# The influence of climate change on Western Australian agriculture.

**Meredith Guthrie, Fiona Evans and David Bowran**, Department of Agriculture and Food, WA.

## Key Messages

Since 1975 there has been a significant shift in the climate of south-west WA, with a decline in winter rainfall, and an increase in summer rainfall, heat stress and frost risk. Climate variability has always challenged farm business and with future climate models indicating temperature increases of 4°C by 2100, farm adaptions are paramount.

## Aims

The aim of this study was to identify areas in the WA wheat belt with significant rainfall and temperature change.

## Method

Patched point climate data was sourced from 332 stations for rainfall in the Western Australian wheat belt from 1900 to 2013 and 56 stations for temperature from 1975 to 2013 to analyse the recent changes and trends in WA climate. The data was mapped using linear model trend plots for each station comparing the annual, growing season, and seasonal trends in rainfall and rain events. Rainfall events were classified as rain 2 mm and greater. For temperature we looked at heat stress in September (days above 22°C) and frost days (temperature below 2°C) were analysed for August and September.

## Results

*Change in annual rainfall*

Rainfall in the southwest has declined since the mid -1970s (IOCI 2005), and it was evident from the map that the rainfall isohyets have moved westward when annual rainfall from 1910 to 1999 was compared to annual rainfall that fell from 2000 to 2011 (Figure 1). For example in Dalwallinu, the average annual rainfall (isohyet) of 325 mm in 1910 to 1999 has dropped by 50mm to 275 mm by the period 2000 to 2011.

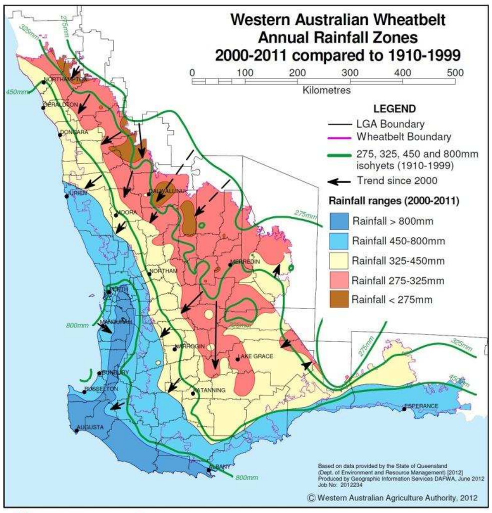

**Figure 1**. **Annual rainfall for Western Australian wheatbelt for years 1910 to 1999 compared to 2000 to 2011.**

*Change in seasonal rainfall*

To identify where the change in annual rainfall has occurred trends in seasonal rainfall was analysed. We found a significant increase (20 to 50 mm) in summer rainfall (December to February) for eastern parts of the agricultural wheatbelt (Figure 2). In the south coast region a significant decrease (30 to 40 mm) in autumn rainfall (March to May) (Figure 3) was found, and in western parts of the wheatbelt a significant decrease (> 40 mm) in winter rainfall (June to August) (Figure 4). There was no significant change in spring rainfall (September to November) (Figure 5).

The number of rain events per season has significantly declined in some areas for autumn and winter and while summer rain events have significantly increased. This means there are less rain days in autumn and winter which impacts on crop growth and the water inflow into dams and soil. The decline in rainfall is strongly associated with a decrease in the number of low pressure systems due to the weakening of the intensity of winter storms and increased persistence of high pressure systems (Hope and Ganter 2010).

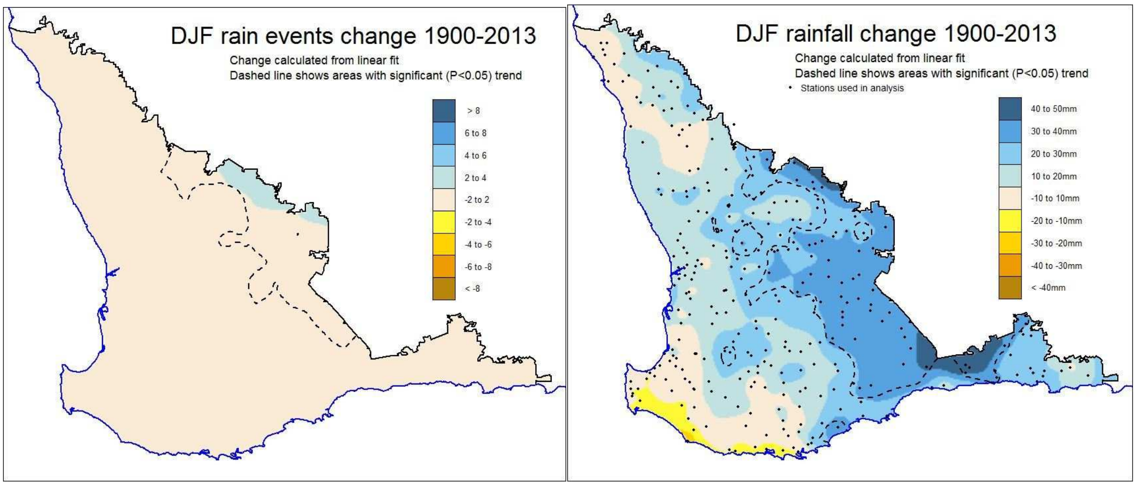


**Figure 2**. **Change in December to February (summer) rainfall from 1900 to 2013. Dashed line shows a significant increase (20 to 50 mm) in summer rainfall for the eastern wheatbelt. b. Change in the number of rain events in summer (December to February).**

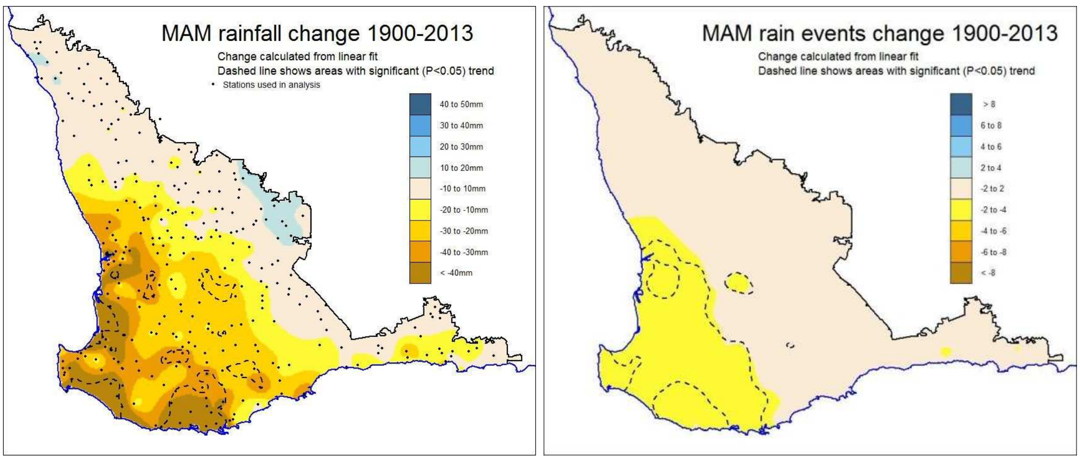


**Figure 3. Change in March to May (autumn) rainfall over the years 1900 to 2013. There has been a significant decline (30 to 40 mm) in the some areas of the central and**

**southern agricultural regions. The number of rain events (days) has significantly declined by 2 to 4 events in autumn for the south-west region.**

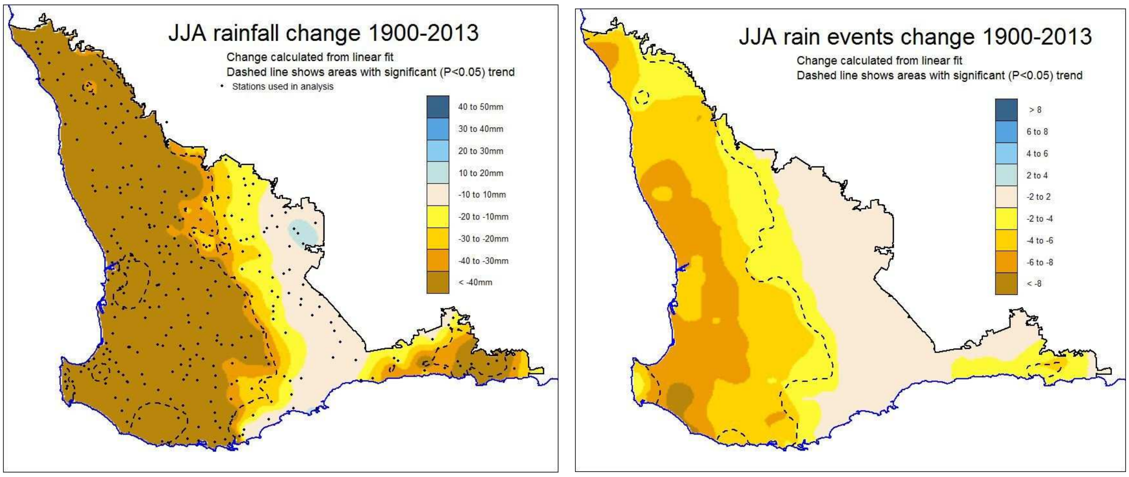


**Figure 4. Change in June to August rainfall over the years 1900 to 2013. A significant decline in rainfall (> 40 mm) has occurred in the western regions only. There has been no significant decline in winter rainfall in eastern wheatbelt (apart from the Esperance region).b. number of rain events has significantly declined by 4 to 6 events in winter.**

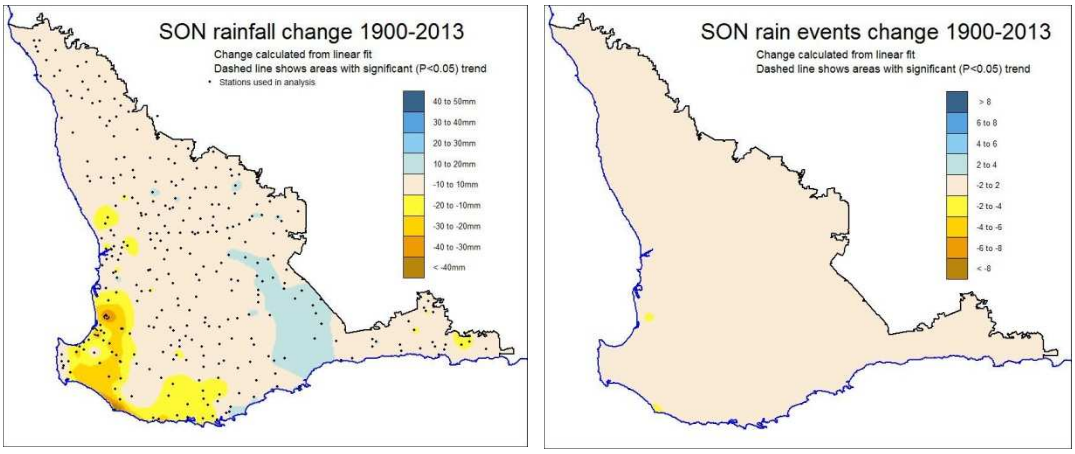


**Figure 5. September to October (spring) rainfall change for the south west of WA from 1900 to 2013. There has been no significant change in rainfall over this time. b. There has been no significant change in the number of rain events in spring.**

*Temperature change*

The annual mean temperature averaged over all of WA has increased by a little over 0.8°C since 1910. Since 1950 there has been an average rate of warming of 0.14°C per decade, with the maxima increasing by almost as much as the minima. Winter and spring have experienced the most warming and summer the least (IOCI 2005).

The increase in temperature since 1950 has involved relatively large increases in the frequency of extreme heat, which has the potential to significantly reduce yields (Asseng et al 2011). Average temperature has increased slightly (0.8°C) over 50 years, but there has been a disproportionate increase in the frequency of hot days during grain filling when wheat yields are adversely affected by high temperatures.

*Increase in heat stress*

The optimum temperature for wheat anthesis and grain filling ranges from 12 to 22 °C. Exposure to temperatures above this can significantly reduce grain yield. In WA, grain filling typically occurs in September as crops grown in frost prone areas are sown later to escape the frost window of August. We found that the northern tip of the Northern Agricultural Region has experienced an increase in number of days above 22°C in September and the most significant increase in the number of days above 22 °C in September was for Mullewa. This pattern was also found on the northern boundary of the southeast coastal district (Figure 6). These increases in temperature may have an impact on grain filling and lead to flower abortion. In contrast temperatures on the central west coast have declined, Badgingarra, had a significant decrease in the number of days above 22°C in September (Figure 6). Wokalup in the south-west also experienced a decrease in the number of days above 22°C. With global temperatures predicted to increase in the future, heat stress may become a more wide spread issue.

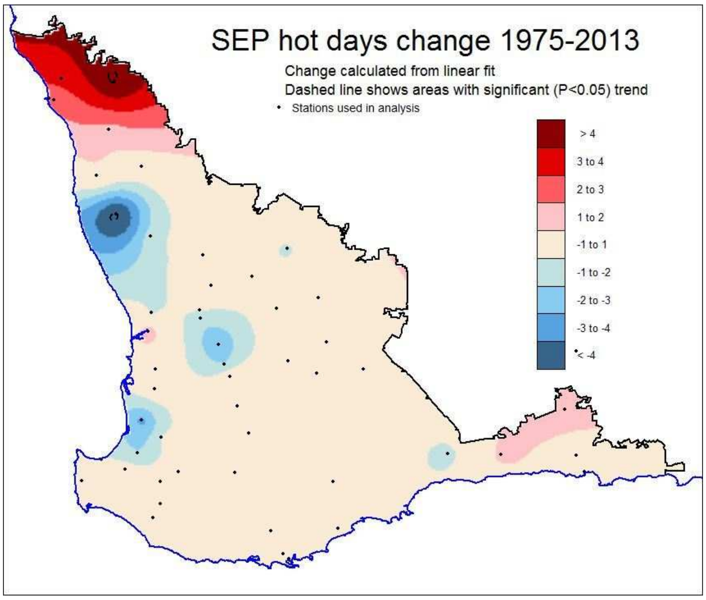


**Figure 6. Number of days above 22°C in September from 1975 to 2013 in the wheatbelt. Increase in frost risk**

*Increase in frost risk*

There has also been an increase in the risk of frost since 1975. We found that the number of days below 2°C has significantly increased in the central agricultural region in August and September increasing the likelihood of frost events in these areas (Figure 7). Northam, Kellerberrin and Wyalkatchem have had 4 more events in August than in the past (using years 1975 to 2013), while in September the events below 2°C for Kellerberrin, Wyalkatchem and Salmon Gums are up by 3 to 4 events, significantly more than in the past (using years 1975 to 2013). This is due to a pattern of higher atmospheric pressure over the Australian continent, resulting in less cloud cover.

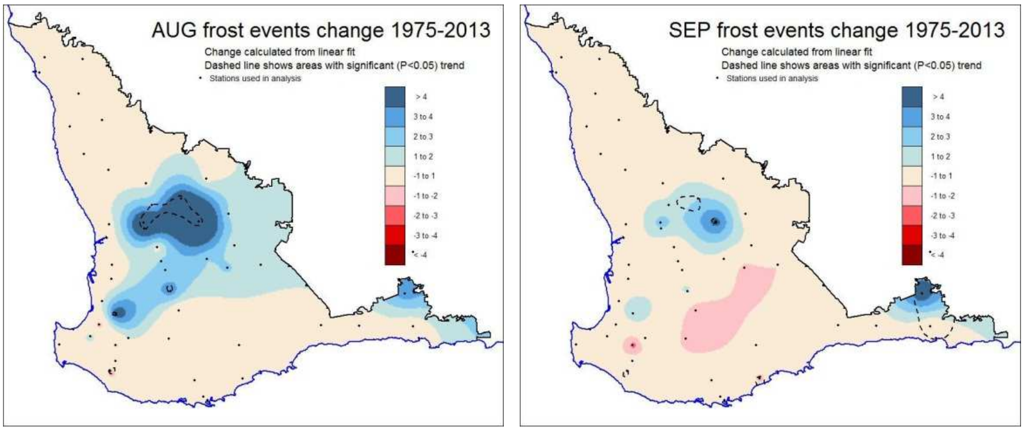


**Figure 7a showing the number of frost events (days below 2°C) in August and (7b) September.**

### Conclusion

Despite a decline in winter rainfall since the mid-1970s, good seasons still occur and WA produced a record 17.2 million tonnes of winter crops in 2013-14, a 55 per cent increase on the previous year. It has been suggested that higher rainfall zones which now receive less rain than before, produce more wheat due to a dramatic decrease in drainage. The lower drainage is matched by lower leaching and therefore more fertiliser uptake (Ludwig et al 2009).

Future climate models indicate that south-west WA autumn and winter rainfall will be reduced by a further 40% by the end of this century with greenhouse gas emissions and stratospheric ozone depletion contributing roughly the same amount to the drying (Delworth and Zeng 2014). Global temperatures are indicated to rise by 4°C by 2100. Studies have shown that the future climate will have major implications for agriculture in WA.

Farmers in some areas may need to adapt to less rainfall and warmer spring temperatures which can be very detrimental to crops. Currently farmers are not as yet using new adaptations to farming, but they are using existing technologies to cope with the drying climate (Kingwell et al 2013, Asseng and Pannell 2013, Howden et al 2007). Current practices are already considered standard best practice in managing climate variability. New adaptations will be required for crop growth in drier and warmer conditions. Some suggestions include diversification of crop varieties, species change, shifting planting seasons, changing crop management practices, i.e. tillage spacing's, rotations, nutrient and salinity management and moisture conservation (Kingwell et al 2013).

**Key words**: climate change, heat stress, frost risk, adaptation

**Paper reviewed by** Kari-Lee Falconer, Department of Agriculture and Food, WA.

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