

Rainfall

- Decline in average annual rainfall and winter-spring rainfall, with potentially an increase in summer rainfall.
- Tendency for heavier rainfall interspersed by longer dry periods, with some extremely dry and wet years, with natural variability continuing to be a major driver of rainfall.[8]

Intensity of rainfall and more time in drought

- Intensity of heavy rainfall events is predicted to increase, with timing and magnitude driven by natural variability.
- A decline in the number, but an increase in the intensity of east coast lows, impacting on average rainfall and heavy rain events.
- Time spent in drought is predicted to increase over the course of this century in line with changes to average rainfall, and the frequency and duration of extreme droughts will increase.

Snow

- Snowfall and maximum snow depth have declined significantly since 1960 and are projected to continue to decline.

Wind

- Little change in annual average wind speed.
- Higher wind speeds during the cooler months (July to October) and lower wind speeds during the warmer months (November to May).

Relative Humidity and Evaporation

- Decrease in relative humidity across all seasons, projections to this effect will intensify over the course of the century.
- A tendency for decreases in humidity to coincide with areas of rainfall decline, leading to reduced effective water availability and decreased streamflow through lower moisture inputs and higher rates of evapotranspiration.

Fire

- More frequent and intense fires are projected as a result of increased temperature and reduced relative humidity and increased time in drought.

Marine and Ocean conditions

- Continued gradual increase in sea levels and more frequent sea level extremes, including storm surge, is projected.
- Warming and acidification of coastal waters is projected to increase with effects becoming apparent late in the century.