CLIMATE PROFILE

GREAT LAKES COUNCIL LOCAL GOVERNMENT AREA

Introduction

The Great Lakes Council Local Government Area (LGA) covers an area of 3,376 square kilometres and has a population of approximately 35,000 people. The LGA contains a series of significant coastal lake and estuary systems including Wallis Lake, Smiths Lake, Myall Lake and the northern foreshore of Port Stephens. .

Great Lakes and the broader region is well known for its historic climate variability and extremes. Recent years have been characterised by major storm and flooding events that have significantly raised community awareness of climate variability and the potential impacts of climate change. Projected sea level rise also has the potential to significantly impact on the LGA.

This climate profile has been developed to further increase understanding of existing and projected climate change as it relates to the Great Lakes LGA. The information it includes has been sourced from research recently completed by the University of Newcastle and Macquarie University on behalf of the Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS).

The profile provides an overview of the key results that have been produced by this research and the process by which they were generated. In particular, it provides the results of analysis of both historical climate variability and projected climate change as it relates specifically to the Great Lakes LGA.

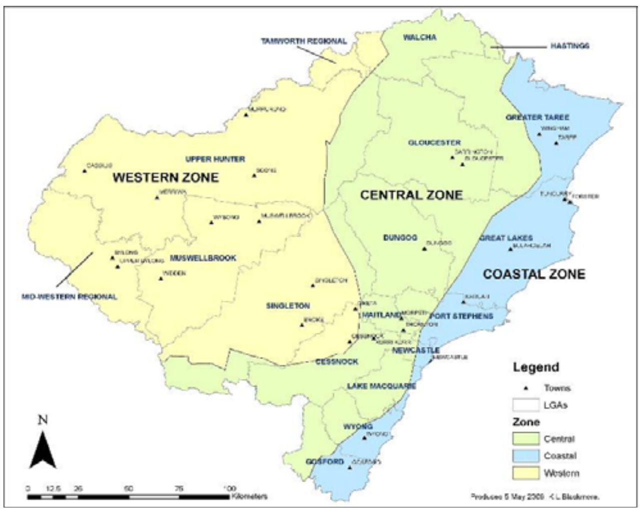
Climate Zones

A key element of the research was the identification of three climate zones for the Hunter, Central and Lower North Coast region. This was achieved through a process known as climate zonation; a statistical process which divides a region into distinct sub-regions or zones where climatic similarity is maximised within zones and minimised between zones.

Twelve synoptic patterns that "drive" climate variability in the region were also identified and a comprehensive review of climate history and an analysis of this variability was completed. This confirmed a relationship between historic climate patterns and these synoptic `weather drivers' in each climate zone.

The CSIRO Global Climate Model (Mk3.5) was then used to identify projected changes in the 12 synoptic types for time periods of 2020-2040, 2040-2060 and 2060-2080. Projections were based on the A2F1 emissions scenario. Because of the strong historical relationship that exists between these synoptic types and weather patterns in the region, these changes could then be used to project changes in climate for each of the three climate zones. Full details of the methodology used are available at www.hccrems.com.au.

The climate zones that have been identified for the region are shown below. The results generated for both the coastal and central zones underpin this climate profile for the Great Lakes LGA.

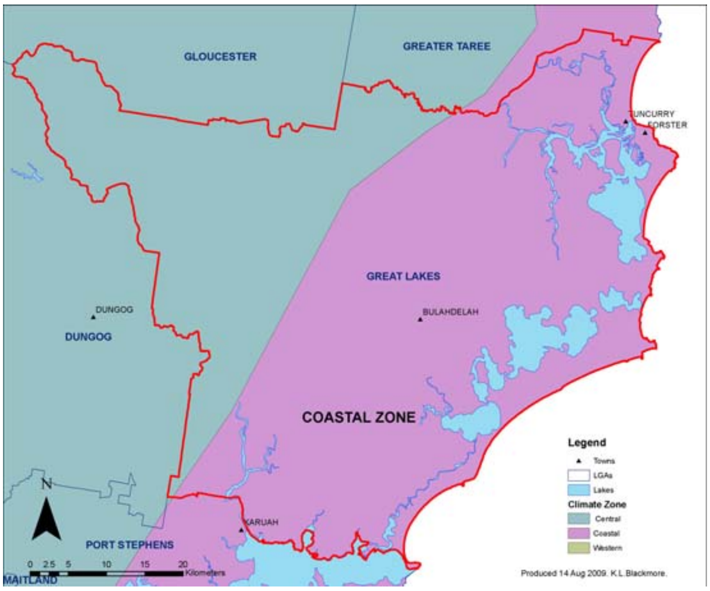


Climate zones within the Region

Great Lakes Council LGA

The Great Lakes Council LGA spans both the coastal and central climate zones. Projected changes in climate for both of these zones are therefore relevant to the area. Because large areas of the LGA lie within both of these zones, historic and projected climate changes for the LGA as a whole are most accurately represented as the mean change between the two.

In this regard, it is also important to note that while each climate zone is represented by a defined boundary, climate is actually a gradual and continuous process between the two. For the purposes of this climate profile, information is provided for each of the zones.



Climate zones - Great Lakes Council LGA

Results

The following results provide both an historical analysis and future projections for a range of climate variables in the coastal and central climate zones. These include rainfall, temperature (minimum, maximum and average annual), humidity, pan evaporation, water balance, wind and extreme events.

Historic trends are analysed for significance using regression analysis. An asterisk (*) is used to identify trends that are found to be statistically significant. The length of historic data used to analyse trends varies according to data available for each variable.

Projections are provided for the period 2020-2040, 2040-2060 and 2060-2080. Where minimal change between these periods is identified, projections are provided for the entire 2020-2080 period. Projected values are relative to the average historic recorded values for each climate parameter. The length of the relative historic period is determined by the availability and quality of historic data.

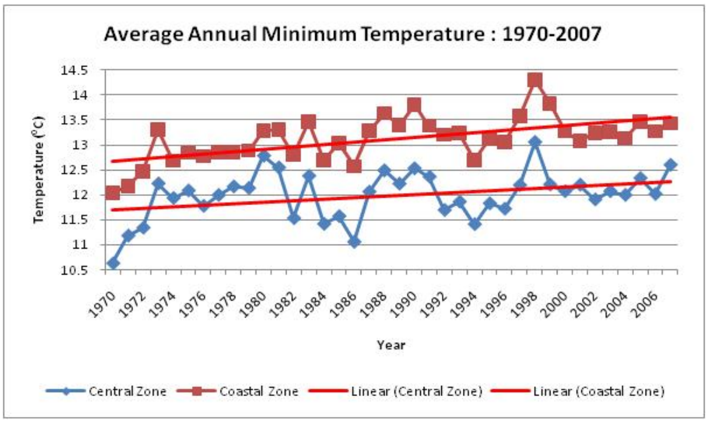
MINIMUM TEMPERATURE

Historical analysis: minimum temperature

Historically, the Great Lakes LGA has experienced a statistically significant annual increase in average minimum temperatures of ~0.9°C in the coastal zone and ~0.6°C in the central zone. More detailed seasonal and zonal changes are summarised below.

Minimum temperature (1970-2007)				
Zone	**Summer**	**Autumn**	**Winter**	**Spring**
Coastal	Warmer: ~0.5°C increase	Warmer: ~0.8°C* increase	Warmer: ~1.2°C* increase	Warmer: ~1.0°C* increase
Central	Warmer: ~0.3°C increase	Warmer: ~0.5°C increase	Warmer: ~0.5°C increase	Warmer: ~0.9°C* increase

* Statistically significant



Trend in average minimum temperature

Projected changes: minimum temperature

Average minimum temperature projections for the coastal and central zones are similar for all seasons. Generally, the Great Lakes LGA is likely to experience warmer average minimum temperatures during autumn and winter, with summer minimums expected to decrease along with a slight decrease during spring. Projected increases during autumn and winter are greater than the projected decreases for summer and spring and thus an overall increase in annual average minimum temperatures is projected.

Minimum temperature (2020-2080) *Projected changes are relative to the 1970-2007 period*				
Zone	**Summer**	**Autumn**	**Winter**	**Spring**
Coastal	Cooler: ~0.9°C decrease	Warmer: ~1.4°C increase	Warmer: ~1.3°C increase	Cooler: ~0.2°C decrease
Central	Cooler: ~0.8°C decrease	Warmer: ~1.5°C increase	Warmer: ~1.2°C increase	Cooler: ~0.2°C decrease

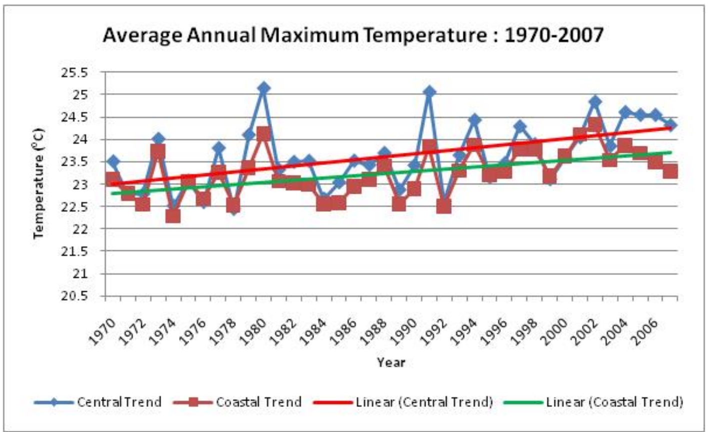
MAXIMUM TEMPERATURE

Historical analysis: maximum temperature

Historically, the Great Lakes LGA has experienced a statistically significant annual increase in average maximum temperatures of ~0.9°C in the coastal zone and ~1.2°C in the central zone. More detailed seasonal and zonal changes are summarised below.

Maximum temperature (1970-2007)				
Zone	**Summer**	**Autumn**	**Winter**	**Spring**
Coastal	Warmer: ~0.9°C increase	Warmer: ~0.5°C increase	Warmer: ~0.9°C* increase	Warmer: ~1.4°C* increase
Central	Warmer: ~1.6°C increase	Warmer: ~0.8°C increase	Warmer: ~1.0°C* increase	Warmer: ~1.7°C* increase

* Statistically significant



Trend in annual average maximum temperature

Projected changes: maximum temperature

Generally, it is projected that average maximum temperatures in the Great Lakes LGA will continue to increase during autumn and winter. Similar or slightly cooler average maximum temperatures are projected to occur during spring and summer. More detailed zonal and seasonal projections are summarised below.

Maximum temperature (2020-2080) *Projected changes are relative to the 1970-2007 period*				
Zone	**Summer**	**Autumn**	**Winter**	**Spring**
Coastal	Cooler: ~0.2°C decrease	Warmer: ~1.1°C increase	Warmer: ~1.3°C increase	Cooler: ~0.7°C decrease
Central	No signifi-cant change	Warmer: ~1.8°C increase	Warmer: ~1.6°C increase	Cooler: ~1.3°C decrease

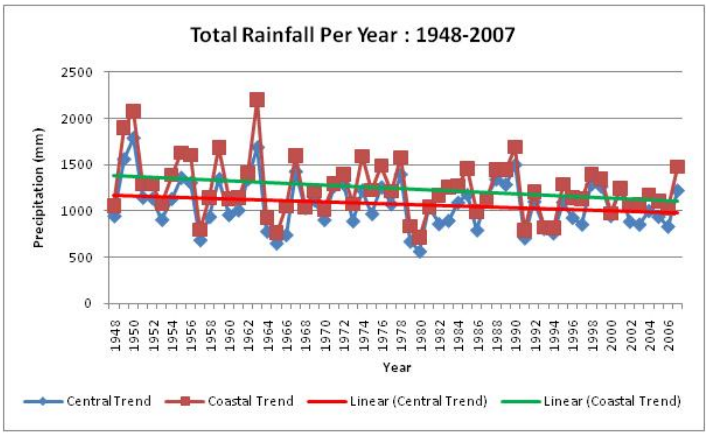
RAINFALL

Historical analysis: rainfall

Historically, the Great Lakes LGA has experienced a statistically significant decrease in annual rainfall (in the coastal zone only) of ~274mm over the period from 1948-2007. More detailed seasonal and zonal changes are summarised below.

Rainfall (1948-2007)				
Zone	**Summer**	**Autumn**	**Winter**	**Spring**
Coastal	Drier: ~46mm* decrease	No change	Drier: ~52mm* decrease	Wetter: ~4mm increase
Central	Drier: ~43mm* decrease	Wetter: ~9mm increase	Drier: ~43mm* decrease	Wetter: ~10mm increase

* Statistically significant

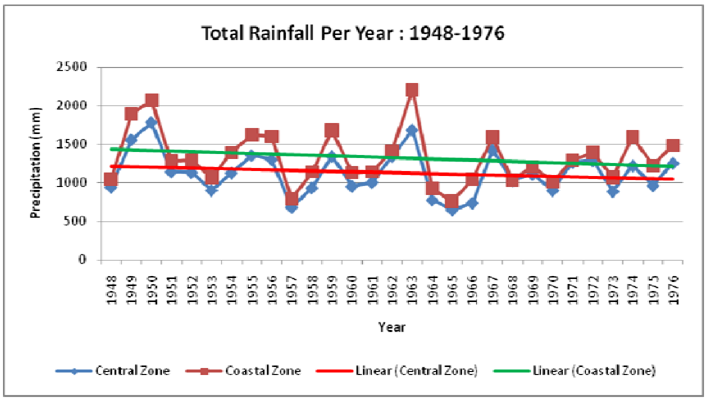


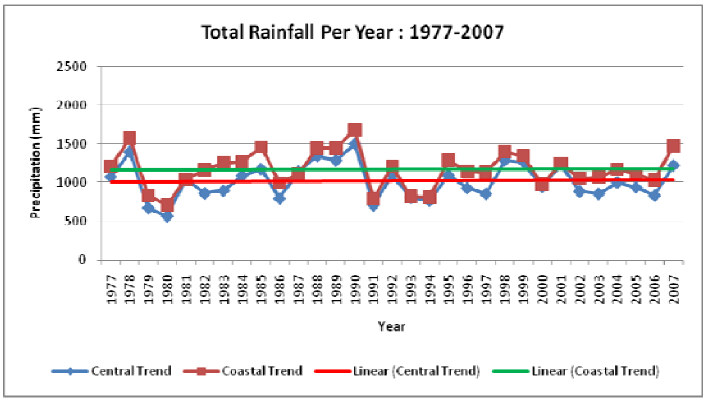
Trend in annual rainfall

Historic climate records are marked by both annual and interdecadal variability. Interdecadal variability within the Australasian and South West Pacific regions is associated with the Interdecadal Pacific Oscillation (IPO).

During the time period from 1948 to 2007 there have been two phases of this oscillation: IPO –ve phase (La Nina-like) from 1948 to 1976; and, IPO +ve phase (El Nino-like) from 1977 to 2007. Rainfall patterns within the region vary according to the IPO.

Although an overall decrease is evident from 1948-2007, a stepwise change occurs between IPO periods and there occurred no change in rainfall during the drier 1977-2007 period. The following graphs show annual rainfall patterns for the coastal and central zones during each IPO period.





Trend in annual rainfall for IPO periods

Projected changes: rainfall

Average annual rainfall patterns for the Great Lakes LGA are projected to stay within the boundaries of existing known natural variability. However, it is projected that rainfall patterns during 2020-2080 will return to the generally wetter and more variable conditions experienced during the 1948-1977 period, which are associated with the negative 'La Nina'-like phase of the Interdecadal Pacific Oscillation. Projected seasonal and zonal changes in rainfall are summarised in the following table.

Rainfall (2020 – 2080) *Projected changes are relative to the 1948-1977 period* *(ie La Nina –ve phase)*				
Zone	**Summer**	**Autumn**	**Winter**	**Spring**
Coast	No significant change	No significant change	Drier: ~13% decrease	Wetter: ~15% increase
Central	No significant change	No significant change	Drier: ~12% decrease	Wetter: ~11% increase

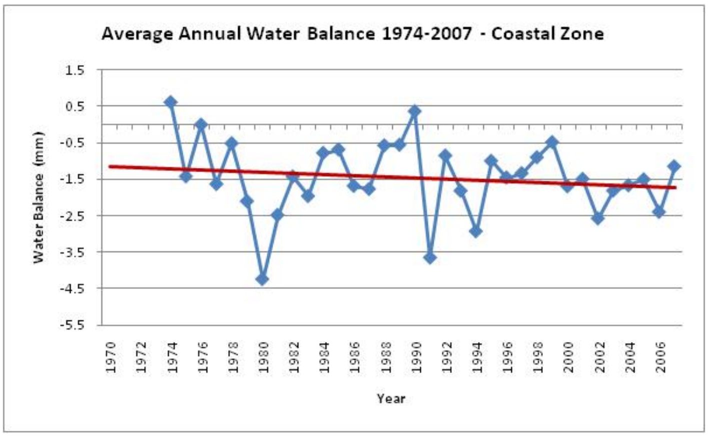
WATER BALANCE

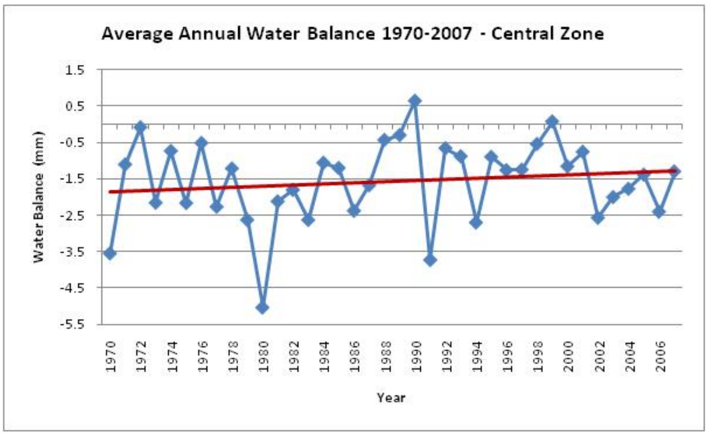
Historical analysis: water balance

Water balance refers to the excess of precipitation over evaporation. It is affected by both the level of precipitation and prevailing temperature conditions.

Historically, the Great Lakes LGA has experienced a total decrease in annual average water balance of 0.5mm per day in the coastal zone between 1973-2007 and an increase of 0.3mm per day in the central zone. More detailed seasonal changes are summarised below.

Water balance (1973-2007)				
Zone	**Summer**	**Autumn**	**Winter**	**Spring**
Coastal	Drier: ~0.5mm/d decrease	Drier: ~1.4mm/d decrease	Wetter: ~0.2mm/d increase	Drier: ~0.2mm/d decrease
Central	Wetter: ~0.6mm/d increase	Wetter: ~0.3mm/d increase	Wetter: ~1.1mm/d increase	Wetter: ~0.9mm/d increase





Coastal and central zone trend in annual water balance

Projected changes: water balance

Seasonal shifts in the coastal and central zones balance out to produce no projected overall annual change. Projected seasonal shifts in water balance are summarised below.

Water Balance (2020-2080)

Changes are reported in average mm per day relative to 1970-2007.

Season	Decrease	Increase
Summer		~1.3 mm Central Zone
Autumn	~1.9 mm Central Zone ~0.9 mm Coastal Zone	
Winter	~0.5 mm Central Zone	~0.7 mm Coastal Zone
Spring		~1.8 mm Coastal Zone ~1.3 mm Central Zone

WIND SPEED

Historical analysis: wind speed

Historically, the Great Lakes LGA has experienced no change in annual average wind speed in the coastal zone and a statistically significant decrease in annual average wind speed of ~6.5km/hr in the central zone. More detailed seasonal and zonal changes are summarised below.

Wind speed (1970-2007)				
Zone	**Summer**	**Autumn**	**Winter**	**Spring**
Coastal	Windier: ~1.4km/hr increase	Windier: ~0.6km/hr increase	Calmer: ~2.0km/hr de-crease	Calmer: ~0.4km/hr decrease
Central	Calmer: ~5.2km/hr* de-crease	Calmer: ~5.8km/hr* de-crease	Calmer: ~7.8km/hr* de-crease	Calmer: ~7.2km/hr* decrease

* Statistically significant

*

Projected changes: wind speed

Seasonal shifts in the coastal and central zones balance out to produce no projected change on an annual basis. Projected seasonal shifts in wind speed during the period 2020-2080 are summarised below.

Wind Speed (2020-2080)

Changes are reported in average km/hr relative to 1970-2007.

Season	Decrease	Increase
Summer	~0.1km/hr Coastal Zone ~0.1km/hr Central Zone	
Autumn		~1.5km/hr Coastal Zone ~1.2km/hr Central Zone
Winter	~0.2km/hr Central Zone	
Spring	~1.4km/hr Coastal Zone ~0.8km/hr Central Zone	

EXTREME EVENTS

Projected changes: extreme events

Extreme weather events such as major storms, flooding rains or extreme temperature days, are a key concern for the community. Their occurrence is a significant source of risk, whether in terms of personal injury, loss of life, economic damage, social disruption or environmental damage. Accordingly, extreme events in the 95th percentile (that is, events in the top 5%) at individual Bureau of Meteorology recording stations have been analysed to project likely changes in their future occurrence.

This analysis has found that the projected frequency of weather patterns responsible for extreme storm events along the NSW coast are likely to increase, suggesting a higher probability of east coast low formation during autumn/winter. Such events are often associated with coastal storm surge (elevated sea levels) caused by intense offshore low pressure cells, and may result in damage to beaches, dune systems and coastal structures.

There are also projected changes in the frequency of occurrence of synoptic patterns associated with high rainfall events. An increase in the frequency of occurrence of high rainfall events in summer and autumn are projected in both the coastal and central climate zones. A corresponding decrease in extreme rainfall events during winter and spring is also projected.

Projected increases in the synoptic pattern linked to high maximum temperatures during summer and autumn is likely to result in an increased frequency of extreme heat days in both the coastal and central zones during the period from 2020-2080. This has a variety of implications including human health and bush fire risk.

A summary of projected changes in the nature and occurrence of extreme events relevant to the Great Lakes LGA for the period 2020 – 2080 are shown below.

Extreme Event	Projected Change
Extreme storms	Increased frequency during autumn & winter
High rainfall events	Increased frequency during summer and autumn. This is matched by a decrease during winter and spring to produce no overall annual change
Extreme Heat Days	Increased frequency during summer and autumn
Frost	No change in winter frost events projected, however increases in autumn and spring are projected for the central zone & western parts of the coastal zone.

How can the results be used?

The climate change projections included in this LGA Climate Profile provide the next order of detail and insight over previous CSIRO (2007) projections available for the Hunter, Central and Lower North Coast region. These projections now make it possible for Great Lakes Council, government agencies, industry and the community to more accurately assess and prepare for the potential risks posed by climate change in the Great Lakes Local Government Area.

More information

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References & Further Reading

- Blackmore, K.L. & Goodwin, I.D (2008). Report 2: Climate Variability of the Hunter, Lower North Coast and Central Coast Region of NSW. A report prepared for the Hunter and Central Coast Regional Environmental Management Strategy, NSW.
- Blackmore, K.L. & Goodwin, I.D (2009). Report 3: Climatic Change Impact for the Hunter, Lower North Coast and Central Coast Region of NSW. A report prepared for the Hunter and Central Coast Regional Environmental Management Strategy, NSW.
- HCCREMS (2009). Fact Sheet—Research Methodology & Findings. Hunter Councils Inc, NSW.
- Verdon, D & Goodwin, I.D. (2007). Progress Report 1 to HCCREMS on Stage 1 of the Regional Climate Change Study. A report prepared for the Hunter and Central Coast Regional Environmental Management Strategy, NSW.

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