Hunter, Central and Lower North Coast

Regional Climate Change Project

2010

CASE STUDY 3: Potential Impacts of Climate Change on Bushfire Risk in the Hunter, Lower North Coast and Central Coast Region

An Initiative of the Hunter & Central Coast Regional Environmental Management Strategy

(Hunter & Central Coast Regional Environmental Management Strategy – a program of the Environment Division of Hunter Councils)

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Potential Impacts of Climate Change on Bushfire Risk in the Hunter, Lower North Coast and Central Coast Region

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GLOSSARY

BOM	BUREAU OF METEOROLOGY
CSIRO	COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION
FFDI	FOREST FIRE DANGER INDEX
GCM	GLOBAL CLIMATE MODEL
IPO	INTERDECADAL PACIFIC OSCILLATION
SD	STATISTICAL DOWNSCALING
SLP	SEA LEVEL PRESSURE
SOM	SELF-ORGANISING MAP
ST	SYNOPTIC TYPE

EXECUTIVE SUMMARY

This case study provides an analysis of both historic and projected changes for a range of key climate variables that are known to significantly influence wildfire behaviour and management in the Hunter, Central and Lower North Coast region of New South Wales. This analysis has identified that changes most likely to heighten the risk posed by wildfire are projected to occur during autumn. These include increases in average wind speed, extreme heat days and average maximum temperatures, combined with projected decreases in relative humidity. These changes are likely to increase the number of days classified using fire danger indices as high or extreme, and may result in an extension of the current observed bushfire season later into this season.

No significant changes in key climate variables are projected to occur during summer, other than a projected increase in onshore wind gusts. Summer rainfall is projected to return to a similar pattern to that experienced during the period from 1948-1976 (i.e. higher and more variable rainfall patterns than those experienced during the last 30 years (1977-2007)). These higher rainfall conditions may result in:

- higher fuel moisture content levels which can decrease the severity of fire weather during summer
- higher fuel loads as a result of increased vegetation growth
- increased rainfall variability across years may also result in medium term (e.g. 3-4 year) wet and dry cycles

Historic records show statistically significant increases in average maximum temperature in winter and spring in all zones, with increases during summer and autumn in the western zone only. Changes projected from the output of the Global Climate Model (GCM) include an overall increase in average annual maximum temperature. No change during summer and a decrease during spring are also projected. These projections do not indicate a continuation of the observed increase in maximum temperature during summer and spring that has been recorded in the western zone. Due to this variation between historic records and projected trends, further analysis of maximum temperature trends is recommended to determine their ongoing strength and direction.

The analysis of historic and projected climate data that is included in the case study has also underpinned a broad scale risk assessment process completed collaboratively by representatives of the NSW Rural Fire Service, NSW Department of Environment, Climate Change & Water, local government and HCCREMS staff. This has identified and ranked the potential risks arising from changes in climate to bushfire activity and management in the region.

The highest level risks identified by this process (i.e. rated extreme) related primarily to:

- changes in autumn and summer wind gusts worsening fire bahaviour and risk during these seasons, particularly in highly populated coastal areas;

- increased difficulty in planning and implementing hazard reduction activities, including potential complacency to undertaking hazard reduction works due to wetter summer rainfall conditions and resuced windows of opportunity for completing hazard reduction works; and

- Increased risk to the health and safety of firefighters arising from projected increases in the number of extreme heat days in the region.

Further details on all of the potential risks identified, their risk rating and the nature of potential adaptation strategies are included in Table 10 and Appendix 1 of the report.

INTRODUCTION

This case study on the potential impacts of climate change on bushfire management and risk has been completed as part of a regional research program to identify the regional and sub regional scale impacts of climate change in the Hunter, Central and Lower North Coast region of New South Wales. In addition to an overall analysis of historic and projected climate change for the region (Blackmore & Goodwin 2008; Blackmore & Goodwin 2009) generated by this research, 4 case studies (of which this is one) have been developed to more specifically analyse and understand the potential impacts of climate change in the region. The focus of these case studies includes the Hunter Valley Wine Industry, Human Health (Extreme Heat), Bushfires and Extreme Events in the Coastal Zone.

This case study utilises existing published information on determining bushfire risk, results from an analysis of climate variability in the region (Blackmore & Goodwin 2008), and projected climate changes to analyse the potential impacts of climate change on bushfire incidence at a sub-regional level. The potential for conditions linked to the incidence and extremity of bushfires to worsen is of concern to key stakeholders such as fire authorities, councils, land managers and the community. The potential for areas to become hotter, drier, and /or windier is of primary relevance. This case study considers historic trends in climate parameters that determine fire weather conditions and then utilises climate change projections to consider the likely future impacts.

To facilitate this case study, existing published information, including two key CSIRO reports investigating climate change impacts on bushfire weather, are utilised. The first of these CSIRO studies was conducted in 2005 and results were published in a report titled ‘Climate change impacts on fire-weather in south-east Australia’ (Hennessy, et al. 2005). It was concluded in this report that an increase in summer temperature would be associated with “... an increase in the frequency of very high and extreme fire danger days, especially in inland areas”. Additionally, based on available global climate model projections, the frequency of fire danger days would increase by 4-25% by 2020 and by 15-70% by 2050. Climate change impacts on fire weather were considered to be more severe in inland areas and it was also suggested that fire danger in autumn, winter and spring would also likely increase, pushing suitable times for prescribed burning into winter.

The second of these CSIRO reports, titled ‘Bushfire weather in southeast Australia: recent trends and projected climate change impacts’ (Lucas, et al. 2007), extends on the work published in the earlier report by including additional sites, extending the analysis to the 2006-07 fire season, and explicitly considering changes to individual seasons and season lengths. The projected changes in the number of days with very high and extreme fire weather, relative to 1990, are between 2 and 25 percent for a low global warming scenario and as much as 20 to 300 percent for a high global warming scenario (Table 1).

	2020		2050	
	Low global warming (0.4°C)	High global warming (1.0°C)	Low global warming (0.7°C)	High global warming (2.9°C)
Very high	+2 - 13%	+10 - 30%	+5 - 23%	+20 - 100%
Extreme	+5 - 25%	+15 - 65%	+10 - 50%	+100 - 300%

Table 1 - Percent changes in the number of days with very high and extreme fire weather - 2020 and 2050, relative to 1990 for the South-east of Australia. Source: Lucas, et al. 2007: 3.

The analysis presented in this case study differs from the work presented in these reports in three key ways. Firstly, this case study analyses changes in climate variables used to define fire weather risk rather than changes in specific bushfire risk indices. Indices exist to qualify and quantify forest fire danger, however it is noted that site specific and/or individual environmental factors make it impossible to capture the concept of fire danger in any single or combination of indices. Given this, the analysis presented in this case study attempts to provide a greater understanding of historic and likely future trends in key climate variables that underpin the concept of fire danger.

Secondly, the method used to derive estimates of projected changes in key climate variables differs. In this case study, synoptic patterns are determined from the CSIRO Mk3.5 Global Climate Model (GCM) and used as the basis for analysing projected changes. This is opposed to directly using the values for key climate variables (i.e. temperature, wind and humidity) output from the GCM to project changes. The process used is described in the methodology section. This difference in process results in variations in the projection estimates used to determine changes in fire weather and thus the findings from this case study may differ to those published else where.

Lastly, differences occur in the scale of the regions analysed. The CSIRO work (Hennessy, et al. 2005 and Lucas, et al. 2007) analyses climate change impacts on fire-weather across the entire south east region of Australia, while this case study focusses specifically on the Hunter, Central and Lower North Coast region of NSW. Because regional and sub regional variability in key climate parameters directly informs our understanding of fire weather, these differences in scale directly influence the variability in research findings between these two bodies of work.

OVERVIEW OF KEY CLIMATE CHANGE CONCERNS

Fire weather information is important because it describes the prevailing weather conditions affecting fire behaviour. The key climate variables that inform the categorisation of fire weather are wind, relative humidity and temperature. These variables, in conjunction with fire fuel information, form the key inputs into commonly used indices of fire hazard or danger rating.

Wind is the major factor that affects the potential for fire (Gorski and Farnsworth, 2000). It is also a key determinant of the rate and direction of spread of a fire. It's fanning affect "aids combustion by causing the flames to lean over closer to unburnt fuel, supplying the fire with oxygen and carrying away moist air which would otherwise restrict the amount of heat available to ignite unburnt fuel" (Sharples, et al. 2009).

Atmospheric humidity is important because it affects the flammability of fuel through its moisture content. Low humidity is associated with dryer conditions as moisture from fuels is transferred to the atmosphere. Temperature has a similar affect with higher temperatures tending to decrease fuel moisture content. Additionally, higher temperatures heat the fuel and thus lead to easier ignition.

Summer rainfall also affects the fuel moisture content and therefore its flammability. A relationship between summer rainfall and the extent of burn areas has been identified with increases in summer rainfall linked to a decline in area burnt (Nicholls and Lucas 2007).

As a result of consultation with key stakeholders including local government, NSW Rural Fire Service and the Department of Environment, Climate Change & Water (DECCW), the following additional key parameters were also identified:

- Pan evaporation – important aspect in the moisture content of fuel;

- Extreme heat days – increases in the frequency of occurrence of extreme heat days were considered important, both in terms of contributing to fire behaviour and their impact on fire fighting resources;
- Seasonal rainfall – in addition to summer rainfall and it's impact on fuel moisture content during the fire season, rainfall patterns in other seasons were also considered important factors, particularly in relation to changes in rainfall patterns during prescribed burning periods.

CASE STUDY METHODOLOGY

A two step methodological process has been adopted for the analysis of climate parameters completed for this case study. Firstly, key climate indices relevant to bushfire risk have been identified and changes in these indices are assessed using historic records obtained from the Bureau of Meteorology (BOM). Secondly, climate projections for the region obtained from the Global Climate Model (GCM) output for the A2 (high) emissions scenario, and a process called Statistical Downscaling (SD), have been utilised to assess likely impacts on the relevant key climate indices for the period from 2020-2080 A.D.

GCMs generate future climate scenarios and provide output for a range of key climate variables. The CSIRO Mk3.5 GCM and the A2 scenario have been determined as the most appropriate to identify projected changes in climate for the Hunter, Central and Lower North Coast region. Because of the coarse scale outputs generated by GCM's however, the additional process of SD has also been used to generate climate projections more relevant and applicable for regional scale analysis and management purposes. SD is a term given to techniques used to derive values for climate variables at a regional or sub-regional level from the coarse scale output of GCMs. Specifically, a weather typing approach to SD has been adopted for the research presented in this case study. In summary, this process has included:

1. Identifying the key synoptic types that drive climate variability in the region.
2. Identifying the relationships between these STs and BOM historic records for key climate variables.
3. Using the GCM to identify projected changes in the frequency of occurrence of these key STs based on sea level pressure (SLP) output data generated by the GCM
4. Combining our understanding of how the region's weather is impacted by these key STs with projected changes in their frequency to project likely changes in key climate variables across the region.

A more detailed description of the methodology is included in the report *Climatic Change Impact for the Hunter, Lower North Coast and Central Coast Region of NSW* (Blackmore & Goodwin 2009). The key benefit of this approach is that it provides a richer understanding of the "drivers" of weather patterns within the region and how these drivers are likely to change in the future.

The climate change projections are reported in terms of three climate zones derived for the (HCLNC) region (Blackmore & Goodwin 2008) (Figure 1).

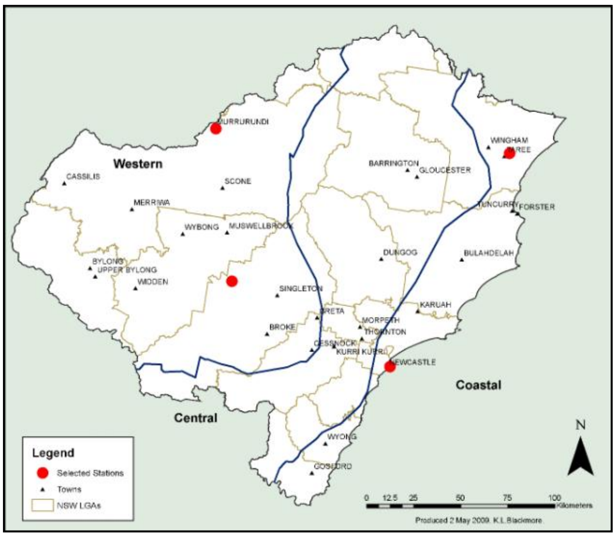

Figure 1 - Study region comprising coastal, central and western climate zones.

HISTORICAL CLIMATE VARIABILITY AND TRENDS

Instrumental climate data sets have been obtained from the National Climate Centre of the Australian Bureau of Meteorology (BOM) for use in the case study. These data represent the recordings from ground stations within the region, from the beginning of collection for the station to 31 December 2007. These data sets form the primary source of information used to study historic climate variability and for the study of future climate change impacts for the region.

It is important to ensure that the data sets used in this study are of a sufficient length, cover a common time span and are reasonably complete. Thus a data interrogation process was used to determine the completeness of each of the records. Each climate parameter time series was checked for missing data between the years of interest (1948 and 2007)[1] and this was converted to percentage completeness. It was determined that a good spatial coverage could still be maintained by restricting the final data set to stations with daily records that are at least 90% complete.

Historic climate records for each key climate variable have been analysed for increasing or decreasing linear trends. Regression analysis has been conducted for each climate variable to assess the statistical significance of linear trends. Regression analysis provides a measure of the statistical significance of the linear trend known as a “p-value”. Where the p-value is found to be less than 0.05, the linear trend is considered to be statistically significant. Linear trends found to be significant are reported in the text.

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. The IPO period represent shifts in the mean climate and are considered in the following analysis of climate variability and trends.

AVERAGE WIND SPEED

The annual average wind speed for the region for the period 1970 to 2007 varies by climate zone with the central zone approximately 19.8km/hr, compared to approximately 9.8km/hr in the central zone and approximately 9.3km/hr in the western zone. Over the period from 1970 to 2007, a decreasing linear trend in annual average wind speed is evident in the cental and western zones. Only the trend in the central zone is statistically significant and is equivalent to a decrease of approximately 6.5km/hr over this entire period.

During summer, wind speed averages 20.3km/hr in the coastal zone, 8.2km/hr in the central zone and 9.5km/hr in the western zone. This decreases to 17.7km/hr (coastal), 7.8km/hr (central) and 8.1km/hr (western) during autumn and increases again to 20.1km/hr (coastal), 12.1km/hr (central) and 9.1km/hr (western) during winter (Figure 2, Figure 3 and Figure 4). Spring wind speed averages 21.1km/hr in the coastal zone, 11.2km/hr in the central zone and 10.6km/hr in the western zone.

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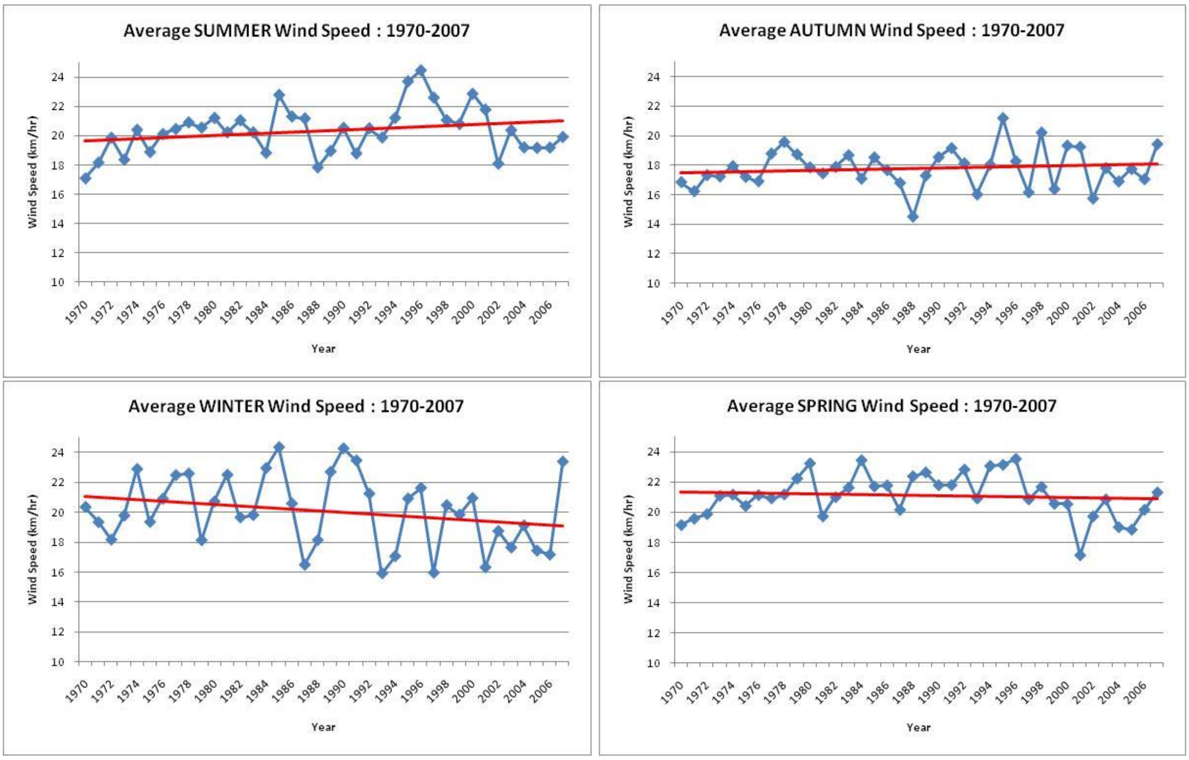
[1] The year 1948 was chosen as the lower bound as this corresponds to the first year for which the atmospheric data is available in the NCEP/NCAR dataset (and therefore was also be the first year for which the synoptic typing was carried out).

In the coastal zone, average wind speed shows increases in summer and autumn and decreases during winter and spring over the period from 1970-2007. The seasonal changes occuring in the coastal zone are not statistically significant. Decreases in average wind speed are evident in all seasons in the central zone. As with the annual trend, the seasonal changes in the central zone are statistically significant. Decreases in all seasons are also evident in the western zone. The trend occurring during autumn (decrease of 2.7km/hr over the period from 1970-2007) is statistically significant.

Coastal Zone



Average SUMMER Wind Speed : 1970-2007

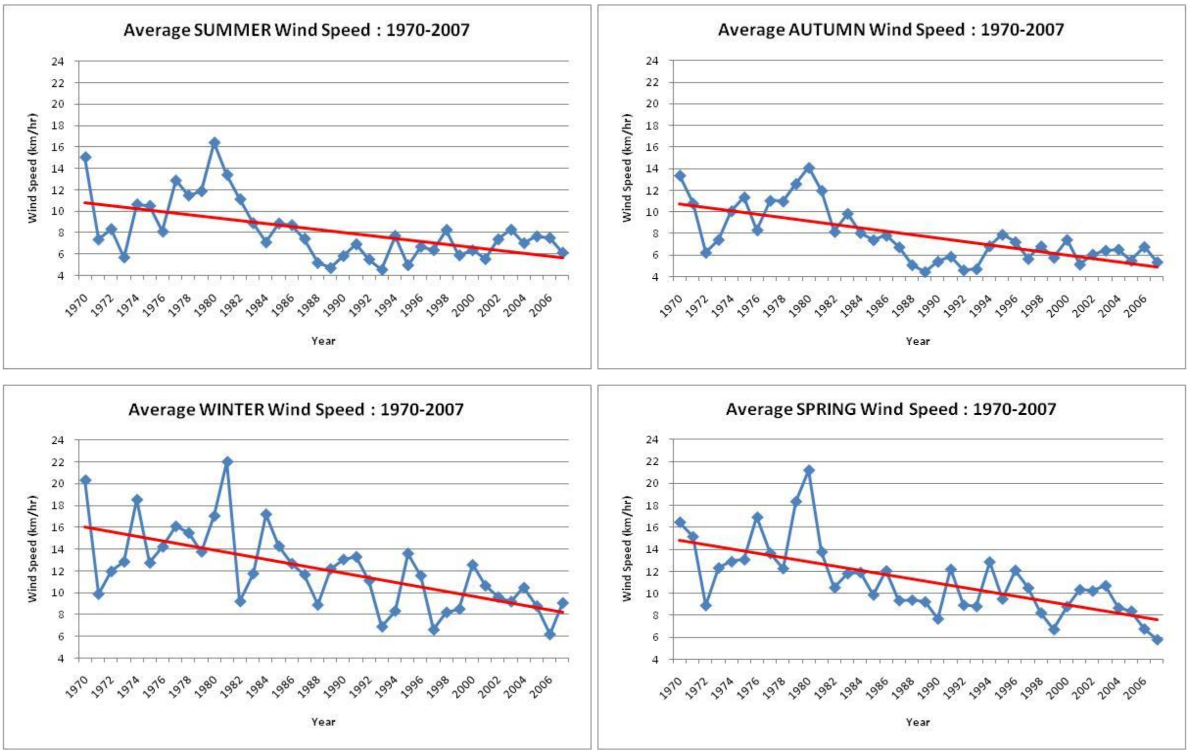
Average AUTUMN Wind Speed : 1970-2007

Average WINTER Wind Speed : 1970-2007

Average SPRING Wind Speed : 1970-2007

Figure 2 - Seasonal trends in average wind speed by for the coastal zone (1970-2007)

Central Zone



Average SUMMER Wind Speed : 1970-2007

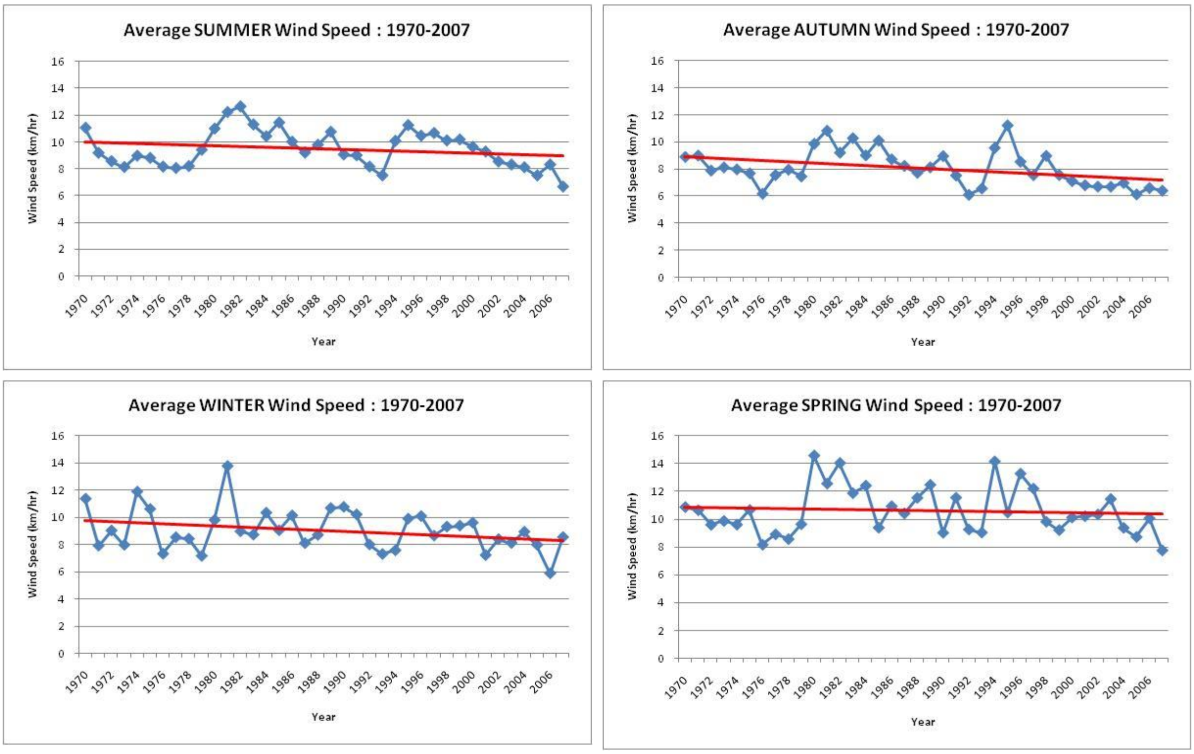
Average AUTUMN Wind Speed : 1970-2007

Average WINTER Wind Speed : 1970-2007

Average SPRING Wind Speed : 1970-2007

Figure 3 - Seasonal trends in average wind speed by for the central zone (1970-2007)

Western Zone



Average SUMMER Wind Speed : 1970-2007

Average AUTUMN Wind Speed : 1970-2007

Average WINTER Wind Speed : 1970-2007

Average SPRING Wind Speed : 1970-2007

Figure 4 - Seasonal trends in average wind speed by for the western zone (1970-2007)

High winds reduce humidity and are a key concern with regard to bushfire weather and behaviour. As such, the frequency of days per annum with average wind speed above 50km/hr are analysed. The threshold of 50km/hr is selected as a measure of an extreme wind day for this case study. Days with average wind speed in excess of 50km/hr occur more frequently in the coastal zone than the central and western climate zones. Days above this threshold occur infrequently in the west of the region. A decreasing linear trend (red lines) is evident in both the coastal and central zones. These trends are statistically significant at the 5% level (i.e. P<0.05).

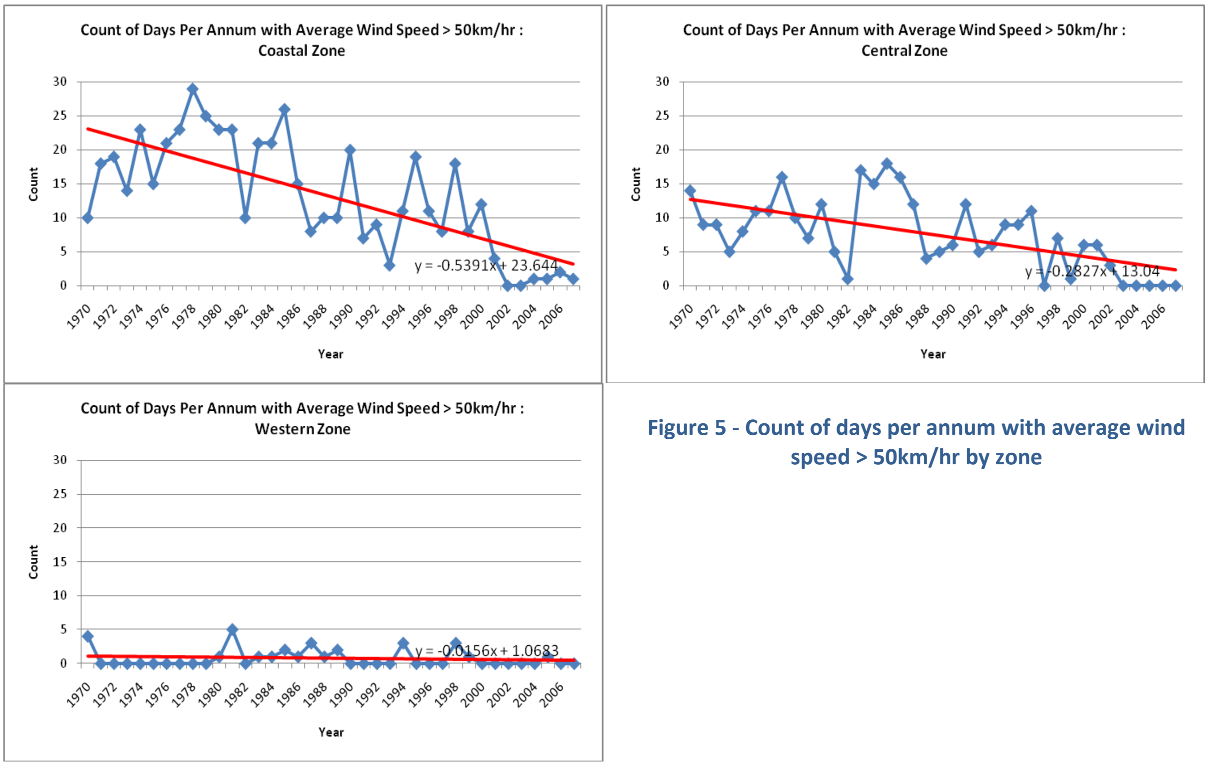


Figure 5 - Count of days per annum with average wind speed > 50km/hr by zone

WIND GUST

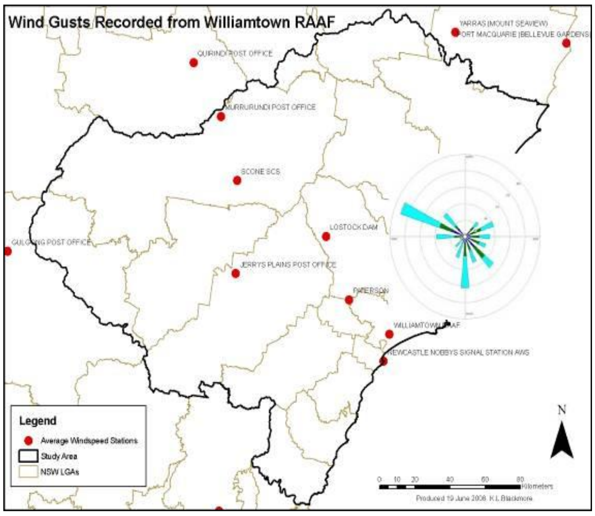


Figure 6 – Wind rose diagram of wind gusts recorded from Williamtwon RAAF.

Suitable (i.e. of a sufficient duration) maximum wind gust data is available from only one station in the study region (Williamtown). Although wind gust station data records from Williamtown RAAF begin 1/10/1942, consistent recording of data does not commence until 1/10/1956. Maximum wind gusts average 44km/hr during summer from a south easterly direction. Autumn and spring wind gusts tend southerly (average of 37.5km/hr and 45.7km/hr respectively). Winter winds tend south westerly with average gusts at 42km/hr. The wind rose diagram in Figure 6 clearly shows the dominance of the westerly wind gusts in the region.

Seasonal trends in wind gusts are shown in Figure 7. All seasons show an increase in average recorded wind gusts over the period from 1957 to 2007. This increase is most pronounced during summer and only the increase in summer was found to be statistically significant (P<0.05).

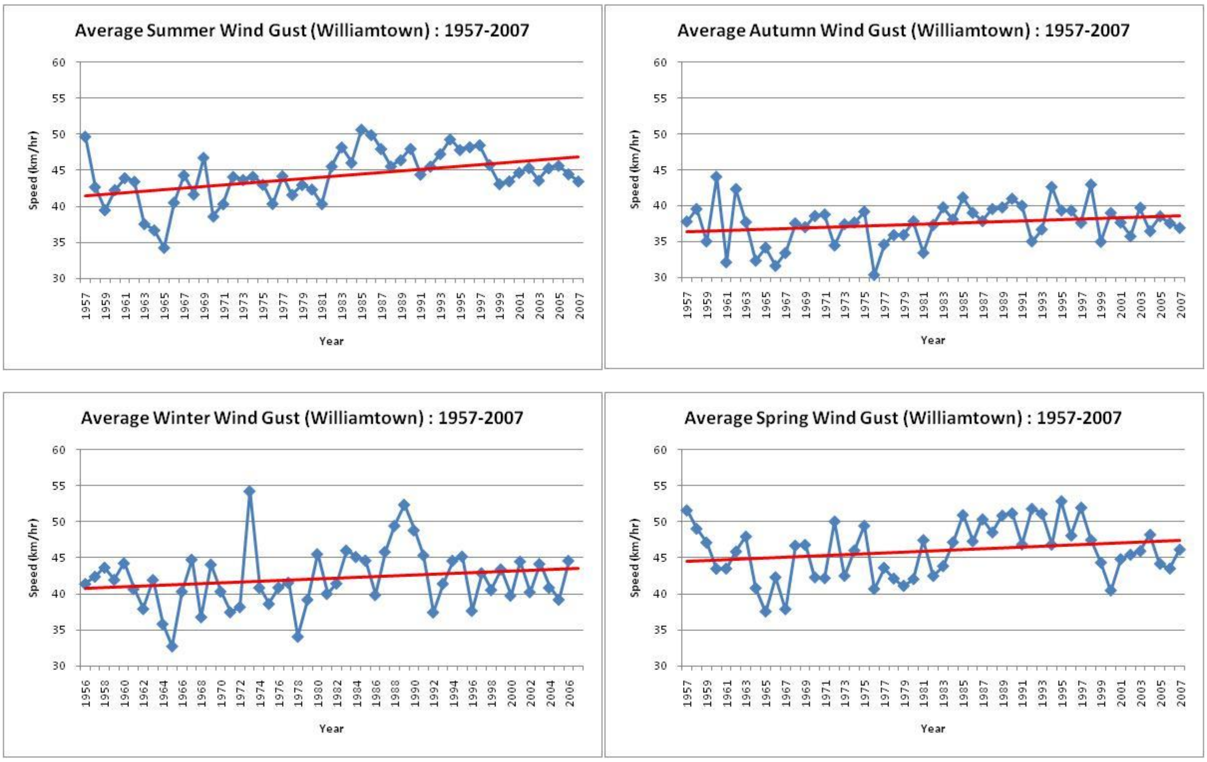
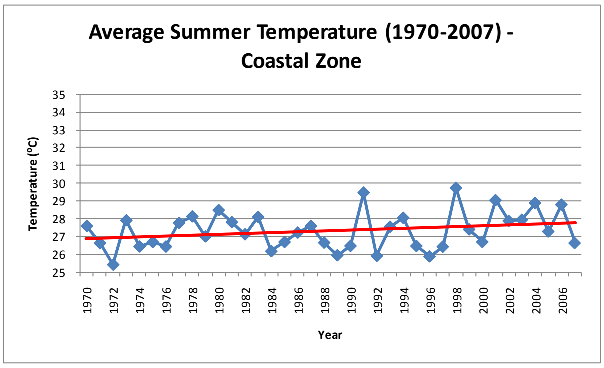
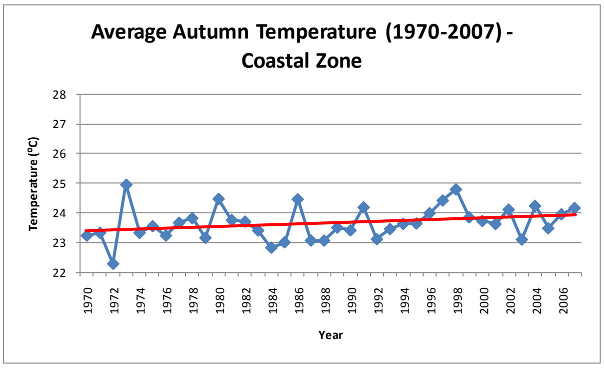


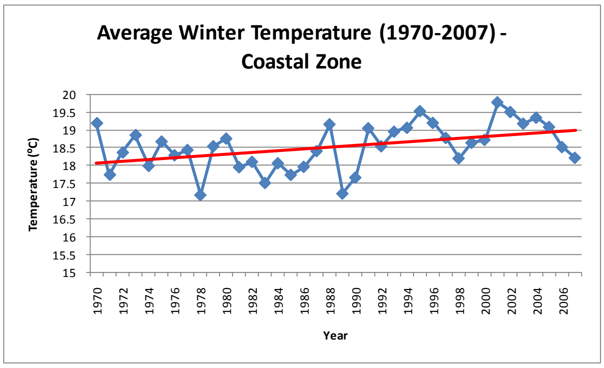
Figure 7 - Seasonal trends in average wind gusts (Williamtown) : 1957-2007

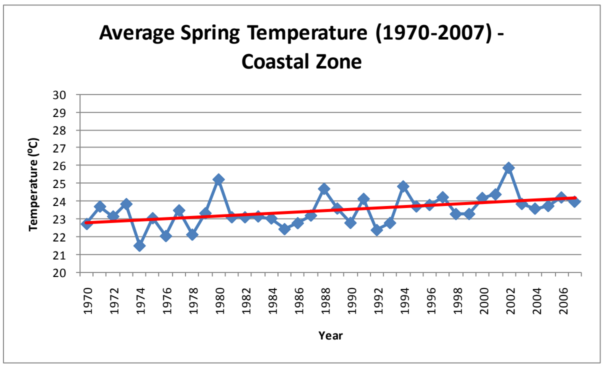
MAXIMUM TEMPERATURE

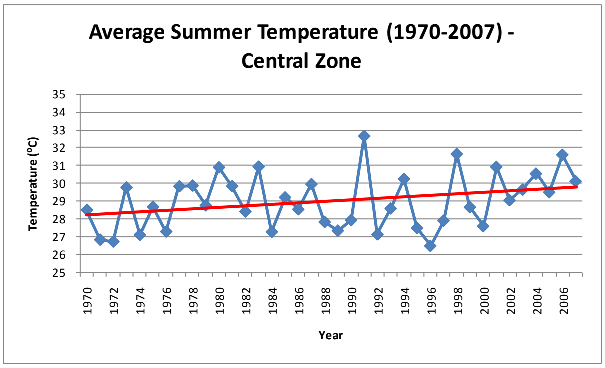
Regionally, increases in maximum temperature of between approximately 0.5°C and 2°C have been experienced in all seasons during the period from 1970-2007 (Figure 8 and Table 2.). The increases occurring in all three zones during winter and spring are statistically significant (i.e. $P<0.05$). During summer and autumn, only increases occuring in the west of the region are statistically significant, with the largest increase occurring during summer (2.02°C) in the western climate zone.

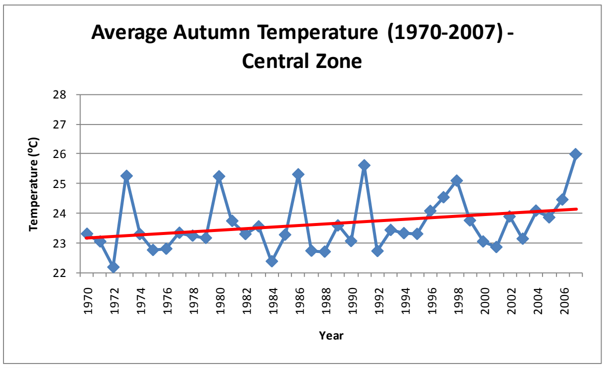


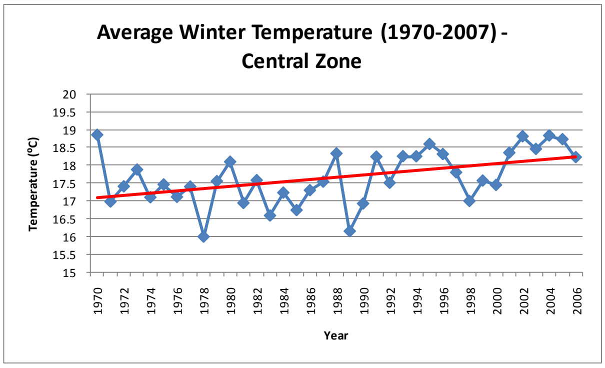


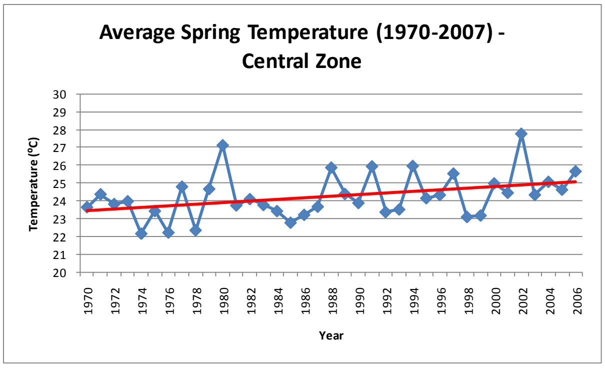


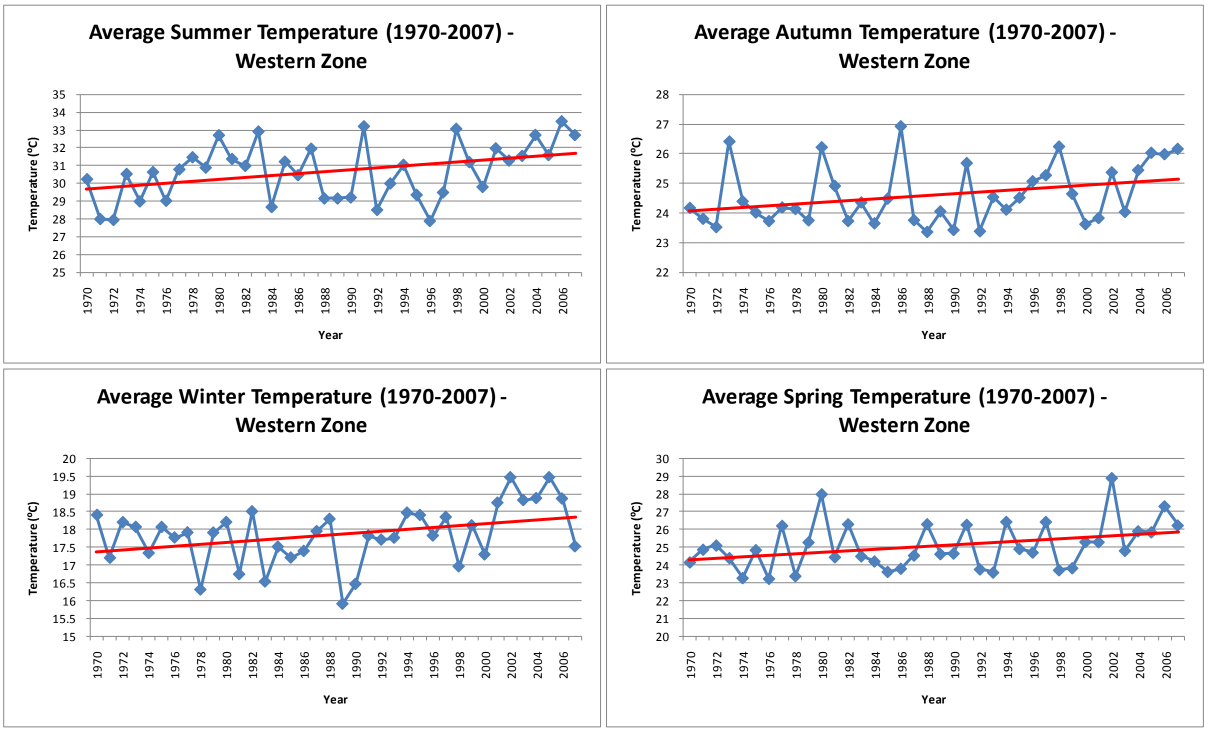












Average Summer Temperature (1970-2007) - Western Zone

Average Autumn Temperature (1970-2007) - Western Zone

Average Winter Temperature (1970-2007) - Western Zone

Average Spring Temperature (1970-2007) - Western Zone

Figure 8 - Seasonal trends in average maximum temperature by zone (1970-2007)

	Coastal				Central				Western			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
^Per Annum (^{o}C)	0.02	0.01	**0.02**	**0.04**	0.04	0.03	**0.03**	**0.04**	**0.05**	**0.03**	**0.03**	**0.04**
Total Change 1970-2007 (^{o}C)	0.91	0.55	**0.91**	**1.39**	1.55	0.96	**1.16**	**1.66**	**2.02**	**1.07**	**0.98**	**1.56**

Bold text represents statistically significant trend.

Table 2 - Historic changes in average seasonal maximum temperature by zone (1970-2007)

RELATIVE HUMIDITY - SUMMER

Relative humidity data for the central zone is limited and thus 9am trends are plotted for 1973-2007 and 3pm humidity is available for the period from 1974 to 1982 (Figure 9). Data for the coastal and western zones are plotted for the period from 1970 to 2007. Some slight trends in 3pm relative humidity recorded during summer are evident in the region (i.e. decrease in the coastal and central zones) however these trends are not statistically significant.

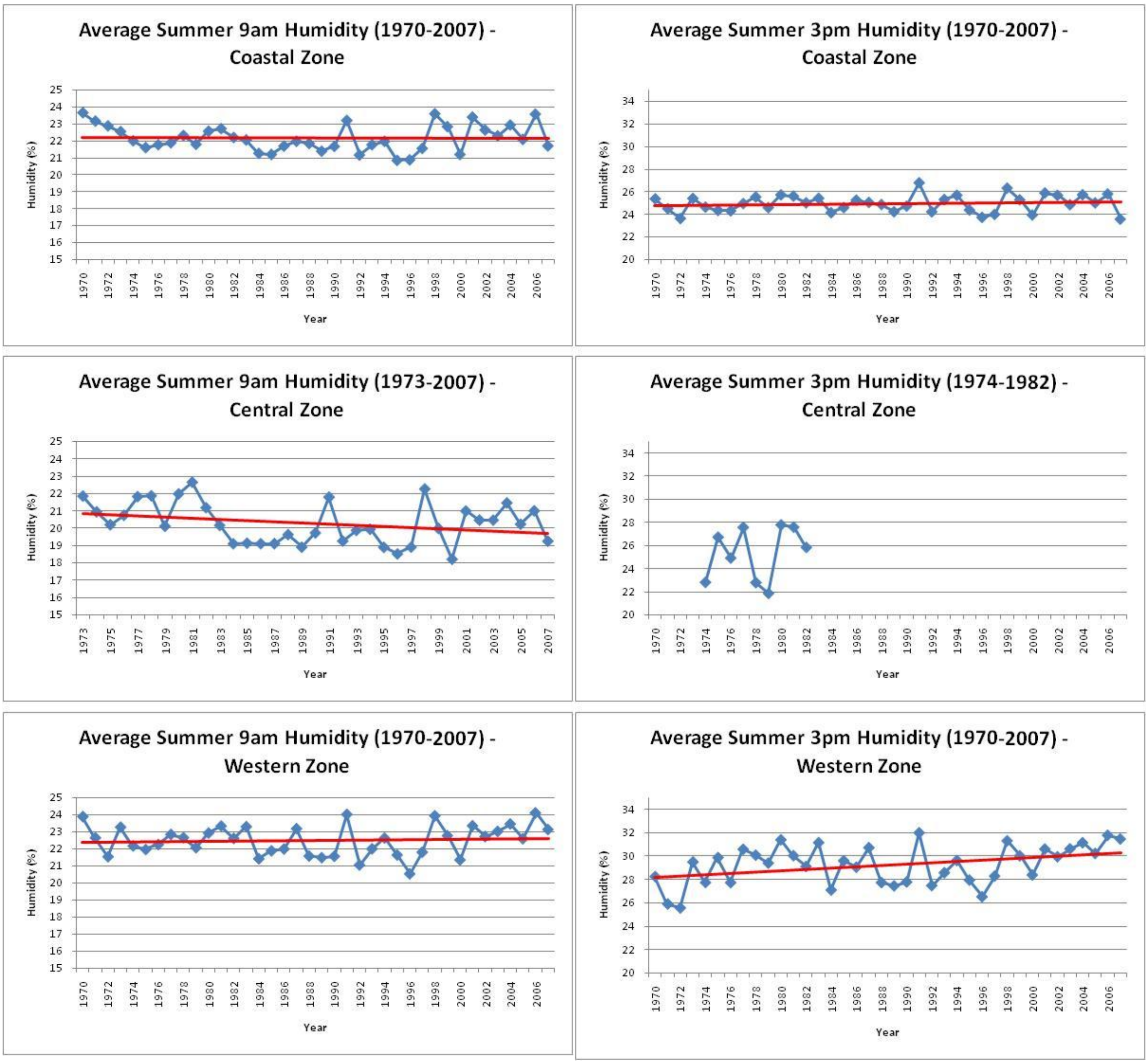


Figure 9 - Seasonal trends in average 9am and 3pm relative humidity by zone (1970-2007)

RAINFALL

SUMMER RAINFALL

Average summer rainfall for the coastal, central and western zones for the period from 1949-2007[2], 1949-1976 and 1977 to 2007 are shown in Figure 10, Figure 11 and Figure 12. The graphs for the entire period from 1949-2007 show clear, statistically significant (i.e. $P<0.05$), decreasing linear trends for all zones. However, the same trends are not evident in the graphs for the two IPO periods (i.e. 1949-1976 and 1977-2007) covered during this time interval. The period from 1949-1976 was a wetter period than the latter 1977-2007 period. These findings indicate a stepwise shift in precipitation patterns rather than a linear decrease over the period from 1949-2007.

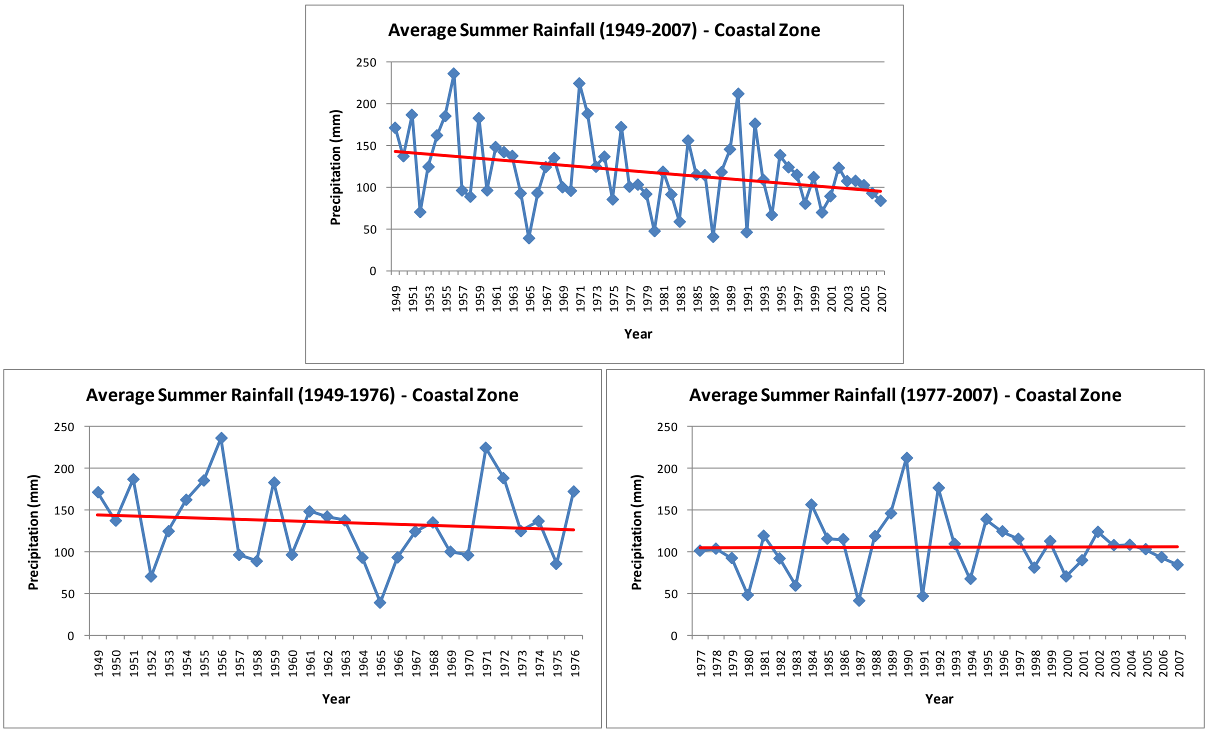


Figure 10 - Average summer rainfall for the coastal zone (1949-2007)

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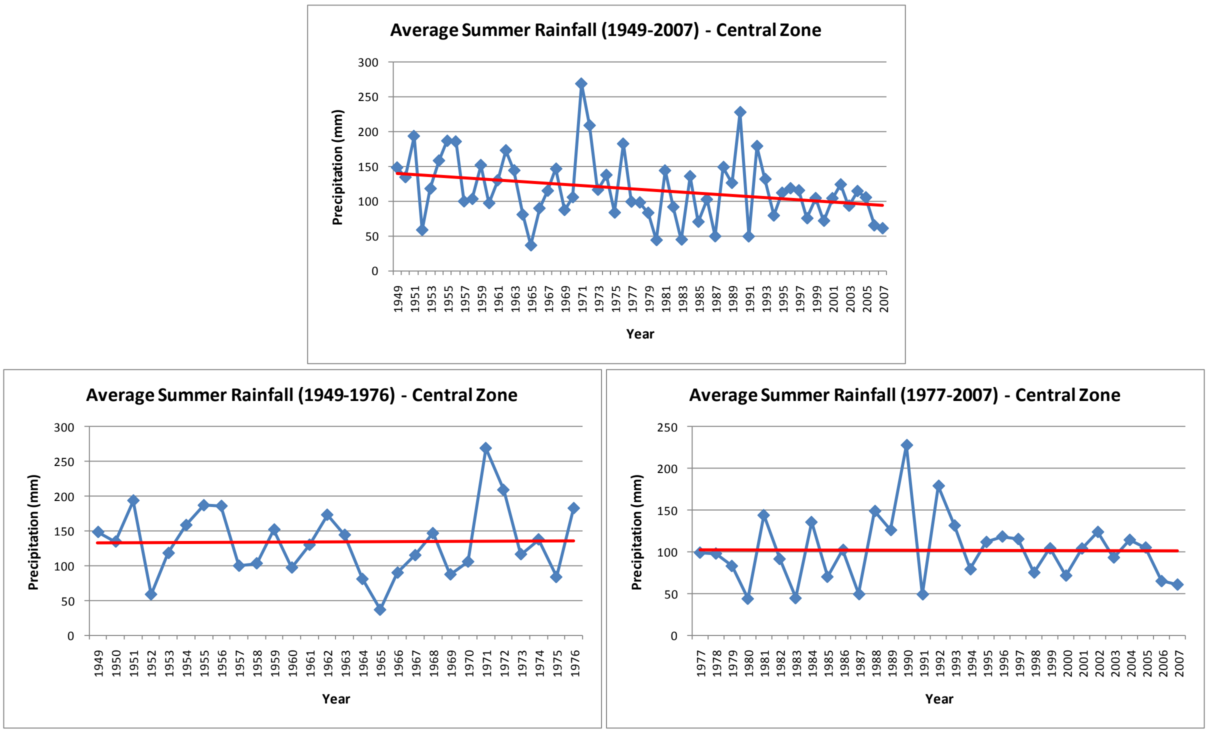
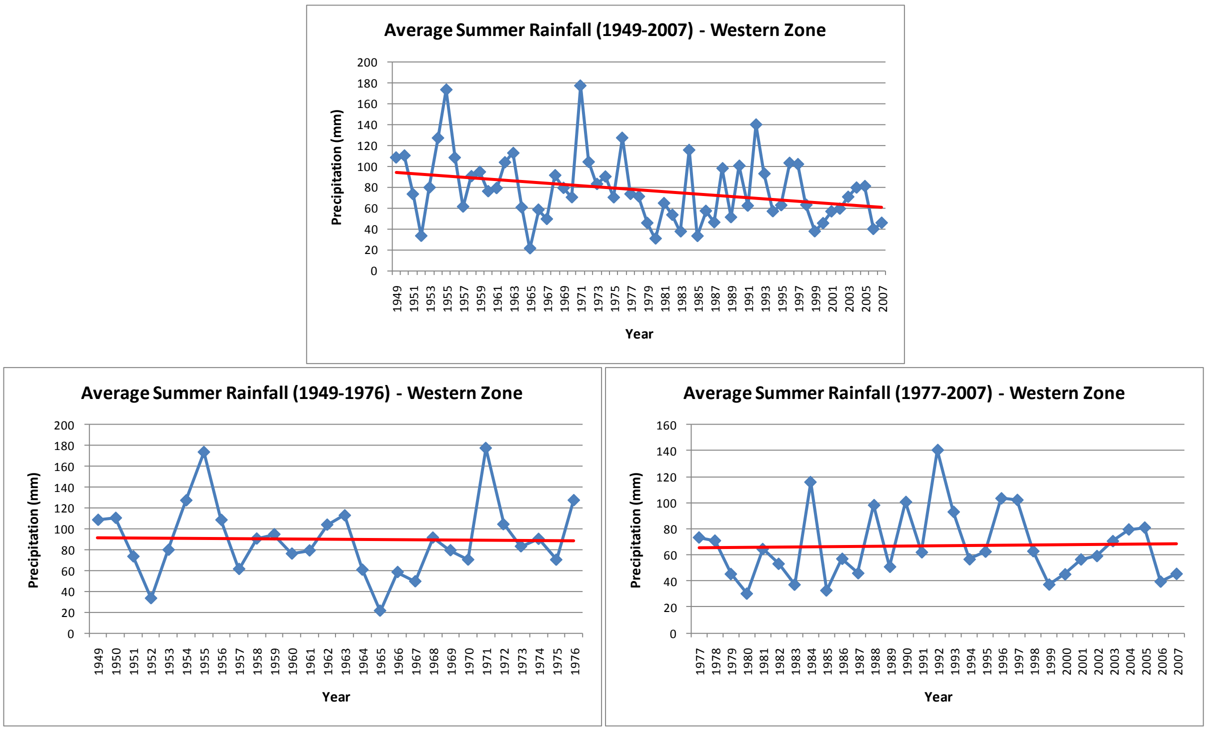
[2] The summer rainfall time series commences in 1949 as data for December 1947 is not available to allow the series to commence in 1948.


Average Summer Rainfall (1949-2007) - Central Zone

Average Summer Rainfall (1949-1976) - Central Zone

Average Summer Rainfall (1977-2007) - Central Zone

Figure 11 - Average summer rainfall for the central zone (1949-2007)


Average Summer Rainfall (1949-2007) - Western Zone

Average Summer Rainfall (1949-1976) - Western Zone

Average Summer Rainfall (1977-2007) - Western Zone

Figure 12 - Average summer rainfall for the western zone (1949-2007)

AUTUMN RAINFALL

Average autumn rainfall for the coastal, central and western zones for the period from 1948-2007, 1948-1976 and 1977 to 2007 are shown in Figure 13, Figure 14 and Figure 15. The graphs for the entire period from 1948-2007 show no significant trends for all zones. The graphs for the two IPO periods (i.e. 1948-1976 and 1977-2007) show slight to moderate decreases however none of these trends are statistically significant. The stepwise shift in precipitation evident in the summer rainfall patterns is not evident during autumn.

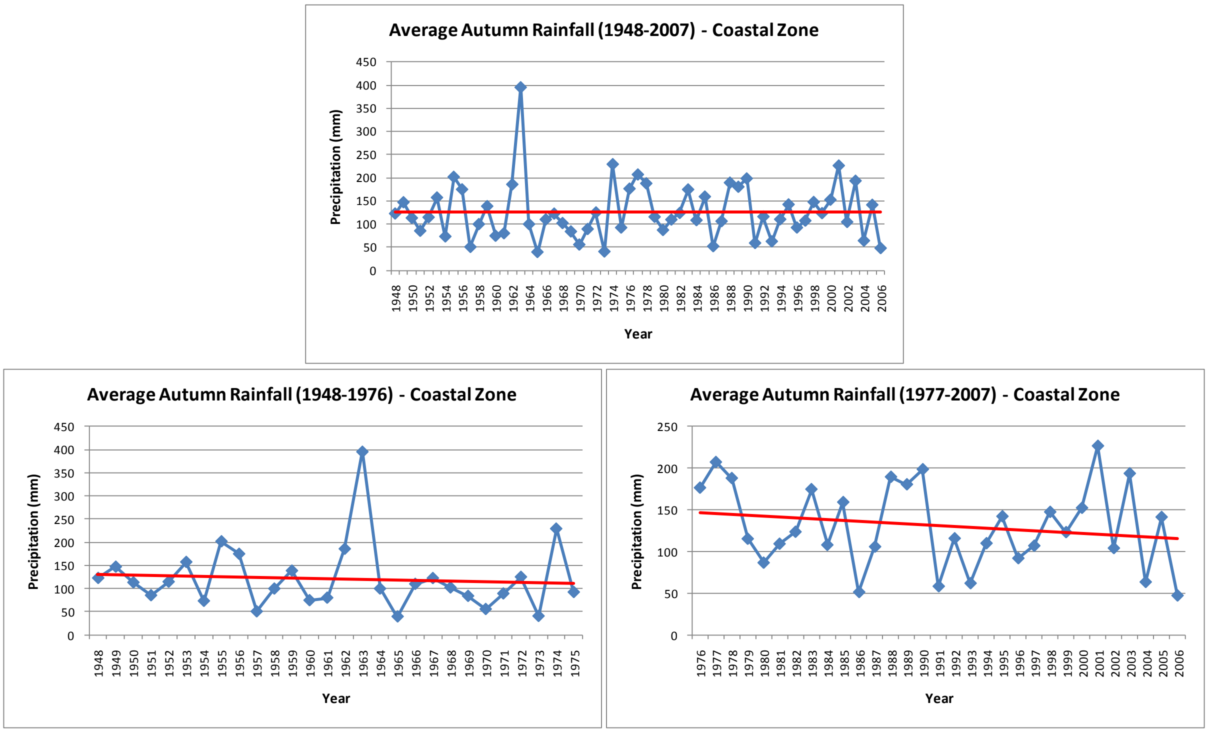


Figure 13 - Average autumn rainfall for the coastal zone (1948-2007)

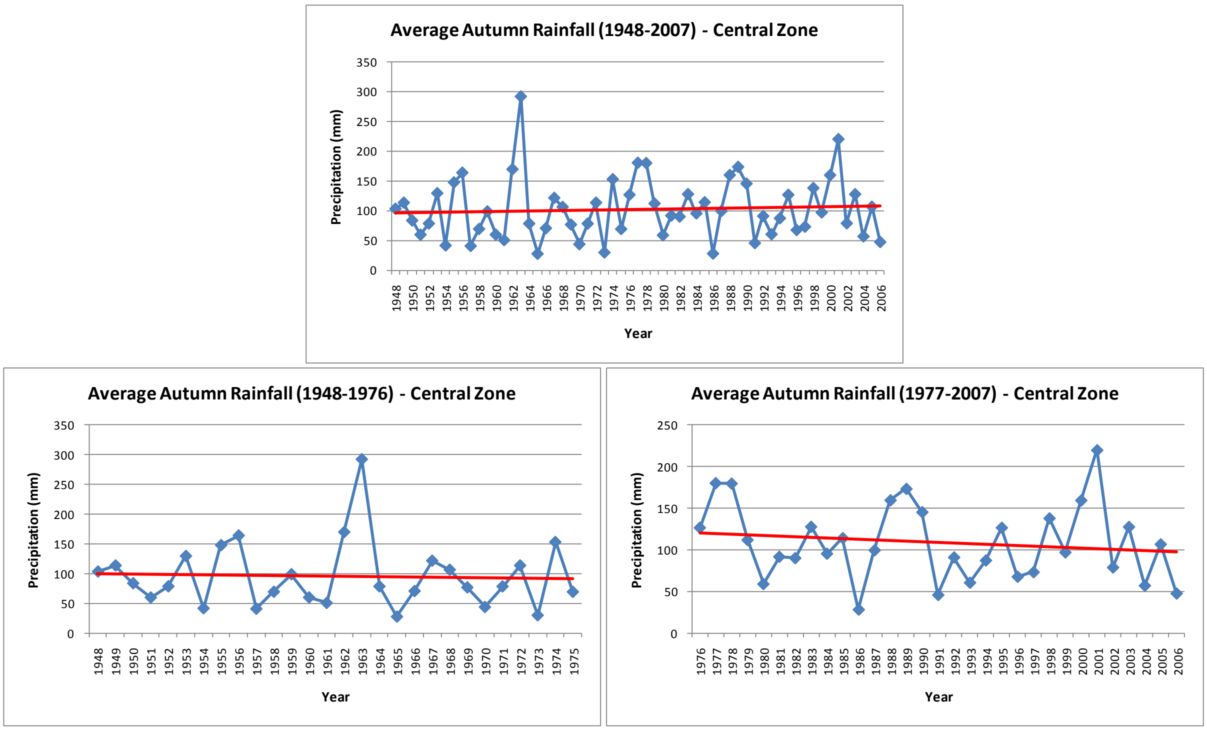


Figure 14 - Average autumn rainfall for the central zone (1948-2007)

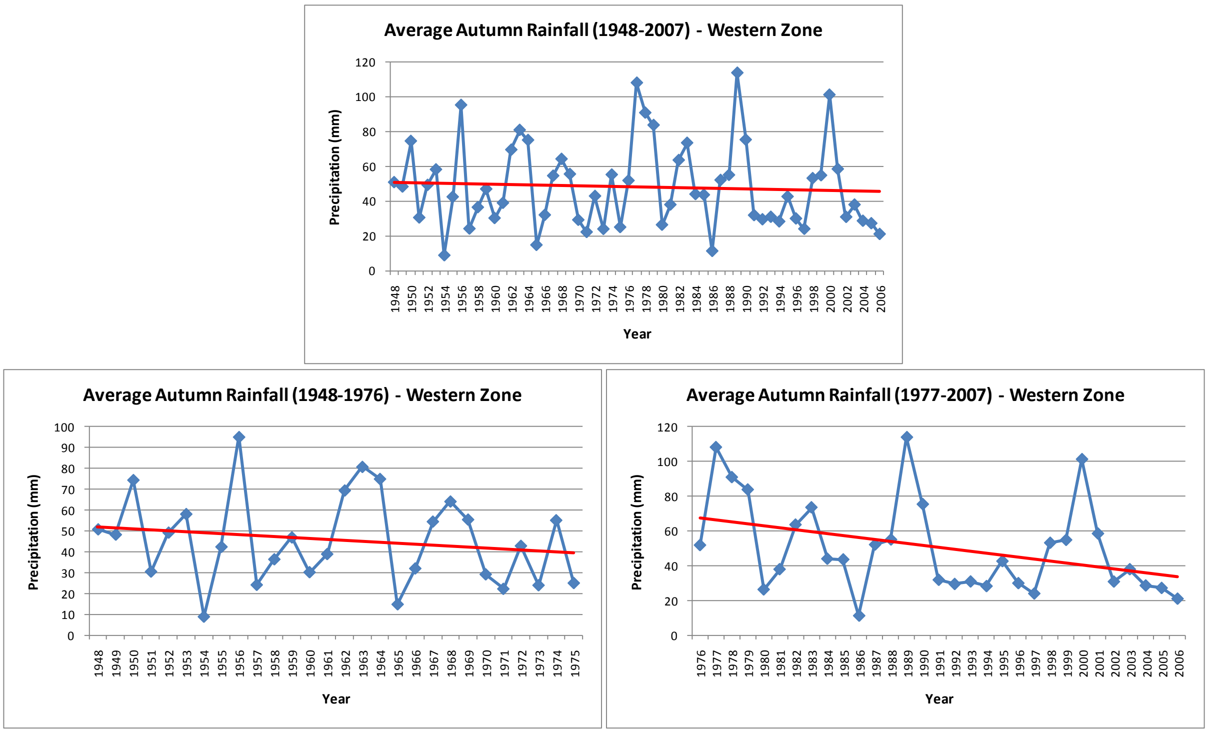


Figure 15 - Average autumn rainfall for the western zone (1948-2007)

WINTER RAINFALL

Average winter rainfall for the coastal, central and western zones for the period from 1948-2007, 1948-1976 and 1977 to 2007 are shown in Figure 16, Figure 17 and Figure 18. The graphs for the entire period from 1948-2007 show decreasing trends for all zones. The decreases occurring in the coastal and central zones are statistically significant. The graphs for the two IPO periods (i.e. 1948-1976 and 1977-2007) show decreases over the period from 1948-1976 in all seasons and no discernable change over the period from 1970-2007. As with summer rainfall patterns, a stepwise shift in winter rainfall patterns is evident for the two IPO periods (i.e. 1948-1976 winter rainfall is higher on average than that recorded during the 1977-2007 period).

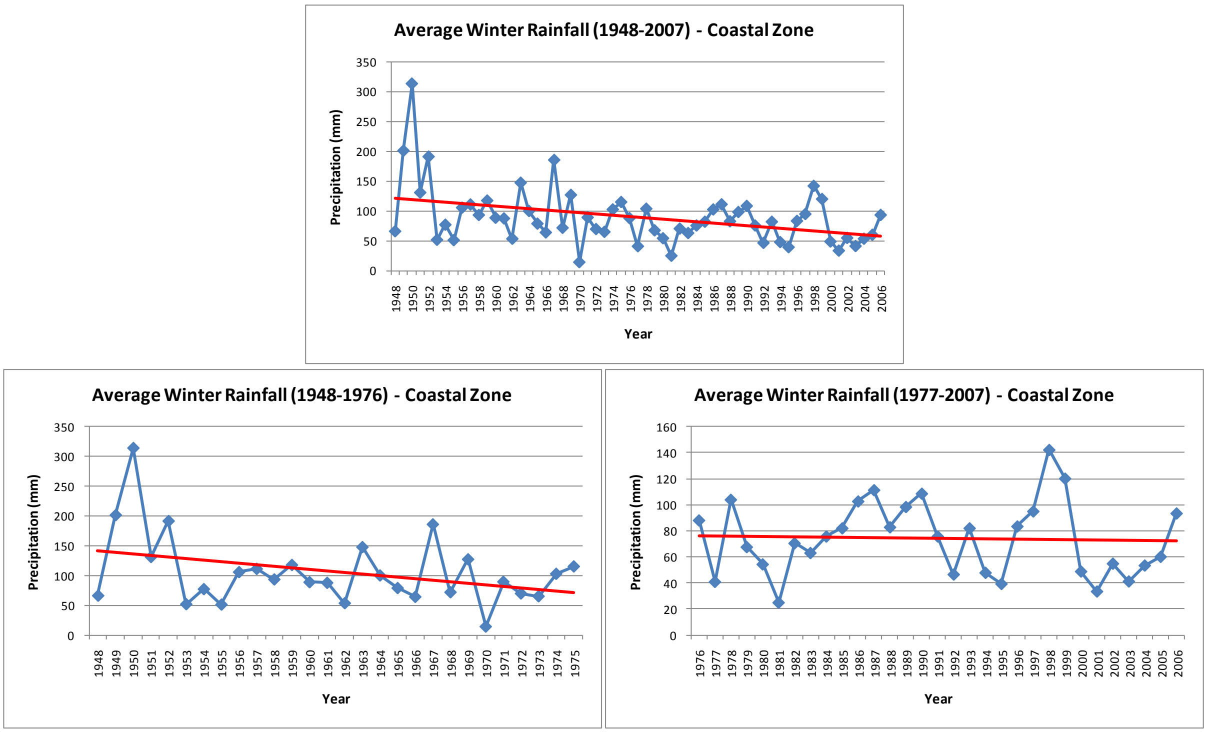


Figure 16 - Average winter rainfall for the coastal zone (1948-2007)

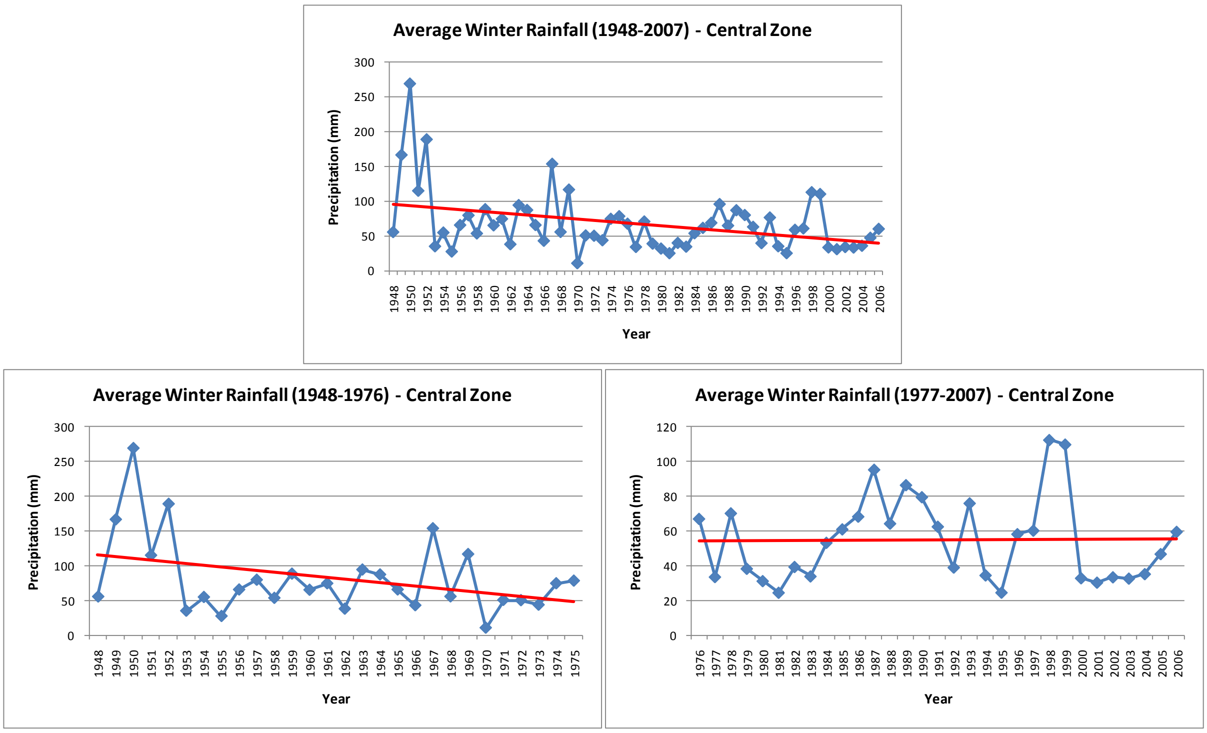


Figure 17 - Average winter rainfall for the central zone (1948-2007)

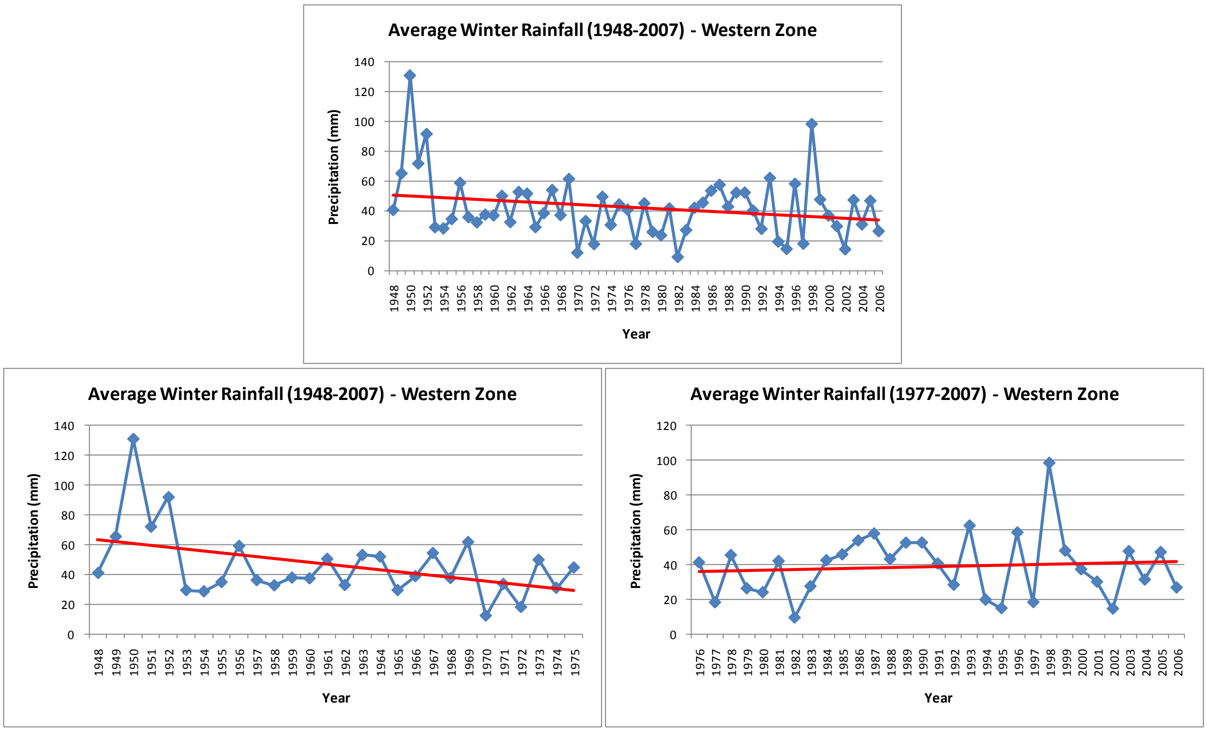


Figure 18 - Average winter rainfall for the western zone (1948-2007)

SPRING RAINFALL

Average spring rainfall for the coastal, central and western zones for the period from 1948-2007, 1948-1976 and 1977 to 2007 are shown in Figure 19. The graphs for the entire period from 1948-2007 show no significant trends for all zones. The graphs for the two IPO periods (i.e. 1948-1976 and 1977-2007) show slight to moderate increases however none of these trends are statistically significant. There is little variation in average rainfall between the two IPO periods.

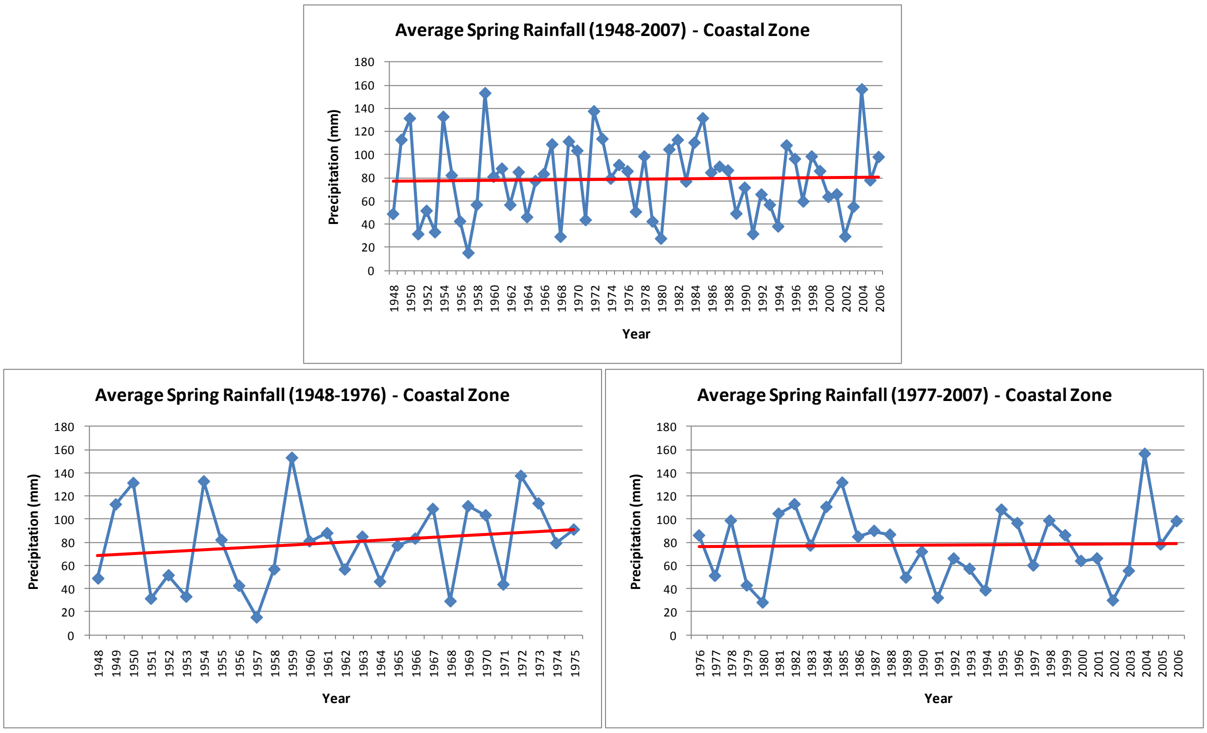


Figure 19 - Average spring rainfall for the coastal zone (1948-2007)

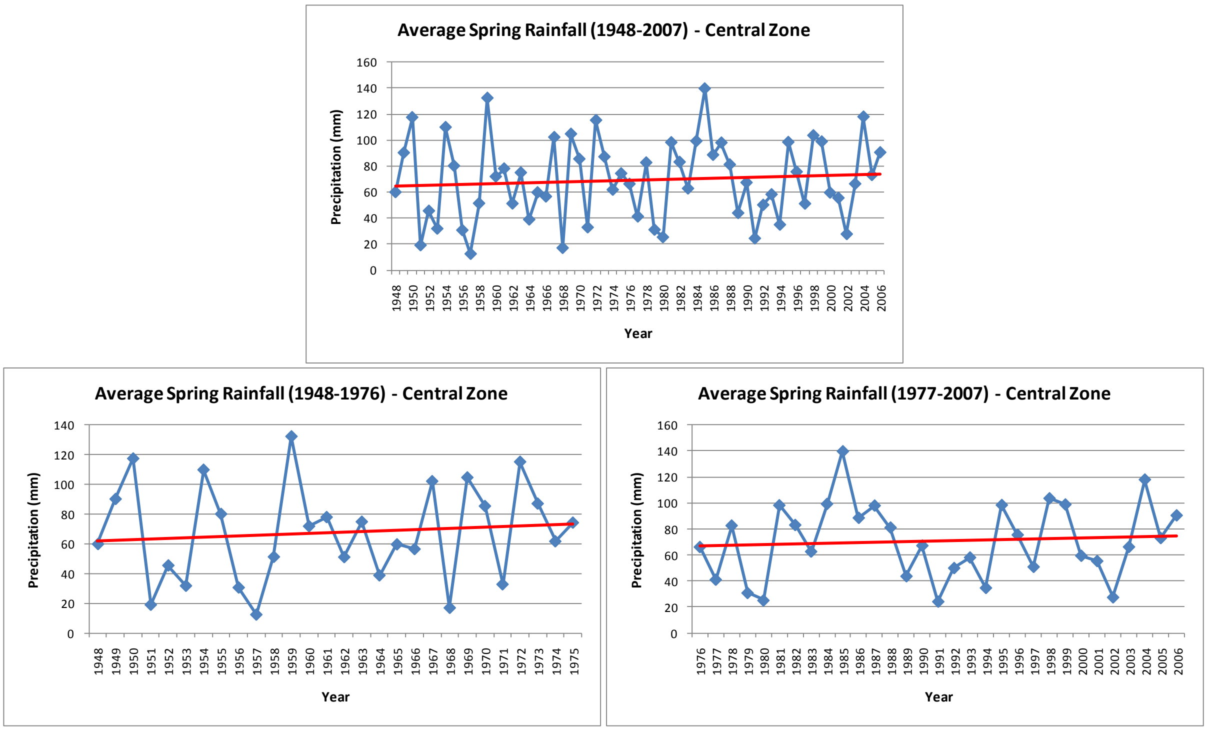


Figure 20 - Average spring rainfall for the central zone (1948-2007)

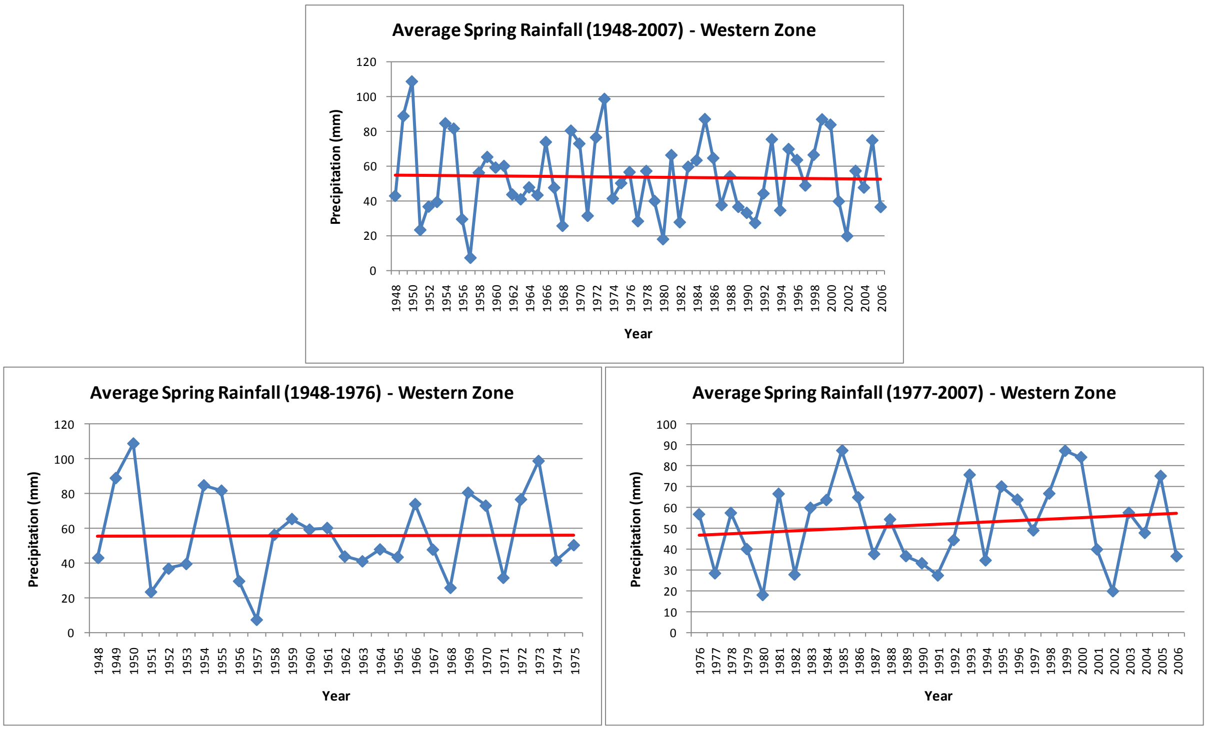


Figure 21 - Average spring rainfall for the western zone (1948-2007)

PAN EVAPORATION

Seasonal pan evaporation for the available period from 1970 to 2007 for the coastal, central and western zone is shown in Figure 22, Figure 23 and Figure 24. Trends in pan evaporation vary seasonally and also by climate region. Generally, no change in pan evaporation is evident in the coastal zone. A statistically significant annual decreasing trend of ~0.8mm/24hr has occurred over the period from 1970 to 2007 in the central zone. This annual trend is also evident in decreasing trends for all seasons. The decreases occurring during autumn and winter are statistically significant. Increasing trends in pan evaporation are evident in the western zone during summer and spring. Only the increasing trend occurring during summer is statistically significant.

Coastal Zone

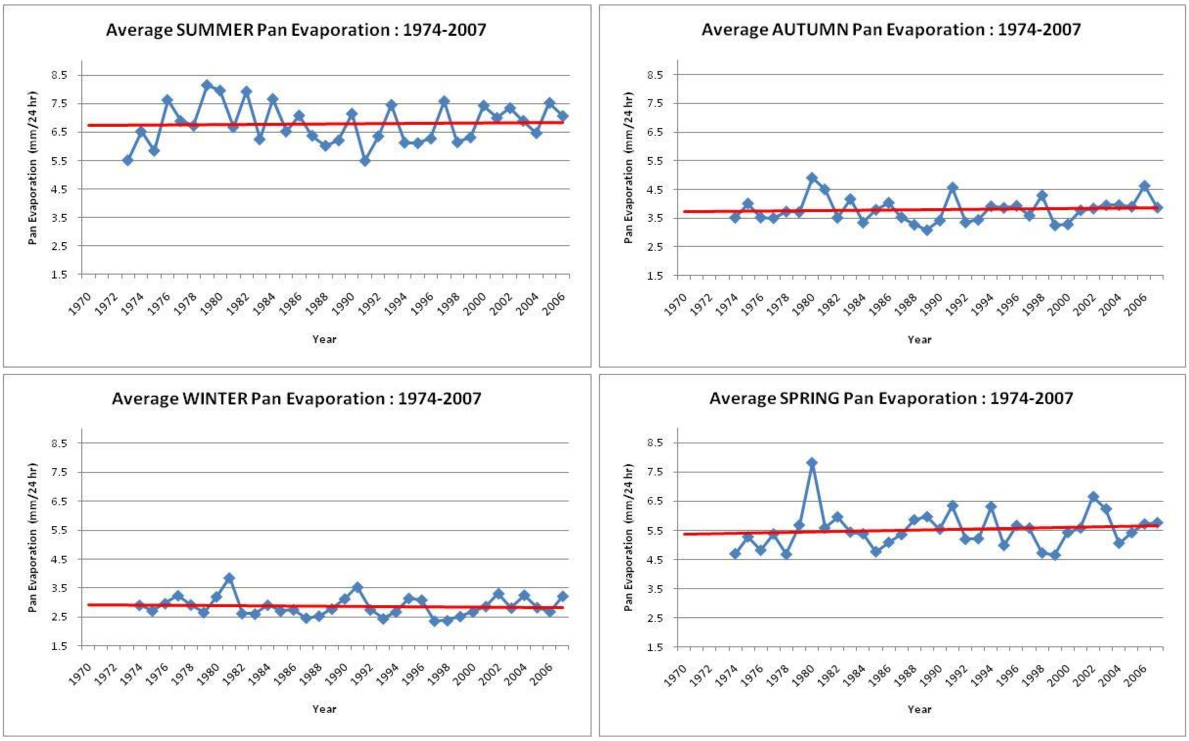


Figure 22 – Average Pan evaporation for the coastal zone (1974-2007)

Central Zone

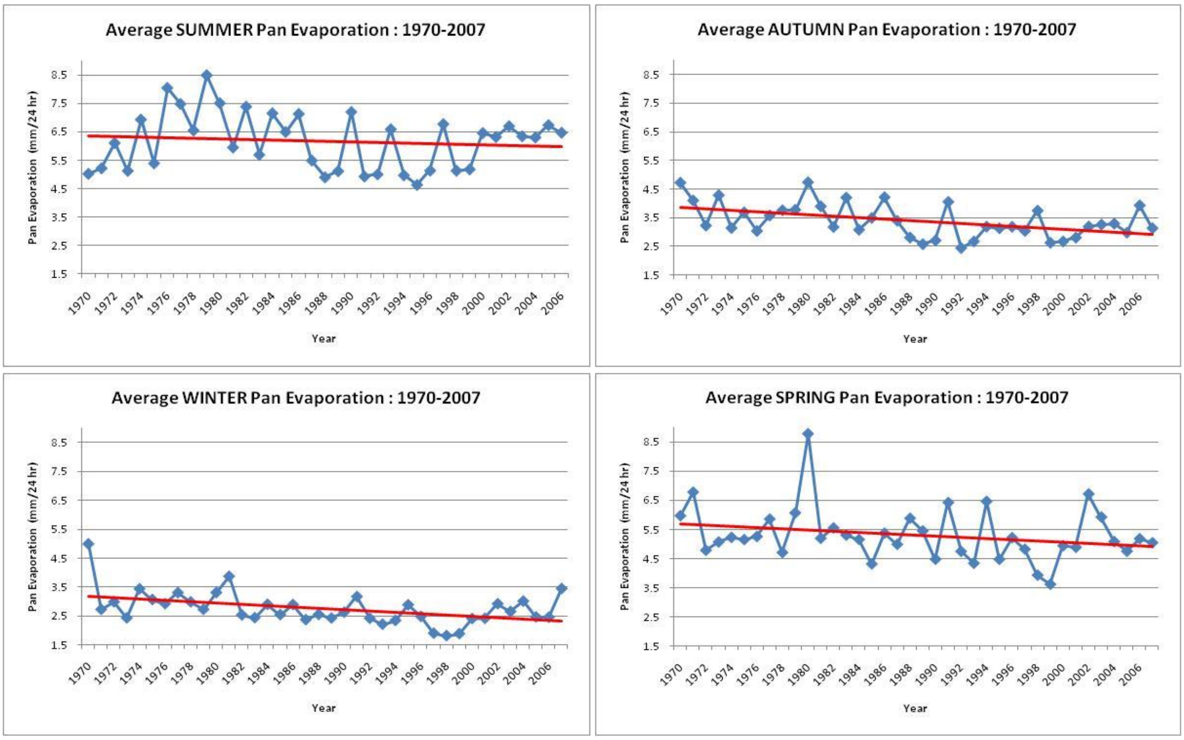


Figure 23 – Average Pan evaporation for the central zone (1970-2007)

Western Zone

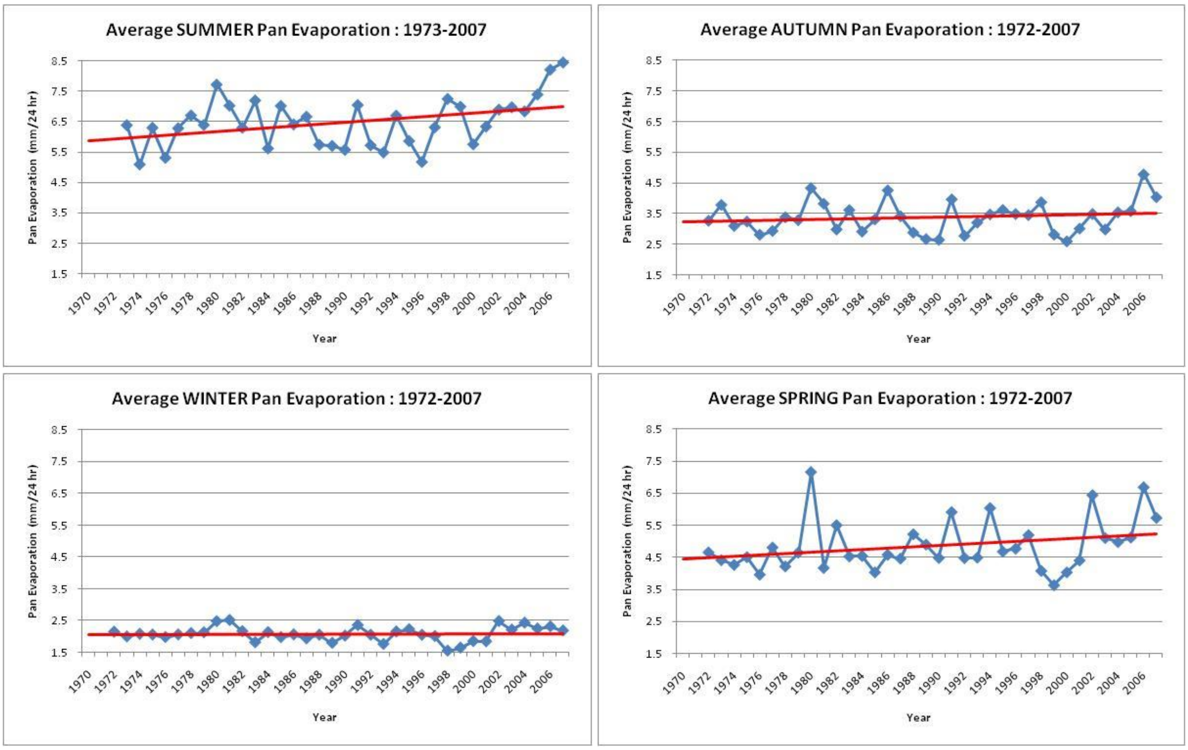


Figure 24 – Average Pan evaporation for the western zone (1973-2007)

EXTREME HEAT DAYS

Extreme heat days are analysed for individual BOM stations within each climate zone. High spatial variability in variables may result in only localised extreme events. Thus analysis on a regional level distorts results in that extreme localised events may be missed or over/under estimated. For this reason, two (2) representative stations within each climate zone are selected for the analysis of extreme heat days (Figure 25).

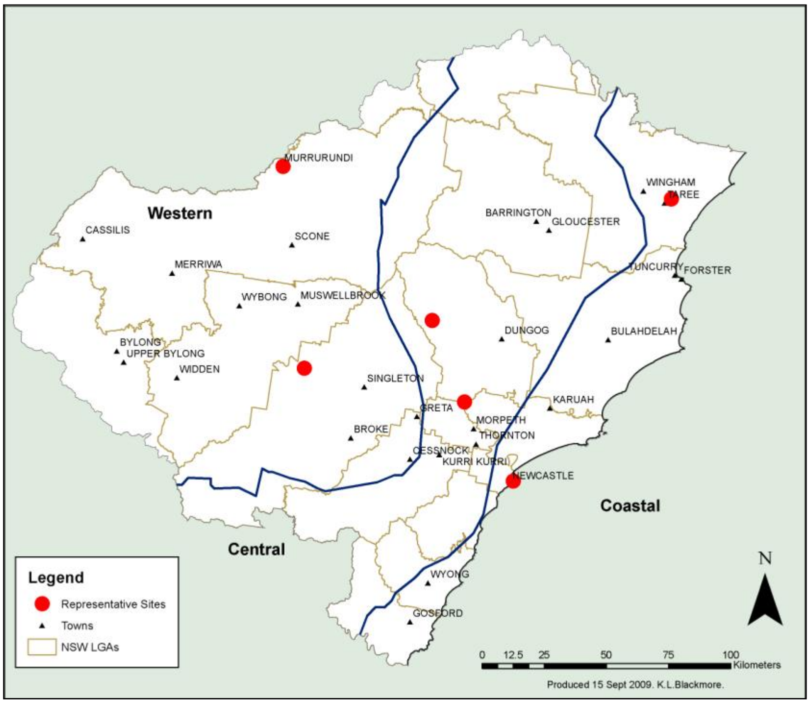


Figure 25 - Representative site within the region for the analysis of extreme heat days

EXTREME HEAT DAYS IN THE COASTAL ZONE

A slight decreasing trend (non significant) in days per year with maximum temperature greater than or equal to 37°C over the period from 1970-2007 is evident at Newcastle. An increasing linear trend is evident at Taree. This increase is statistically significant. On average, Taree records between 3 and 4 days per annum with temperatures greater than or equal to 37°C. Over the period from 1970 to 2007, an increase of approximately 3.3 days in total is evident.

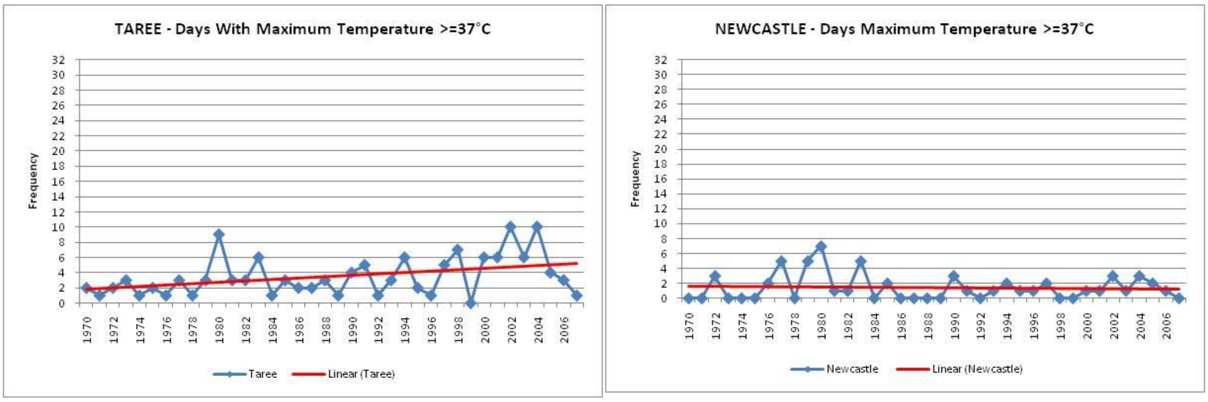


Figure 26 - Annual trend in extreme heat days at Taree and Newcastle

EXTREME HEAT DAYS IN THE CENTRAL ZONE

An increasing linear trend (non significant) in days per year with maximum temperature greater than or equal to 37^{o}C over the period from 1970-2007 is evident at Lostock Dam and Paterson. On average, Lostock Dam and Paterson record 7 to 8 and 5 to 6 days per annum with temperatures greater than or equal to 37^{o}C respectively.

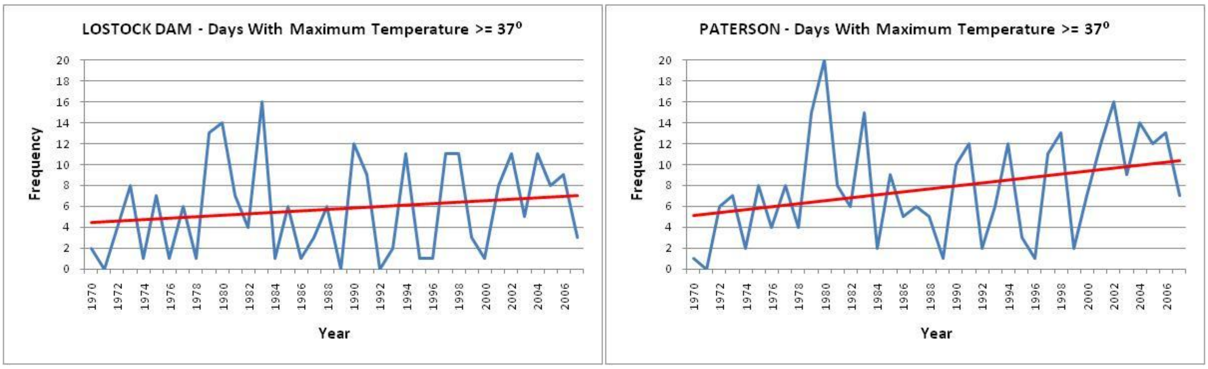


Figure 27 - Annual trend in extreme heat days at Taree and Newcastle

EXTREME HEAT DAYS IN THE WESTERN ZONE

An increasing linear trend in days per year with maximum temperature greater than or equal to 37^{o}C is evident at both Murrurundi and Jerry's Plains. The increase recorded at Murrurundi is statistically significant. On average, Murrurundi records between 2 and 3 days per annum with temperatures greater than or equal to 37^{o}C. Over the period from 1970 to 2007, an increase of approximately 2.5 days in total is evident.

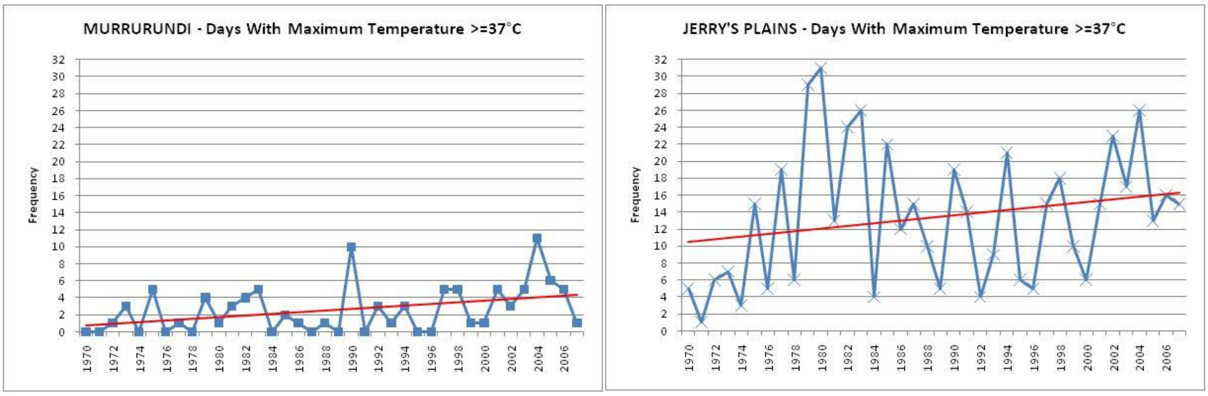


Figure 28 - Annual trend in extreme heat days at Murrurundi and Jerry's Plains

PROJECTED CHANGES IN CLIMATE

AVERAGE WIND SPEED PROJECTIONS

Annual average wind speed is not projected to change in the period to 2080, however some seasonal shifts are projected (Figure 29). Increases in average wind speed of approximately 1km/hr are projected for autumn. These increases are offset by a similiar decrease projected to occur during spring.

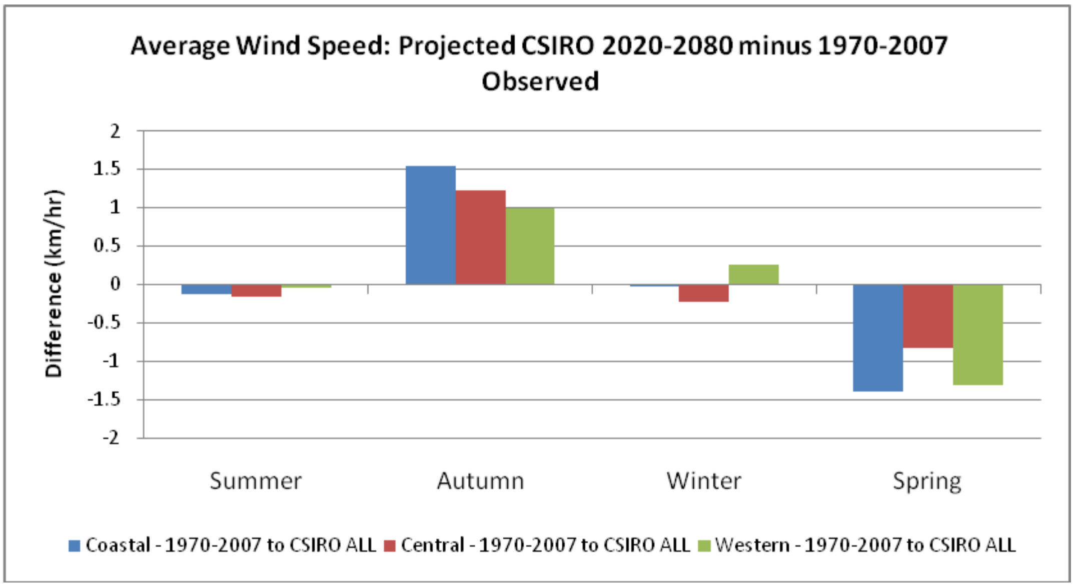


Figure 29 - Projected changes in average wind speed : CSIRO 2020-2080 minus 1970-2007 observed

WIND GUST PROJECTIONS

Projected changes in wind gusts are derived from analysing the change in frequency of each of the twelve (12) synoptic types (STs) identified that drive climate variability in the region. Projected decreases in the frequency of occurrence of STs 2 and 3 during winter should decrease the frequency of wind gusts in the region during this season. Conversely, increases in STs 11 and 12 should produce more onshore wind gusts during summer. Although the frequency may increase, there is no indication from the ST patterns that the intensity of summer wind gusts will change. These changes are summarised in Table 3.

ST	Dominant Wind Direction	Change Projected
1	North-Westerly	Increase in autumn, winter and spring
2	North-Westerly	Increase in autumn and spring, decrease in winter
3	North-Westerly	Decrease in winter, increase in spring
4	North-Westerly, Southerly	Increase in autumn

5	North-Westerly, Southerly	Decrease in autumn and spring
6	North-Westerly, Southerly	Decrease in autumn and spring
7	Southerly, North-Westerly	Increase in autumn
8	Southerly, North-Westerly	Decrease in summer, increase in spring
9	Southerly, North-Westerly	Decrease in summer and spring
10	Southerly, South-Easterly	Increase in summer, decrease in autumn
11	Southerly, South-Easterly, Easterly	Increase in summer and autumn
12	Southerly, North-Easterly, South-Easterly	Increase in summer and autumn

Table 3 - Summary of projected wind gust changes for each synoptic type

MAXIMUM TEMPERATURE PROJECTIONS

The most significant changes in average maximum temperatures are projected to occur during autumn and winter in the region (Figure 30). Projections (2020-2080) in the coastal and western zones for summer are for decreases in average maximum temperature of ~0.2^{o}C relative to the 1970-2007 period. No change for summer is projected in the central zone. Increases in all three zones are projected for autumn; ~1.2^{o}C in the coastal zone, ~1.8^{o}C in the central zone and ~2.0^{o}C in the western zone. Winter projections are for warmer average maximum temperatures, ~1.3^{o}C in the coastal zone, ~1.6^{o}C in the central zone and ~1.8^{o}C in the western zone. The study region is likely to experience lower spring average maximum temperatures with a decrease of ~0.7^{o}C projected for the coastal zone, and ~1.3^{o}C in the central and western zones.

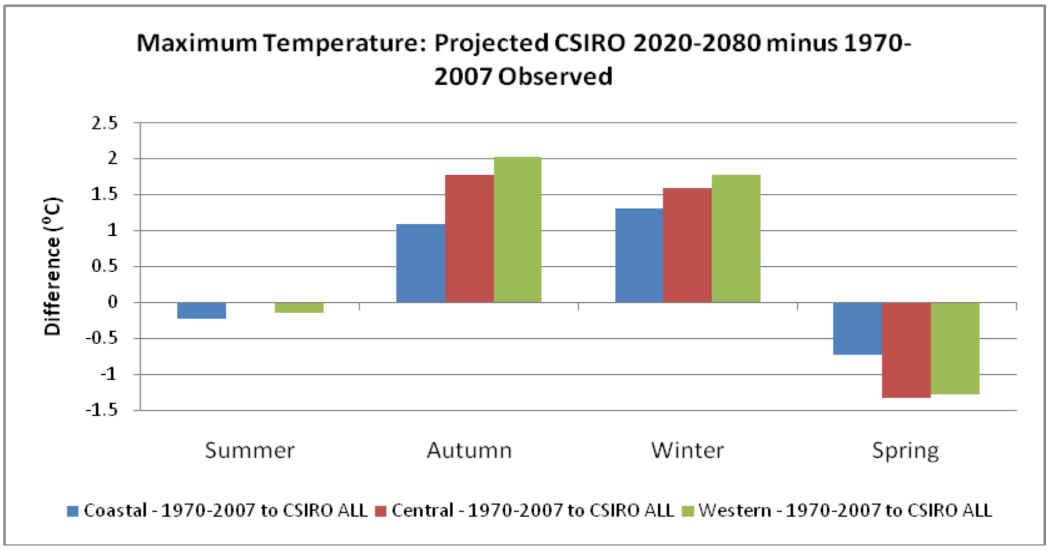


Figure 30 - Projected changes in maximum temperature : projected CSIRO 2020-2080 minus 1970-2007 observed

RELATIVE HUMIDITY PROJECTIONS

Humidity is projected to remain relatively unchanged during summer with only a 0.4% increase projected in 9am humidity and a 0.2% decrease in 3pm (Figure 31). Lower humidity levels are projected for autumn and winter. Autumn 9am levels are projected to decrease by 3.4% and 3pm by 2.2%. Similarly, winter 9am humidity is projected to decrease by 2.2% and 3pm by 0.6%. The greatest shift is projected to occur in spring 9am humidity, with an increase of 6.3% anticipated. A 2.2% increase in 3pm humidity is also projected for spring.

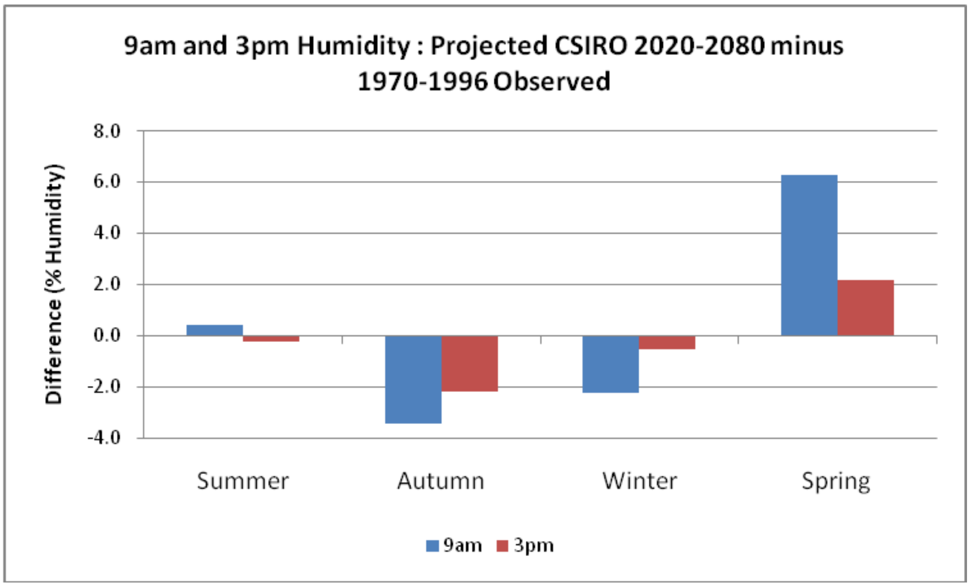


Figure 31 - Projected changes in relative humidity : CSIRO 2002-2080 minus 1970-1996 observed

RAINFALL PROJECTIONS

SUMMER RAINFALL PROJECTIONS

Projected summer precipitation for the period from 2020-2080 shows little or no variability however an interesting pattern is evident. The histograms presented in Figure 32 show average summer precipitation for the following time periods: 1948-1976, 1977-2007, 2020-2040, 2040-2060, and 2060-2080. Average summer rainfall for the projected time period (2020-2080) does not vary within this period, however, projections clearly see a return to average summer precipitation patterns similar to those experienced during the 1948-1976 time period. This period relates to a –ve phase (La Nina-like) of the Interdecadal Pacific Oscillation (IPO). Historic records indicate that summer and winter precipitation in the region was higher during this time period than that recorded during the following +ve phase (i.e. El Nino-like for 1977-2007). Summer estimates are for precipitation ~5% (3-7mm) less than that recorded for the 1948-1976 historic period but higher (~22%) than those experienced during the 30 year period from 1977-2007. The projected changes relative to these historical periods are summarised in Table 4.

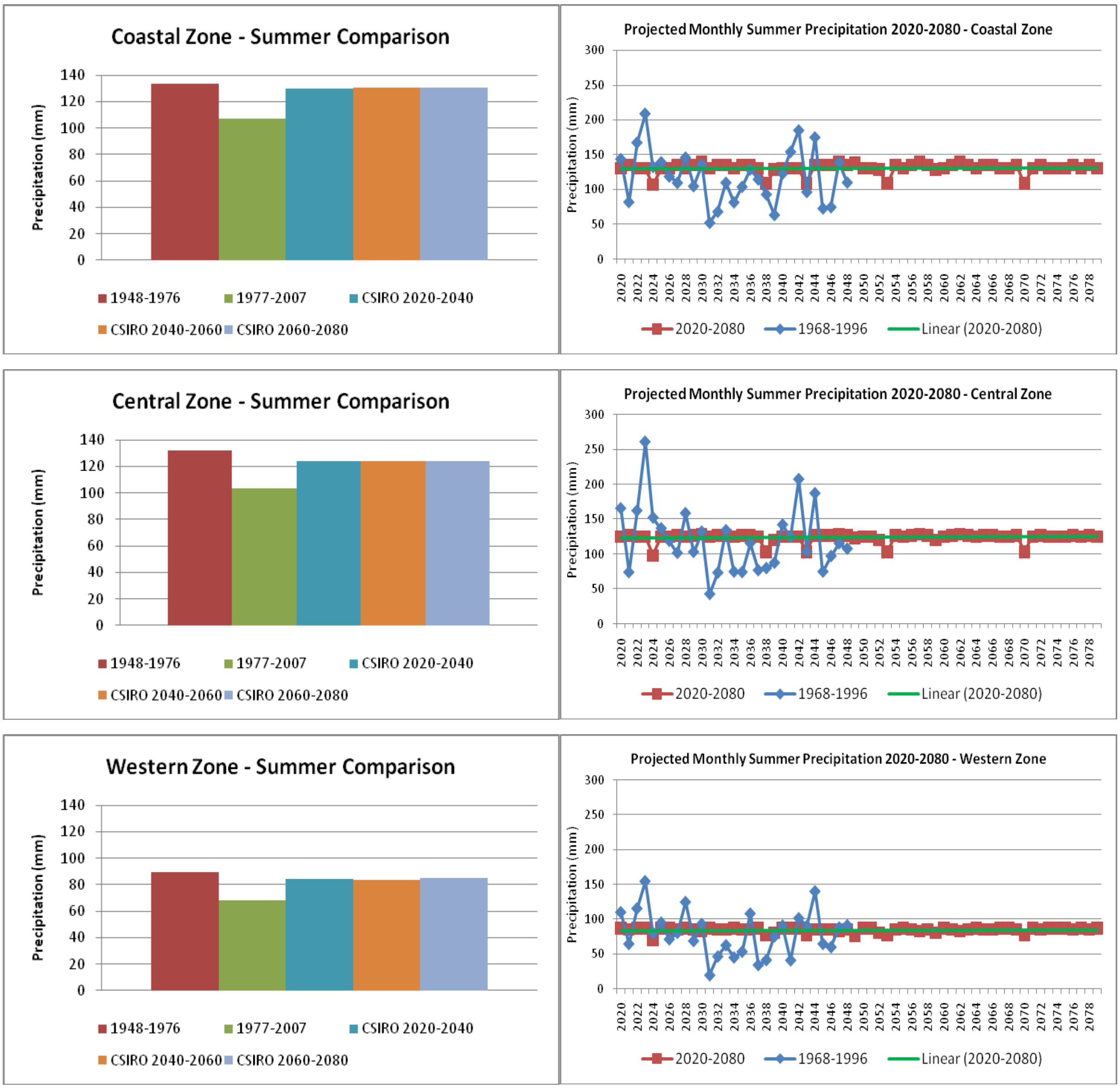


Figure 32 - Projected changes in summer precipitation

Season	Zone	Observed 1948-1976	Projected Change (2020-2080) Relative to 1948-1976 (mm)	Projected Change (2020-2080) Relative to 1948-1976 (%)	Observed 1977-2007	Projected Change (2020-2080) Relative to 1977-2007 (mm)	Projected Change (2020-2080) Relative to 1977-2007 (%)
Summer	Coastal (1)	134	-3	-2%	107	24	22%
	Central (2)	132	-7	-6%	103	21	20%
	Western (3)	89	-4	-5%	68	17	25%

Table 4 - Summary of projected changes in summer rainfall by zone

AUTUMN RAINFALL PROJECTIONS

Projected autumn precipitation for the period from 2020-2080 shows little or no variability over the 2020-2060 time period and a slight increase in the 2060-2080 period. Projections for the coastal zone show a slight decrease in rainfall relative to both the historical IPO periods whereas projections for the central zone show a return to rainfall levels similar to those recorded during 1948-1977. This represents a slight decrease on historical autumn rainfall for the 1977-2007 period. Projections for the western zone show an increase on rainfall relative to the 1948-2007 period. The projected changes relative to the historical periods are summarised in Table 5.

Figure 33 - Projected changes in autumn precipitation

Season	Zone	Observed 1948-1976 (mm)	Projected Change (2020-2080) Relative to 1948-1976 (mm)	Projected Change (2020-2080) Relative to 1948-1976 (%)	Observed 1977-2007 (mm)	Projected Change (2020-2080) Relative to 1977-2007 (mm)	Projected Change (2020-2080) Relative to 1977-2007 (%)
Autumn	Coastal (1)	123	-12	-9%	129	-17	-14%
	Central (2)	96	-2	-2%	107	-13	-12%
	Western (3)	**46**	**15**	**33%**	50	11	22%

Bold text represents statistically significant.

Table 5 - Summary of projected changes in autumn rainfall by zone

WINTER RAINFALL PROJECTIONS

Projected winter precipitation for the period from 2020-2080 shows little or no variability over this time period. Average winter rainfall for the projected time period (2020-2080) shows a return to average winter precipitation patterns similar to those experienced during the 1948-1976 time period for all zones (Figure 34 over page). The projected changes relative to the historical periods are summarised in Table 6.

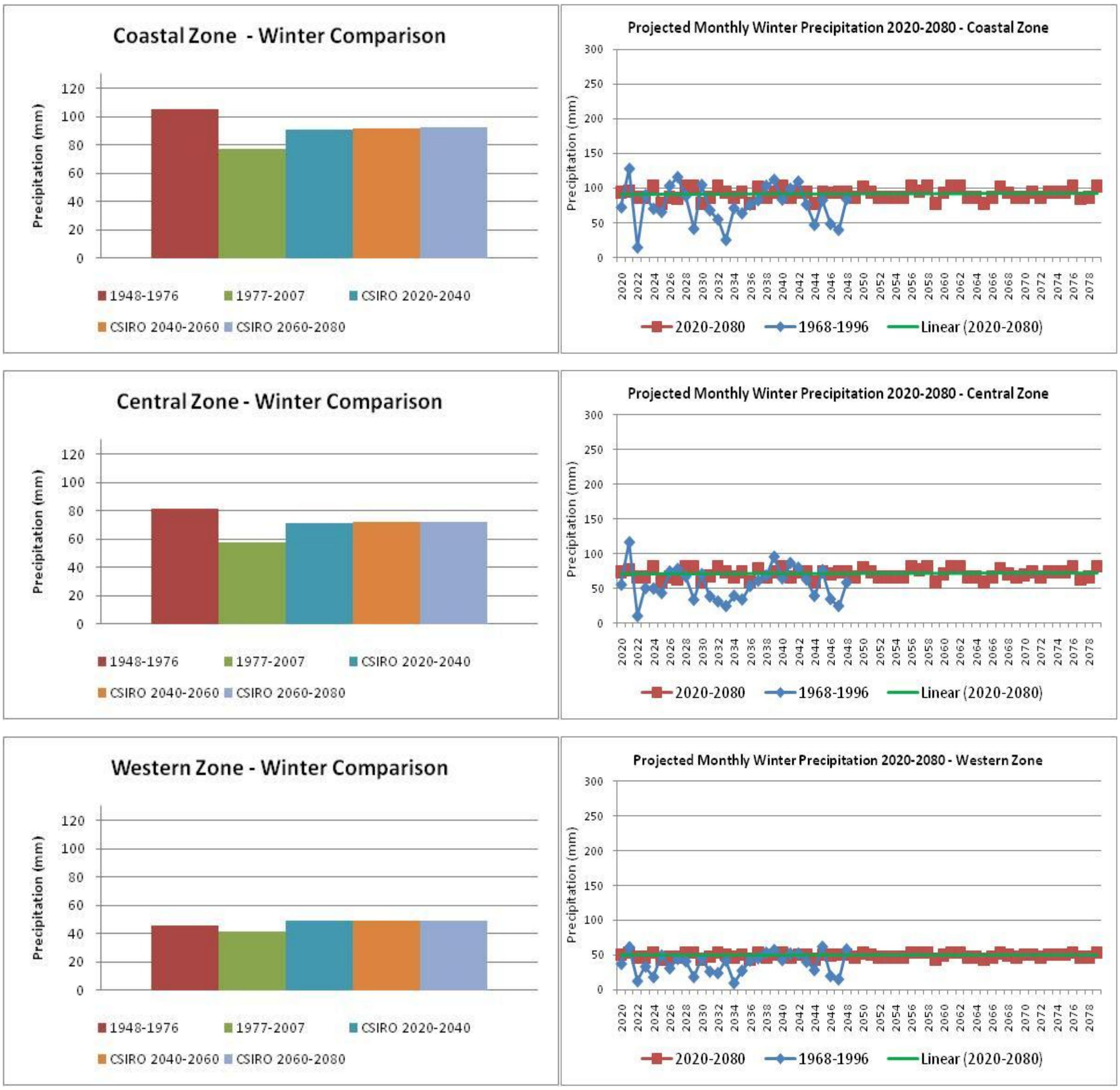


Figure 34- Projected changes in winter precipitation

Season	Zone	Observed 1948-1976 (mm)	Projected Change (2020-2080) Relative to 1948-1976 (mm)	Projected Change (2020-2080) Relative to 1948-1976 (%)	Observed 1977-2007 (mm)	Projected Change (2020-2080) Relative to 1977-2007 (mm)	Projected Change (2020-2080) Relative to 1977-2007 (%)
Winter	Coastal (1)	106	-14	-13%	77	15	19%
	Central (2)	81	-10	-12%	58	14	24%
	Western (3)	**46**	**3**	**7%**	41	8	20%

Bold text represents statistically significant.

Table 6 - Summary of projected changes in winter rainfall by zone

SPRING RAINFALL PROJECTIONS

Projected spring precipitation for the period from 2020-2080 shows some variability over the 2020-2080 period with a decrease occurring during 2040-2060 (relative to 2020-2040) followed by an increase during 2060-2080. Projections for the coastal zone show a slight increase in rainfall relative to both the historical IPO periods. Slight increases are also evident in the central zone. Projections for the western zone show little change to the actual rainfall received during the 1948-2007 period. The projected changes relative to the historical periods are summarised in Figure 23 and Table 7.

Figure 35- Projected changes in spring precipitation

Season	Zone	Observed 1948-1976 (mm)	Projected Change (2020-2080) Relative to 1948-1976 (mm)	Projected Change (2020-2080) Relative to 1948-1976 (%)	Observed 1977-2007 (mm)	Projected Change (2020-2080) Relative to 1977-2007 (mm)	Projected Change (2020-2080) Relative to 1977-2007 (%)
Spring	Coastal (1)	80	12	15%	78	14	18%
	Central (2)	67	7	11%	71	4	5%
	Western (3)	**56**	**-3**	**-5%**	52	1	2%

Bold text represents statistically significant.

Table 7 - Summary of projected changes in spring rainfall by zone

PAN EVAPORATION PROJECTIONS

The seasonal increases and decreases in pan evaporation (for the entire 2020 to 2080 projected period), relative to the 1970-2007 observations, are shown in Figure 36 and summarised in Table 8. Projections for summer show a decrease in pan evaporation on the 1970-2007 seasonal average in all climatic zones in the region. Similar results are shown for spring, with a decrease in pan evaporation also projected, albeit larger. Increases in pan evaporation are projected for autumn and winter. Seasonal shifts appear to balance out to produce no projected change in annual pan evaporation.

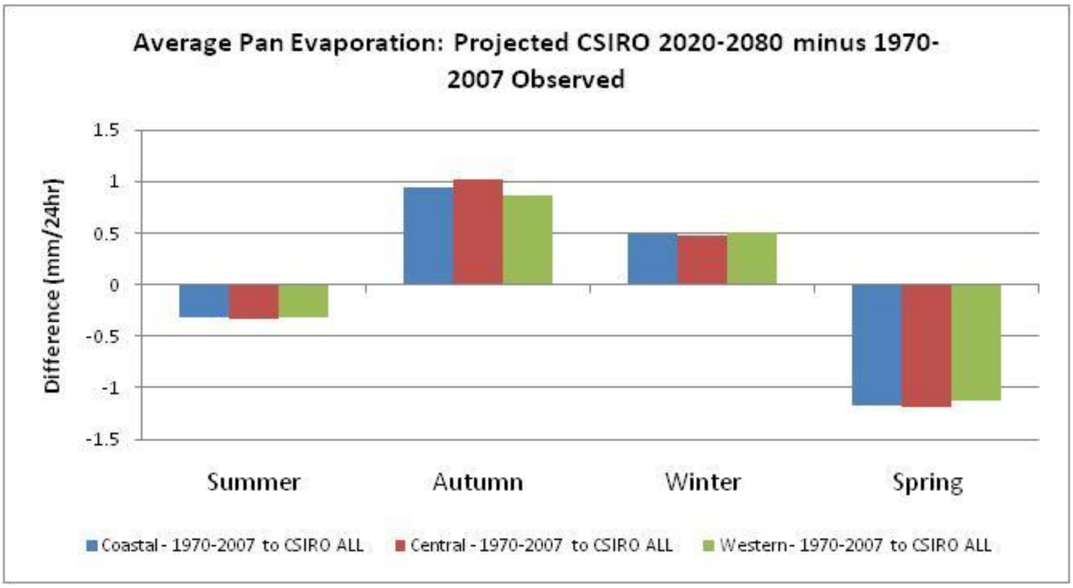


Figure 36 - Projected changes in pan evaporation : projected CSIRO 2020-2080 minus 1970-2007 observed

Season	Zone	Observed 1970-2007 (mm/24hr)	Projected Change (2020-2080) Relative to 1970-2007 (mm/24hr)	Projected Change (2020-2080) Relative to 1970-2007 (%^)
Summer	Coastal (1)	6.8	-0.3	-4.8%
	Central (2)	6.2	-0.3	-5.4%
	Western (3)	6.5	-0.3	-4.8%
Autumn	Coastal (1)	3.8	0.9	24.8%
	Central (2)	3.4	1.0	30.1%
	Western (3)	3.4	0.9	25.9%
Winter	Coastal (1)	2.9	0.5	17.3%
	Central (2)	2.8	0.5	17.3%
	Western (3)	2.1	0.5	24.7%
Spring	Coastal (1)	5.5	-1.2	-21.1%
	Central (2)	5.3	-1.2	-22.4%
	Western (3)	4.9	-1.1	-23.2%

Table 8 - Summary of projected seasonal changes in pan evaporation by zone

EXTREME HEAT DAY PROJECTIONS

A clear relationship between ST12 and extreme heat days (EHDs) exists for the BOM stations analysed for extreme events (Figure 37 over page). This relationship is strongest in the western and central parts of the region where ~62% of all EHDs (daily temperature greater than or equal to 37°C) occur when ST12 is the dominant monthly type.

Projected increases in this ST during summer and autumn are likely to result in increased frequency of EHDs (approximately 2.5%) across the region during the period 2020-2080 (relative to 1970-2007). This includes a projected increase of 4.8% between 2020-2040, a 3.6% decrease between 2040-2060 and a 6.4% increase between 2060-2080.

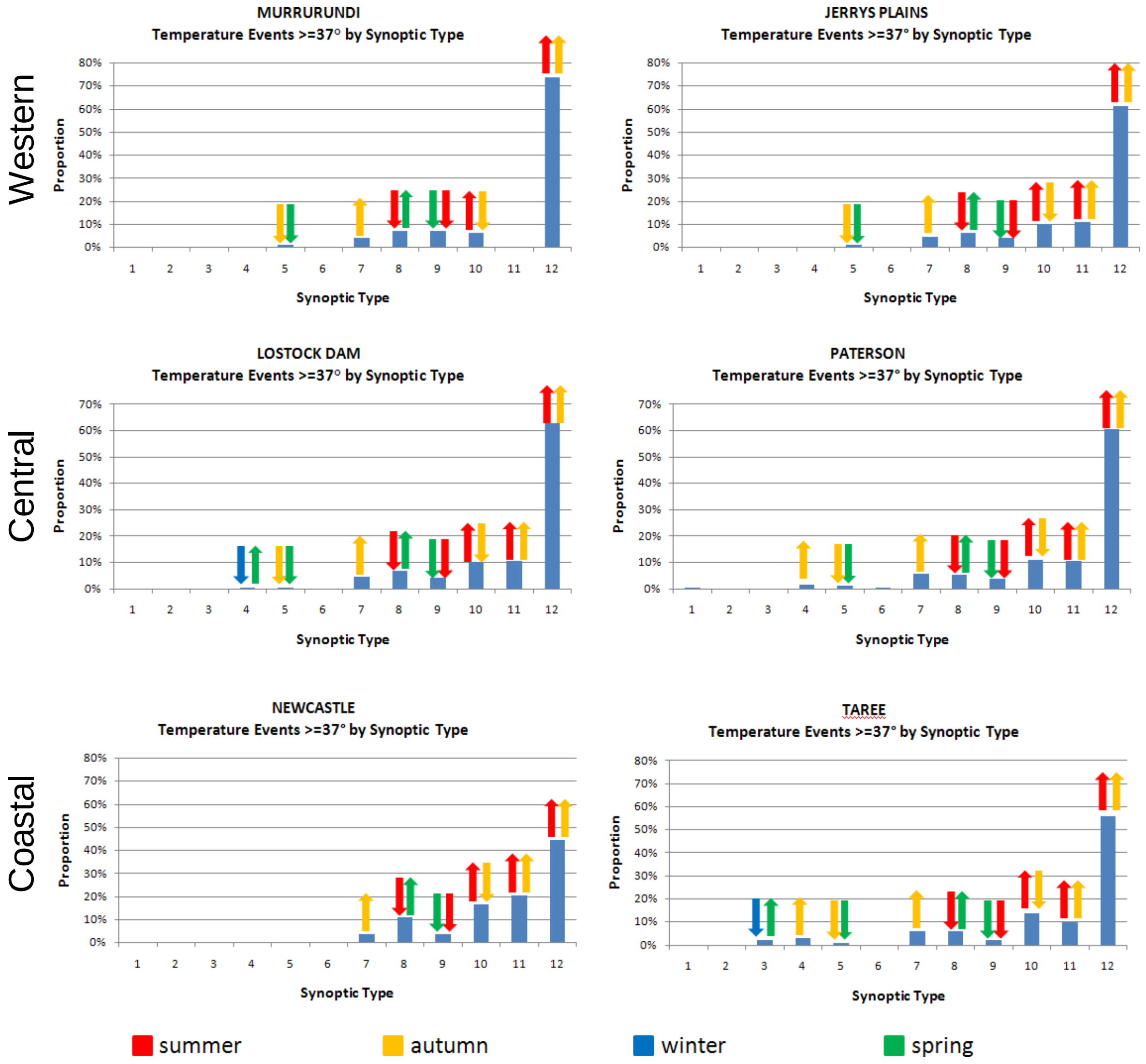


Figure 37 - Extreme heat day projections

IMPACTS OF PROJECTED CHANGES IN CLIMATE ON BUSHFIRE RISK IN THE REGION

Changes in key climate variables that drive and inform fire weather, are projected for the period from 2020-2080 AD, and are summarised in Table 9 below. Based on estimates for the projected period, the most significant changes to bushfire related climate variables in the region are projected to occur during autumn. Increases in average wind speed, extreme heat days and maximum temperatures in this season, combined with projected decreases in relative humidity are likely to result in increases in the number of days classified using fire danger indices as high or extreme. No changes in these variables are projected for summer, and summer rainfall is projected to return to a similar pattern to that experienced during the period from 1948-1976 (i.e. higher rainfall than that experienced in the last 30 years (1977-2007)). These higher rainfall conditions are likely to result in higher fuel moisture content levels.

Climate Variable	Change
Average wind speed	Increases in average wind speed of approximately 1km/hr are projected for autumn. These increases are offset by a similiar decrease projected to occur during spring
Maximum temperature	Decrease during summer and spring and increases during winter and autumn
Relative humidity	Decreases during autumn and winter. Increase during spring.
Precipitation	No trend however a return to precipitation patterns experienced during the 1948-1976 period is projected (i.e. higher rainfall than that experienced in the last 30 years)
Pan Evaporation	Decreases during summer and spring are offset by increases during autumn and winter
Extreme Heat Days	Increases during summer and autumn

Table 9 - Summary of projected climate changes

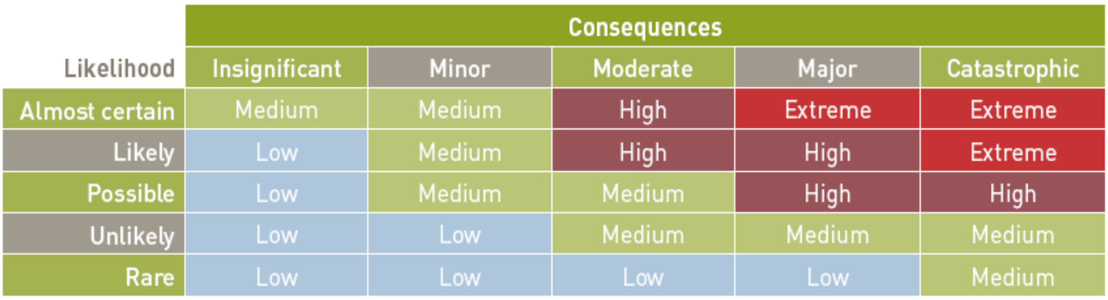
These projected impacts for the Hunter, Central and Lower North coast provide an additional perspective to that published in the recent CSIRO reports on climate change impacts on bush fire cited in the introduction section of this case study. Two key differences in the analysis approaches result in some variations in results. Firstly, temperature projections used in the CSIRO analysis are based on the annual global mean warming and are uniformly applied to all months (Hennessey, et al. 2005 pg.16) whereas the approach adopted in this case study relies on projected seasonal differences.

Secondly, this case study has focussed explicitly on the Hunter, Central and Lower North Coast region of NSW whereas the CSIRO research considers the entire south-east region of Australia. As such, the weather data (i.e. actual temperature, wind, rainfall and humidity records from the BOM) used to downscale output from the GCM to the region differs and this may account for some variability in results. Despite this, projected autumn increases in key climate variables is in agreement with the CSIRO position that fire danger in autumn is likely to increase, pushing suitable times for prescribed burning into winter.

RISK ASSESSMENT PROCESS AND OUTCOMES

In addition to providing an analysis of historic and projected climate change as it relates to bushfire risk in the Hunter, Central and Lower North Coast region of NSW, this Case Study also aims to demonstrate the applicability of this climate data to risk assessment and adaptation planning processes. For this purpose, a broad scale risk assessment process has been completed collaboratively by a working group comprising representatives of the NSW Rural Fire Service, NSW Department of Environment, Climate Change & Water, Gosford City Council, local government and HCCREMS staff.

The Risk Assessment Framework used as the basis for this process is shown in the following figure. This has been sourced from `*Climate Change Impacts and Risk Management: A Guide for Business & Government, Commonwealth of Australia 2006*'. A summary of the outcomes of the risk assessment process are included in Table 10 on the following page. The complete risk analysis matrix identifying all of the climate data that informed the risk assessment process, the potential risks identified and their rating, and the potential adaptation strategies for managing these are also included in Attachment 1. The identified risk rating has been determined directly from the likelihood and consequences scales agreed to for each risk by the working group. Guidelines for the determination of liklihood and consequence scales are included in Appendix 2.



	Consequences				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

Figure 38 - Table 10 - Risk Assessment Matrix (source: Commonwealth of Australia 2006. Climate Change Impacts and Risk Management: A Guide for Business & Government).

NB. In determining the Consequence Rating, it has been assumed that no current management practices are in place.

The interpretation of the risk priority levels is usually as follows:

- Extreme risks demand urgent attention at the most senior level and cannot be simply accepted as a part of routine operations without executive sanction.
- **High** risks are the most severe that can be accepted as a part of routine operations without executive sanction but they will be the responsibility of the most senior operational management and reported upon at the executive level.
- **Medium** risks can be expected to form part of routine operations but they will be explicitly assigned to relevant managers for action, maintained under review and reported upon at senior management level.
- Low risks will be maintained under review but it is expected that existing controls will be sufficient and no further action will be required to treat them unless they become more severe.

Table 10 - Summary of Outcomes – Risk Assessment Process

Nature of Risk	Risk Rating	Potential Adaptation Responses
Wildfire Behaviour / Incidence		
Increased frequency of NW wind gust during Autumn could worsen fire behavior / makes control more difficult during this season	Extreme	• Undertake scenario planning to identify assets with greatest exposure to projected changes in climatic conditions • Modify existing policy regarding length of declared fire season (ie extend the current declared fire season (October 1st to March 31st) later into autumn. • Maintain / increase resources available for firefighting during autumn due to extended period of risk • Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control over a longer season. • Review policy for construction standards for new buildings in fire prone areas (ie at interface and beyond) to ensure adequate protection from ember attack. • Examine possibilities for retrofitting existing housing stock to improve fire resistance, particularly from ember attack. • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies • Increase resources available for firefighting during summer in the western zone due to both increased probability of fire occurrence and control difficulty • Increase level of resources allocated to monitoring of fuel levels • Maintain appropriate levels of fire preparedness and firefighting resources regardless of prevailing seasonal conditions over the medium and longer term
Significant increase in FFDI during summer and autumn arising from projected increase in extreme heat days	Extreme	
Increase in on shore wind gusts during summer may result in more intense and/or frequent fires in areas of highest populations (eg tourist season along coastal areas)	Extreme	
Increases in average wind speed during autumn could potentially increase fire risk in this season	High	
Increased average maximum temperature during summer in the *western zone* could increase FFDI days.	High	
Increase in average maximum temperature during autumn could increase fire risk in this season in *all climate zones* (ie coastal, central and western)	High	
Decrease in relative humidity during autumn could potentially increase fire risk in this season in all climate zones	High	
While higher summer rainfall (particularly during wetter periods of cycle) may decrease fire incidence during that season, it may increase plant growth & subsequent fuel levels for the following season	High	
Increase in pan evaporation during autumn could potentially increase fire risk in this season in all climate zones	Medium	

TABLE 10. SUMMARY OF OUTCOMES – RISK ASSESSMENT PROCESS		
Nature of Risk	**Risk Rating**	**Potential Adaptation Responses**
Hazard Reduction & Fire Preparedness		
Increased difficulty in planning and implementing hazard reduction over medium term planning cycles (eg 3- 4 years) due to variable rainfall cycles over these time periods.	Extreme	• Maintain appropriate levels of fire preparedness and firefighting resources regardless of prevailing seasonal conditions over the medium and longer term • Ensure allocation of resources for hazard reduction, fire preparedness and fire fighting reflect medium term cycles to enable flexibility in the allocation of available funding & resources for these activities relevant to the period of the rainfall cycle. • Increase / reallocate planning, communication and funding for hazard reduction and general fire preparation to enable such activities to be completed over shorter available time periods. This could include shifting resources across regions and seasonal crews who could conduct preparation works during optimum periods. • Greater focus on mechanical / permanent fire breaks and strategic provision / location / rationalization of fire trails / containment lines because of reduced opportunity for hazard reduction burning and to avoid the environmental impacts of hazard reduction burning during spring. • Review policy for construction standards for new buildings in fire prone areas to ensure adequate preparedness for fire. • Examine possibilities for retrofitting existing housing stock to improve fire resistance • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Promote the synthesis of different programs (eg weed management, wetland management) to promote integrated fire risk assessment and management practices.
Complacency toward hazard reduction activities, fire preparedness and fire fighting capability - particularly after wet cycles	Extreme	
Increases in average wind speed during autumn could negatively impact on suitable weather conditions for prescribed burns	High	
Decreases in average wind speed during spring could positively impact on suitable weather conditions for prescribed burns	Medium	
Wetter and more variable rainfall conditions during winter may decrease opportunities for hazard reduction burning during the following spring.	Medium	

TABLE 10. SUMMARY OF OUTCOMES – RISK ASSESSMENT PROCESS		
Nature of Risk	**Risk Rating**	**Potential Adaptation Responses**
Health & Safety		
Increased OHS impacts (eg heat exhaustion, stress & fatigue) on fire fighters working in extreme heat conditions	Extreme	• Maintain / increase resources available for fire fighting during summer and autumn to manage additional stress on firefighters. • Implement shorter shifts for firefighters during extreme heat conditions • Utilise technological improvements in equipment & resources to reduce stress on firefighters (eg Personal; Protective Equipment and air-conditioning in buildings, machinery and trucks • Ensure medical equipment/ first aid training delivered to firefighting and support staff includes managing and responding heat exposure / stress

CONCLUSION

This case study provides an analysis of both historic and projected changes for a range of key climate variables that are known to significantly influence wildfire behaviour and management in the Hunter, Central and Lower North Coast region of New South Wales. This analysis has identified that changes most likely to heighten the risk posed by wildfire are projected to occur during autumn. These include increases in average wind speed, extreme heat days and average maximum temperatures, combined with projected decreases in relative humidity. These changes are likely to increase the number of days classified using fire danger indices as high or extreme, and may result in an extension of the current observed bushfire season later into this season.

No significant changes in key climate variables are projected to occur during summer, other than a projected increase in onshore wind gusts. Summer rainfall is projected to return to a similar pattern to that experienced during the period from 1948-1976 (i.e. higher and more variable rainfall patterns than those experienced during the last 30 years (1977-2007)). These higher rainfall conditions may result in:

- Higher fuel moisture content levels which can decrease the severity of fire weather during summer
- Higher fuel loads as a result of increased vegetation growth
- Increased rainfall variability across years may also result in medium term (e.g. 3-4 year) wet and dry cycles

Historic records show statistically significant increases in average maximum temperature in winter and spring in all zones, with increases during summer and autumn in the western zone only. Changes projected from the output of the GCM include an overall increase in average maximum temperature. No change during summer and a decrease during spring are also projected. These projections do not indicate a continuation of the observed increase in maximum temperature during summer and spring that has been recorded in the western zone. Due to this variation between historic records and projected trends, further analysis of maximum temperature trends is recommended to determine their ongoing strength and direction.

This analysis of historic and projected climate data that is included in the case study has also underpinned a broad scale risk assessment process completed collaboratively by representatives of the NSW Rural Fire Service, NSW Department of Environment, Climate Change & Water, local government and HCCREMS staff. This process has identified and ranked the potential risks arising from changes in climate to bushfire activity and management in the region.

The highest level risks identified by this process (i.e. rated extreme) related primarily to:

- Changes in autumn and summer wind gusts worsening fire bahaviour and risk during these seasons, particularly in highly populated coastal areas;

- Increased difficulty in planning and implementing hazard reduction activities, including potential complacency to undertaking hazard reduction works due to wetter summer rainfall conditions and resuced windows of opportunity for completing hazard reduction works; and

- Increased risk to the health and safety of firefighters arising from projected increases in the number of extreme heat days in the region.

A summary of all of the risks that were identified, their risk rating and the nature of potential adaptation strategies identified are included in Table 10 of this case study. The full risk assessment matrix is also included in Appendix 1.

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APPENDIX 1 – RISK ASSESSMENT MATRIX

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
Average Wind Speed						
Historic trend • Coastal Zone - historic increase in average wind speed during summer and autumn and decreases during winter and spring (NB changes not statistically significant). • Central zone – statistically significant decreases in average wind speed during all seasons • Western zone - decreases in average wind speed during all seasons. Statistically significant decrease during autumn of 2.7km/hr Projected change • No change in average annual wind speed (all climate zones) • Seasonal shifts include: – Increases in average wind speed of ~1km/hr during autumn (all climate zones)	Increases in average wind speed during autumn could potentially increase fire risk in this season	Possible	Major	High	• Extension of bushfire season into Autumn (ie a longer fire danger period than currently exists) • Increased difficulty in fire control during Autumn due to higher average wind speeds • Reduced ability to conduct hazard reduction burns during autumn due to less favourable wind conditions. • Increased potential for ember attack beyond bushland / property interface during autumn due to higher average wind speeds.	• Modify existing policy regarding length of declared fire season (ie extend the current declared fire season (October 1st to March 31st) later into autumn. • Maintain / increase resources available for firefighting during autumn due to extended period of risk • Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control over a longer season. • Review policy for construction standards for new buildings in fire prone areas (ie at interface and beyond) to ensure adequate protection from ember attack. • Examine possibilities for retrofitting existing housing stock to improve fire resistance, particularly from ember attack. • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
– Decreased average wind speed during spring of ~1% (all climate zones)	Decreases in average wind speed during spring could positively impact on suitable weather conditions for prescribed burns	Possible	Minor	Medium	Less windy conditions may result in more days with suitable conditions for prescribed burning during spring (i.e. increased number of burns, hectares burnt and properties protected). However, burning during spring has the potential for greater environmental impact on the reproductive lifecycle stages of flora and fauna species.	• Increase / reallocate planning, communication and funding for hazard reduction and general fire preparation to enable increased levels of these activities to occur during spring. This could include shifting resources across regions and seasonal crews who could conduct preparation works during optimum periods. • Greater focus on mechanical / permanent fire breaks and strategic provision / location / rationalization of fire trails / containment lines to avoid the environmental impacts of hazard reduction burning during spring.
	Increases in average wind speed during autumn could negatively impact on suitable weather conditions for prescribed burns	Possible	Major	High	Windier conditions may result in less days with suitable conditions for prescribed burning (i.e. decreased number of burns, hectares burnt and properties protected)	• Increase / reallocate planning, communication and funding for hazard reduction and general fire preparation to enable more to be conducted over a shorter available time period. This could include shifting resources across regions and seasons to conduct preparation works during optimum periods. • Increase focus on mechanical / permanent fire breaks because of reduced opportunity for hazard reduction burning.

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
Wind Gust (NB data only available for Williamtown)						
Historic trend (1957-2007) Coastal – All seasons show an increase in average recorded wind gust. This increase is most pronounced during summer, which has recorded a statistically significant increase. Projected change • Decreased frequency of wind gusts during winter • Increased frequency of onshore wind gusts during summer. • No change projected in the intensity of summer wind gusts • Decreased frequency of north westerly wind gusts during summer, increase during autumn.	Increase in on shore wind gusts during summer may result in more intense and/or frequent fires in areas of highest populations (eg tourist season along coastal areas)	Almost Certain	Major	Extreme	• Limited time to respond effectively • Higher potential for life and property damage/loss	• Undertake scenario planning to identify assets with NE exposure • Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control in areas with NE exposure. • Review policy for construction standards for new buildings (at bushland interface and beyond) in fire prone areas with NE exposure to ensure adequate protection from ember attack. • Examine possibilities for retrofitting existing building stock in areas with NE exposure to improve fire resistance, particularly from ember attacck • Explore the opportunity for developing individual property planning programs in areas with NE exposure. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies
	Increased frequency of NW wind gust during Autumn could worsen fire behavior / makes control more difficult during this season	Almost Certain	Major	Extreme	• Limited time to respond effectively • Higher potential for life and property damage/loss	• Undertake scenario planning to identify assets with NW exposure • Modify existing policy regarding length of declared fire season (ie extend the current declared fire season (October 1st to March 31st) later into autumn. • Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control over a longer season. • Maintain / increase resources available for firefighting during autumn due to extended period of risk • Review policy for construction standards for new buildings in fire prone areas (ie at interface and beyond) to ensure adequate protection from ember attack. • Examine possibilities for retrofitting existing building stock to improve fire resistance, particularly from ember attack

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
						• Explore the opportunity for developing individual property planning programs in areas with NW exposure. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies

Historic & Projected Climate Change	**Potential Impacts**	**Risk Assessment**			**Nature of Consequences**	**Potential Adaptation Strategies**
		Likelihood	**Consequences**	**Risk Priority**		
Average Maximum Temperature						
Historic trend (1970-2007) • Regionally, increases in max temp of between 0.5oC and 2oC have been experienced in all seasons • Statistically significant increases have occurred during winter and spring (all climate zones) • Statistically significant increases during summer and autumn are only recorded in the western climate zone. The largest increase has occurred during summer (2.02oC)	Summer Increased average maximum temperature during summer in the *western zone* could increase FFDI days.	Almost Certain	Moderate	High	• Higher probability of fire occurrence and difficulties in control in the western zone during summer • Increased difficulty in fire control due to higher temperatures in the western zone during summer	• Increase resources available for firefighting during summer in the western zone due to both increased probability of fire occurrence and control difficulty • Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control during summer in the western zone. • Review policy for construction standards for new buildings in fire prone areas • Examine possibilities for retrofitting existing building stock to improve fire resistance • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	**Consequences**	**Risk Priority**		
Projected Change • summer – decreases in the coastal and western zones of ~0.2oC. No change in central zone. • autumn – increases in all zones including coastal zone (~1.2oC), central zone (`1.8oC) & western zone (~2oC) • winter – increases in all zones including coastal zone (~1.3oC), central zone (`1.6oC) & western zone (~1.8oC) • spring – decreases in coastal zone (~0.7oC) and central & western zones of (~1.3oC)	Autumn Increase in average maximum temperature during autumn could increase fire risk in this season in *all climate zones* (ie coastal, central and western)	Almost Certain	Moderate	High	• Extension of the fire season into autumn • Higher probability of fire occurrence and difficulties in control • Increased difficulty in fire control due to higher temperatures	• Modify existing policy regarding length of declared fire season (ie extend the current declared fire season (October 1st to March 31st) later into autumn. • Maintain / increase resources available for firefighting during autumn due to extended period of risk • Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control over a longer season. • Review policy for construction standards for new buildings in fire prone areas (ie at interface and beyond) to ensure adequate protection from fire. • Examine possibilities for retrofitting existing housing stock to improve fire resistance • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
Extreme Heat Events (days > 37°C)						
Historic trend • Increase of ~3 days in total recorded over the period from 1970-2007 (all climate zones) Projected change • Increases are projected to occur during summer and autumn (all climate zones) • Projected changes (relative to 1970-2007) include a ~2.5% increase overall across the region from 2020-2080. This comprises a projected 4.8% increase (2020-2040), a 3.6% decrease (2040-2060) and a 6.4% increase (2060-2080).	Significant increase in FFDI during summer and autumn arising from projected increase in extreme heat days	Almost Certain	Major	Extreme	• Higher probability of fire occurrence and difficulties in control • Increased difficulty in fire control due to higher temperatures • Increase in the number of total fire ban days leading to a range of economic and social impacts (eg tourism, construction works, etc)	• Maintain / increase resources available for fire fighting during summer and autumn to manage increased fire risk, increased difficulty in control and conditions that place additional stress on firefighters. • Modify existing policy regarding length of declared fire season (ie extend the current declared fire season (October 1st to March 31st) later into autumn. • Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control over a longer season. • Review policy for construction standards for new buildings in fire prone areas (ie at interface and beyond) to ensure adequate protection from fire. • Examine possibilities for retrofitting existing housing stock to improve fire resistance. • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies
	Increased OHS impacts (eg heat exhaustion, stress & fatigue) on fire fighters working in extreme heat conditions	Almost Certain	Catastrophic	Extreme	• Increased death and severe injuries of fire fighters • Reduction in available resources for fire fighting	• Maintain / increase resources available for fire fighting during summer and autumn to manage additional stress on firefighters. • Implement shorter shifts for firefighters during extreme heat conditions • Utilise technological improvements in equipment & resources to reduce stress on firefighters (eg Personal; Protective Equipment and air-conditioning in buildings, machinery and trucks • Ensure medical equipment/ first aid training delivered to firefighting and support staff includes managing and responding heat exposure / stress

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
Relative Humidity (Summer)						
Historic trend No statistically significant trends identified across all climate zones. Projected Change - Relatively no change during summer (all climate zones) - Lower humidity levels during autumn & winter (all climate zones) - Significant increase in spring (all climate zones)	- Decrease in relative humidity during autumn could potentially increase fire risk in this season in all climate zones	Possible	Major	High	- Extension of the fire season into autumn - Higher probability of fire occurrence and difficulties in control during autumn	- Modify existing policy regarding length of declared fire season (ie extend the current declared fire season (October 1st to March 31st) later into autumn. - Maintain / increase resources available for firefighting during autumn due to extended period of risk - Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control over a longer season. - Review policy for construction standards for new buildings in fire prone areas to ensure adequate protection from fire. - Examine possibilities for retrofitting existing housing stock to improve fire resistance - Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire - Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
Seasonal Rainfall						
Historic trend • Summer : Decrease over the period from 1948-2007 (~46mm coastal; ~43mm central; ~32mm western). (NB statistically significant in the coastal and central zones only) • Autumn : No change • Winter : Decrease over the period from 1948-2007 (~52mm coastal; ~43mm central; ~10mm western). (NB statistically significant in the coastal and central zones only) • Spring: No change Projected change • Summer: return to rainfall patterns similar to those experienced during the 1948-1976 IPO period (i.e. wetter and more variable than that experienced	Complacency toward hazard reduction activities, fire preparedness and fire fighting capability - particularly after wet cycles	Almost Certain	Catastrophic	Extreme	• Reduced hazard reduction undertaken leading to potentially worse fire conditions in following years • Potential for inadequate levels of fire preparedness and firefighting resources	• Maintain appropriate levels of fire preparedness and firefighting resources regardless of prevailing seasonal conditions over the medium and longer term
	Wetter and more variable rainfall conditions during winter may decrease opportunities for hazard reduction burning during the following spring.	Possible	Moderate	Medium	Potential for higher probability of fire occurrence and difficulties in control due to high fuel levels.	• Maintain / increase resources available for fire fighting to manage increased fire risk and difficulty in control • Enhance focus on strategic provision / location / rationalization of mechanical / permanent fire breaks, fire trails & containment lines because of reduced opportunity to undertake hazard reduction burning. • Increase / reallocate planning, communication and funding for hazard reduction and general fire preparation to enable increased levels of these activities to occur within a shorter window of opportunity. This could include shifting resources across regions and seasonal crews who could conduct preparation works during optimum periods. • Review policy for construction standards for new buildings in fire prone areas (ie at interface and beyond) to ensure adequate protection from fire. • Examine possibilities for retrofitting existing housing stock to improve fire resistance. • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
during 1977-2007) • Autumn : No change • Winter: return to rainfall patterns similar to those experienced during the 1948-1976 IPO period (i.e. wetter and more variable than that experienced during 1977-2007) • Spring : No change	Increased difficulty in planning and implementing hazard reduction over medium term planning cycles (eg 3- 4 years) due to variable rainfall cycles over these time periods.	Almost Certain	Catastrophic	Extreme	Potential for higher probability of fire occurrence and difficulties in control	• Ensure allocation of resources for hazard reduction, fire preparedness and fire fighting reflect medium term cycles to enable flexibility in the allocation of available funding & resources for these activities relevant to the period of the rainfall cycle. • Greater focus on mechanical / permanent fire breaks because of reduced opportunity for hazard reduction burning. • Enhance focus on strategic provision / location / rationalization of mechanical / permanent fire breaks, fire trails & containment lines because of reduced opportunity to undertake hazard reduction burning. • Review policy for construction standards for new buildings in fire prone areas to ensure adequate protection from fire. • Examine possibilities for retrofitting existing housing stock to improve fire resistance • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Promote the synthesis of different programs (eg weed management, wetland management) to promote integrated fire risk assessment and management practices.
	While higher summer rainfall (particularly during wetter periods of cycle) may decrease fire incidence during that season, it may increase plant growth & subsequent fuel levels for the following season	Likely	Major	High	Greater fuel loads causing larger fires during following fire seasons	• Increase level of resources allocated to monitoring of fuel levels • Maintain appropriate levels of fire preparedness and firefighting resources regardless of prevailing seasonal conditions over the medium and longer term

Historic & Projected Climate Change	Potential Impacts	Risk Assessment			Nature of Consequences	Potential Adaptation Strategies
		Likelihood	Consequences	Risk Priority		
Pan Evaporation						
Historic trend • Coastal zone – no change (seasonal or annual) • Central zone – annual decrease of ~0.8mm/24hr from 1970-2007. Decreases in all seasons (NB decreases in autumn and winter statistically significant) • Western zone – annual increase of ~0.5mm/24hr from 1973-2007. Increases during summer and spring (NB summer increase statistically significant) Projected change • No overall annual change (all climate zones) • *Coastal zone* –summer decrease (~4.8%), autumn increase (~24.8%), winter increase (~17.3%) & spring decrease (~21.1%) • *Central Zone* - summer decrease (~5.4%), autumn increase (~30.1%), winter increase (~17.3%) & spring decrease (~22.4%) • *Western zone - summer decrease (~4.8%), autumn increase (~25.9%), winter increase (~24.7%) & spring decrease (~23.2%)*	Increase in pan evaporation during autumn could potentially increase fire risk in this season in all climate zones	Possible	Moderate	Medium	• Extension of the fire season into autumn • Higher probability of fire occurrence and difficulties in control	• Modify existing policy regarding length of declared fire season (ie extend the current declared fire season (October 1st to March 31st) later into autumn. • Maintain / increase resources available for firefighting during autumn due to extended period of risk • Enhance focus on strategic provision / location / rationalization of fire trails / containment lines to enhance capacity / ability for fire control over a longer season. • Review policy for construction standards for new buildings in fire prone areas (ie at interface and beyond) to ensure adequate protection from ember attack. • Examine possibilities for retrofitting existing housing stock to improve fire resistance, particularly from ember attack. • Explore the opportunity for developing individual property planning programs. Such programs would aim to engage property owners and provide them with information to assist in preparing their properties for fire • Encourage independent power and water supplies in bushfire prone areas to improve fire fighting capacity and reduce reliance on centralized power and water supplies

APPENDIX 2 – GUIDELINES FOR ASSESSING LIKLIHOOD AND CONSEQUENCE SCALES

(source: Commonwealth of Australia 2006. Climate Change Impacts and Risk Management:
A Guide for Business & Government)

Likelihood Scales

It is necessary to describe the likelihood of a risk arising if a particular climate change scenario comes about. This is a conditional likelihood, to be assessed as if the climate change scenario was going to happen.

A five point scale can be effectively applied for likelihood ratings. The extreme ends of this scale are those risks that are almost certain to happen and those that are almost, but not quite, certain not to happen.

There is one potential source of confusion to be addressed concerning how often the same risk might occur. Some risks are most realistically thought of as events that could happen once, such as the loss of an endangered plant or animal species at the centre of a tourism business or a permanent move of population from increasingly arid land to regional centres and major cities.

Other risks make more sense when considered as recurring events such as structural damage to domestic buildings from severe storms or episodes of heat related deaths. A scale that can be used to rate the likelihood of both single and recurrent events is shown in Table 11 below.

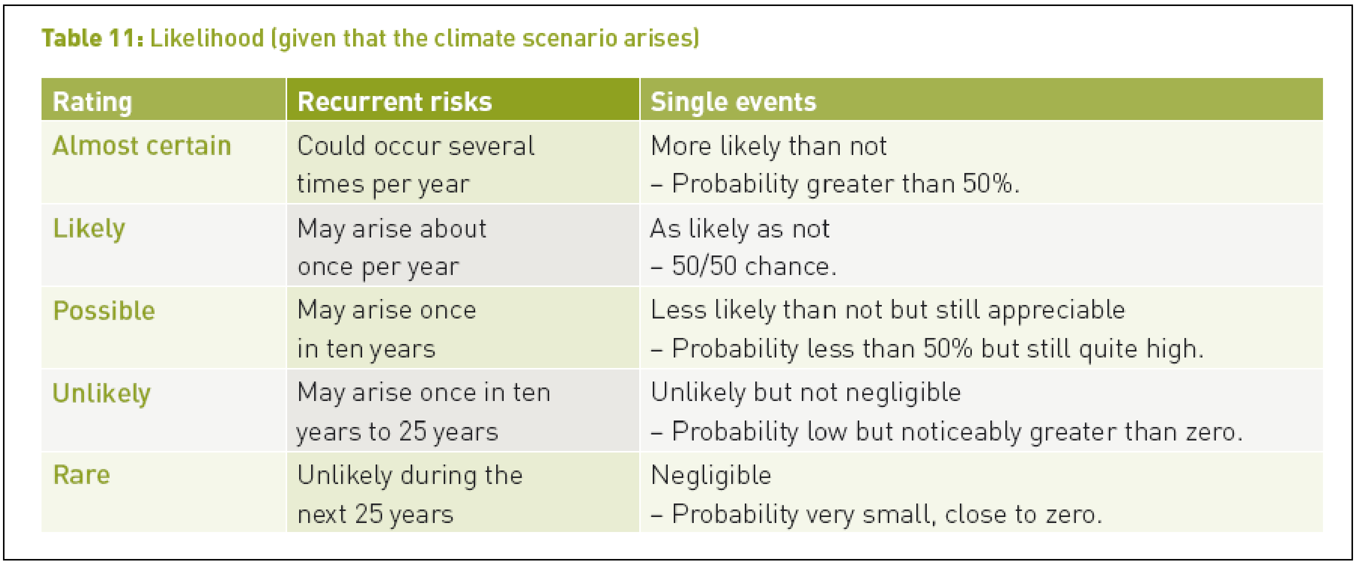


Table 11: Likelihood (given that the climate scenario arises)

Rating	Recurrent risks	Single events
Almost certain	Could occur several times per year	More likely than not – Probability greater than 50%.
Likely	May arise about once per year	As likely as not – 50/50 chance.
Possible	May arise once in ten years	Less likely than not but still appreciable – Probability less than 50% but still quite high.
Unlikely	May arise once in ten years to 25 years	Unlikely but not negligible – Probability low but noticeably greater than zero.
Rare	Unlikely during the next 25 years	Negligible – Probability very small, close to zero.

Source: Commonwealth of Australia 2006. Climate Change Impacts and Risk Management: A Guide for Business & Government.

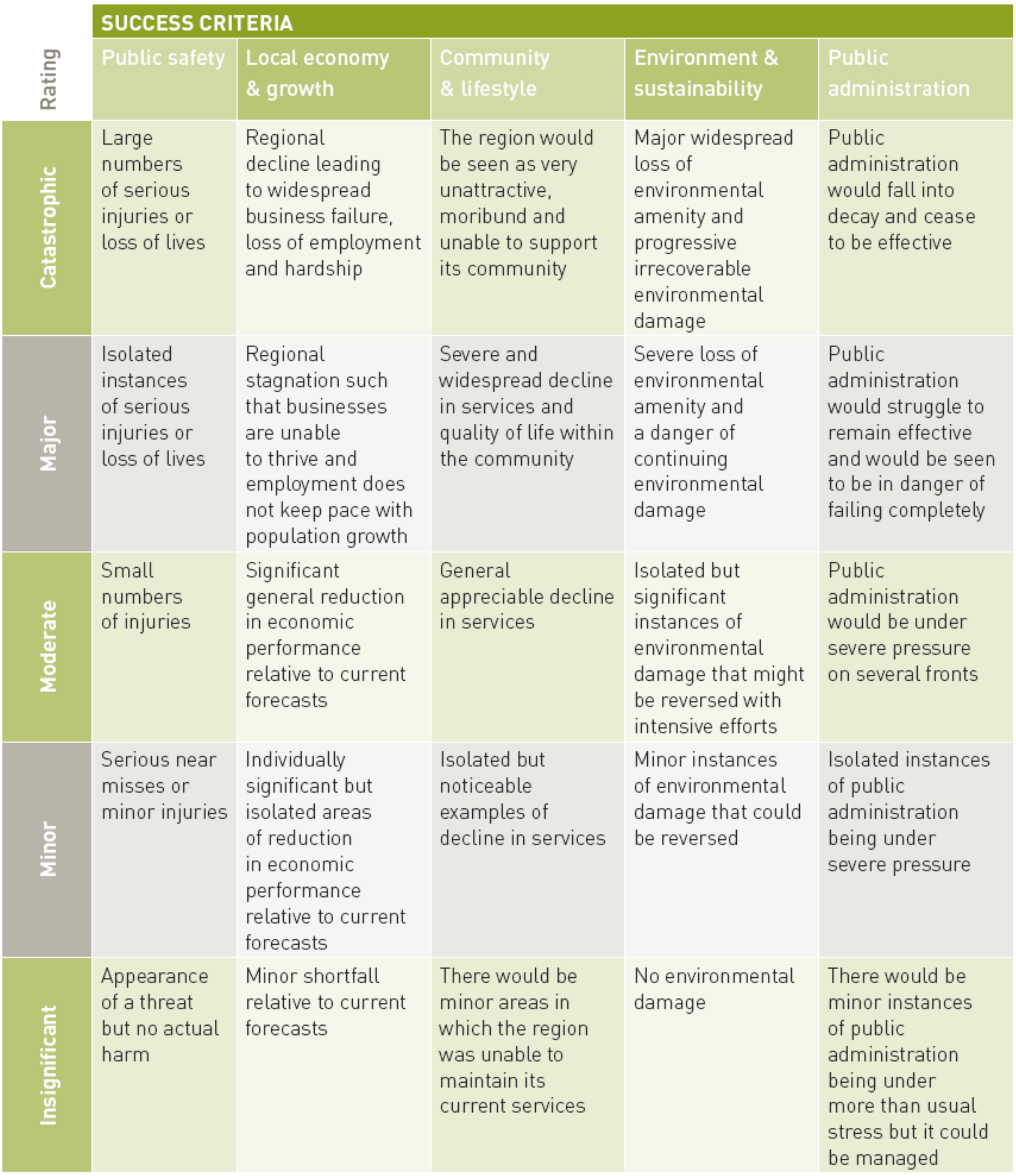
Consequence Ratings

To complete the risk assessment process it is also necessary to describe the level of consequence arising from the identified risks. This is usually achieved by defining a five point scale that describes levels of consequences ranging from:

- **catastrophic**, the level that would constitute a complete failure; to
- **insignificant**, a level that would attract no attention or resources.

Scales like those in Table 8 and 9 on the following pages are proven mechanisms for describing the consequences of risks. Note that they contain no firm numbers but use simple descriptions that are understood by the participants in the process. There may be occasions where numbers are appropriate, such as in describing levels of financial loss, but even here descriptions of how the organisation would react may be adequate: for example, Catastrophic may equate to closure of operations or replacement of the senior management team, Major to having to carry a financial burden over into future years, Moderate to having to curtail planned expenditure in the short to medium term and so on.

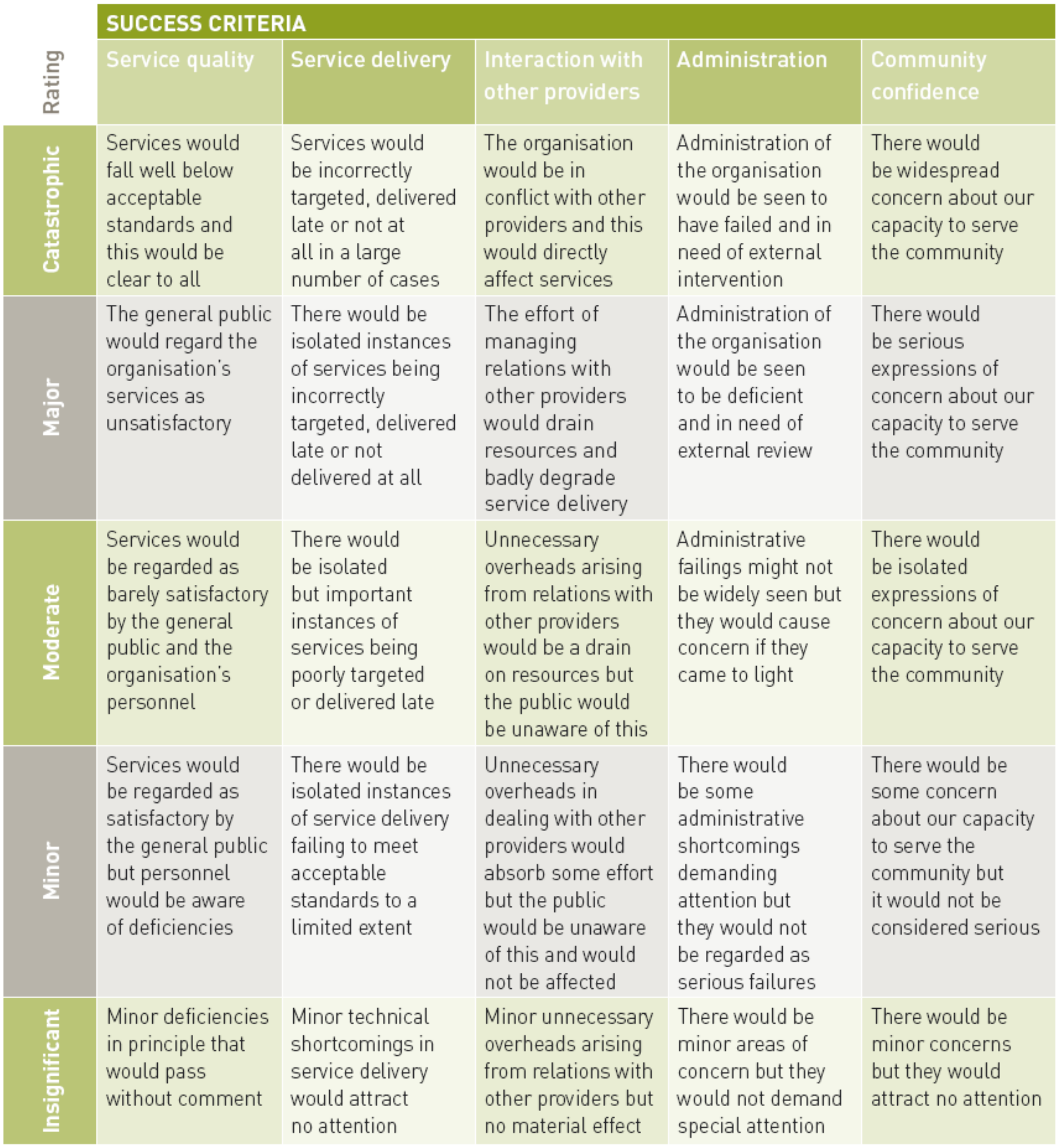
Table 8: Example – consequence scales for a local authority



Rating	SUCCESS CRITERIA				
	Public safety	Local economy & growth	Community & lifestyle	Environment & sustainability	Public administration
Catastrophic	Large numbers of serious injuries or loss of lives	Regional decline leading to widespread business failure, loss of employment and hardship	The region would be seen as very unattractive, moribund and unable to support its community	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Public administration would fall into decay and cease to be effective
Major	Isolated instances of serious injuries or loss of lives	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Severe and widespread decline in services and quality of life within the community	Severe loss of environmental amenity and a danger of continuing environmental damage	Public administration would struggle to remain effective and would be seen to be in danger of failing completely
Moderate	Small numbers of injuries	Significant general reduction in economic performance relative to current forecasts	General appreciable decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Public administration would be under severe pressure on several fronts
Minor	Serious near misses or minor injuries	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Isolated but noticeable examples of decline in services	Minor instances of environmental damage that could be reversed	Isolated instances of public administration being under severe pressure
Insignificant	Appearance of a threat but no actual harm	Minor shortfall relative to current forecasts	There would be minor areas in which the region was unable to maintain its current services	No environmental damage	There would be minor instances of public administration being under more than usual stress but it could be managed

Source: Commonwealth of Australia 2006. Climate Change Impacts and Risk Management: A Guide for Business & Government.

Table 9: Example - consequence scales for a public utility



Rating	SUCCESS CRITERIA				
	Service quality	Service delivery	Interaction with other providers	Administration	Community confidence
Catastrophic	Services would fall well below acceptable standards and this would be clear to all	Services would be incorrectly targeted, delivered late or not at all in a large number of cases	The organisation would be in conflict with other providers and this would directly affect services	Administration of the organisation would be seen to have failed and in need of external intervention	There would be widespread concern about our capacity to serve the community
Major	The general public would regard the organisation's services as unsatisfactory	There would be isolated instances of services being incorrectly targeted, delivered late or not delivered at all	The effort of managing relations with other providers would drain resources and badly degrade service delivery	Administration of the organisation would be seen to be deficient and in need of external review	There would be serious expressions of concern about our capacity to serve the community
Moderate	Services would be regarded as barely satisfactory by the general public and the organisation's personnel	There would be isolated but important instances of services being poorly targeted or delivered late	Unnecessary overheads arising from relations with other providers would be a drain on resources but the public would be unaware of this	Administrative failings might not be widely seen but they would cause concern if they came to light	There would be isolated expressions of concern about our capacity to serve the community
Minor	Services would be regarded as satisfactory by the general public but personnel would be aware of deficiencies	There would be isolated instances of service delivery failing to meet acceptable standards to a limited extent	Unnecessary overheads in dealing with other providers would absorb some effort but the public would be unaware of this and would not be affected	There would be some administrative shortcomings demanding attention but they would not be regarded as serious failures	There would be some concern about our capacity to serve the community but it would not be considered serious
Insignificant	Minor deficiencies in principle that would pass without comment	Minor technical shortcomings in service delivery would attract no attention	Minor unnecessary overheads arising from relations with other providers but no material effect	There would be minor areas of concern but they would not demand special attention	There would be minor concerns but they would attract no attention

Source: Commonwealth of Australia 2006. Climate Change Impacts and Risk Management: A Guide for Business & Government.

HCCREMS Member Councils

muswellbrook shire council

MAITLAND CITY COUNCIL

WYONG SHIRE COUNCIL

Great Lakes COUNCIL

CITY OF Lake Macquarie

GOSFORD CITY COUNCIL

DUNGOG SHIRE COUNCIL 1958

Greater Taree CITY COUNCIL

Port Stephens COUNCIL
... a community partnership

Singleton COUNCIL
For a better future...

Gloucester Shire Council

CCC CESSNOCK CITY COUNCIL

The City of Newcastle

Upper Hunter Shire Council