Impact of Extreme Climatic Events on Wheat Productivity in South West, Western Australia

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Extreme climate events are challenging for Australian agricultural systems, imposing significant damage on commodities of primary industries. More than a decade ago, it was of major concern that a potential change in climate will increase extreme events. In recent years there are evidences of increases in the frequency and intensity of such events. Modelling of extreme climatic events and application to biophysical simulations is a viable approach to determine the effects on plant productivity and growth in future climate scenarios.

Methods

Historical, extreme climate trend data (minimum & maximum temperature, rainfall) and 2030 projected Global Climate Model (GCM) data sets were compared and downscaled using a quantile matching (QM) technique to a biophysical model – Agricultural Production Systems sIMulator (APSIM) to determine the effect of extreme climatic events on wheat productivity in two sites, Katanning and Merredin, located in South West Wester Australia (SW, WA).

- An historical trend analysis (1900-2015) conducted on climate extremes for both sites, to determine historical occurrence of extreme events.
- An extreme event was determined by defining a set of Climate Extreme Indices (CEIs).
- A GCM dataset (GFDL-CM3) was applied to recent historical datasets (1990-2015) from each site to determine the change in the intensity and frequency of extreme events in 2030.
- These datasets were then downscaled through QM to APSIM to calculate the effect of climate extremes from both recent historical periods and future projections (2030) to determine Katanning wheat productivity.

Results

It was found that extreme event intensity is expected to decrease as frequency increases for both sites in SW, WA. Occurrence of extreme events in future projected climates (2030) showed that wheat yield has decreased seasonal stability, with overall significant decreases through time (Figure 1).

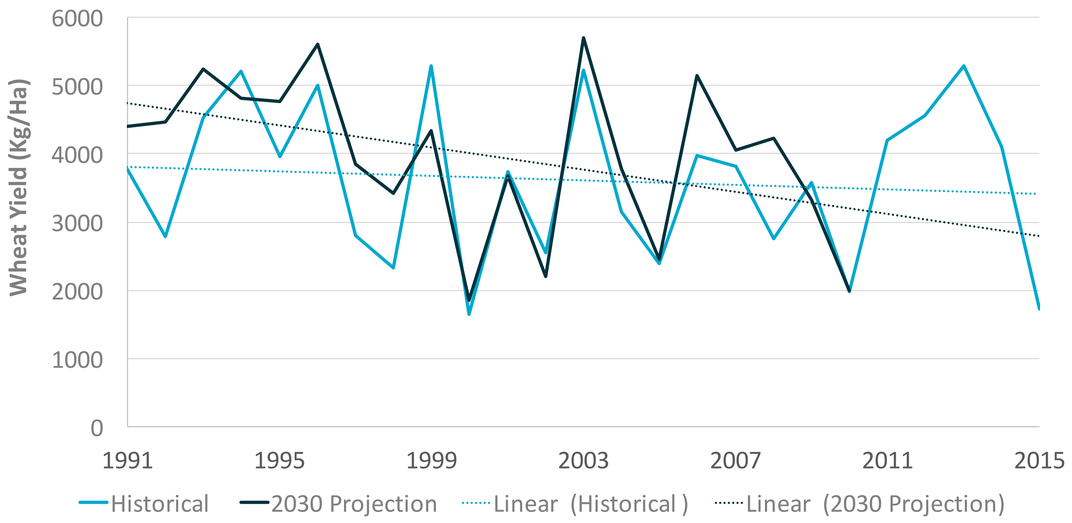
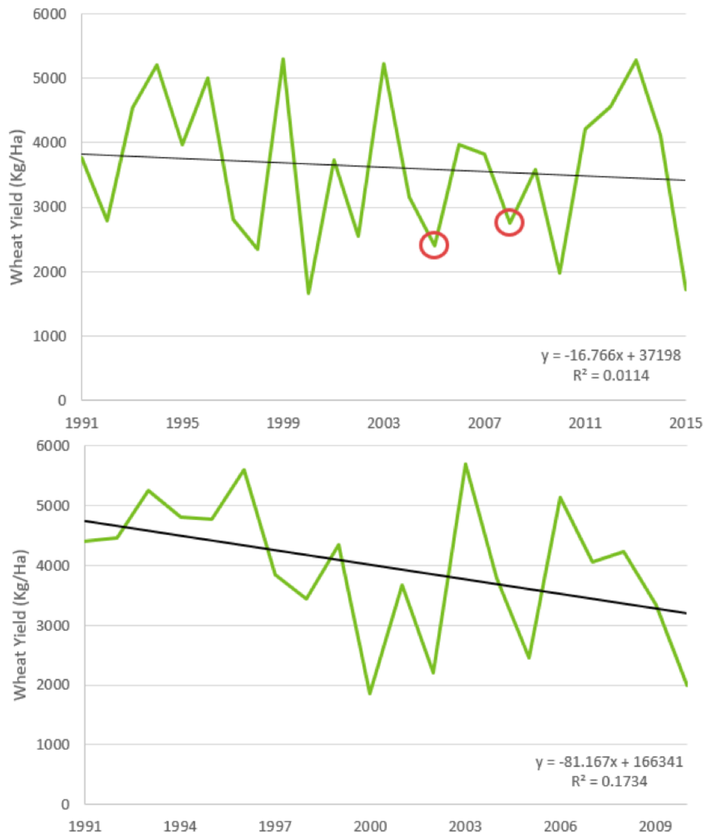


Figure 1: Comparison of annual trends between the recent historical dataset and the GCM (2030 Projected) dataset through time.

Significantly, it was identified that the intensity of extreme events through critical growing periods is the most significant factor determining the overall wheat yield for crop growth during a given season for the SW, WA wheat belt.

- Changes in extreme minimum temperatures and extreme minimum rainfall negatively affects the vernalisation growth stage. In years where these events occurred in vernalisation periods an overall decrease in wheat yield was found (Figure 2).
- Extreme maximum temperatures were found to be significantly impacting the amount of grain produced through the anthesis growth stage. In years where an extreme maximum temperature event occurred during anthesis, a decrease in wheat yield was experienced (Figure 2).



Indicator	Growing Season Average (% change)
Temperature Frequency Indicators	
Tmax	1.1
Tmin	3.3
Rainfall Frequency Indicators	
Rmax	-2.6
Rmin	4.3

Indicator	Growing Season Average (% change)
Temperature Frequency Indicators	
Tmax	1.8
Tmin	0.5
Rainfall Frequency Indicators	
Rmax	-3.6
Rmin	5.7

Figure 2: Above; recent historical dataset APSIM simulation (1991-2015). Below; GCM (2030 projection) dataset APSIM simulation.

Key Findings

- Extreme event intensity is decreasing through time, while extreme event frequency is increasing through time.
- This leads to an overall decrease in yield in the SW, WA wheat belt due to extreme temperature events and a lack of extreme, significant rainfall events through critical growing periods.

Table 1: The average wheat yield for 5-year intervals during a 20-year period within the recent history of Katanning for both the historical and GCM – 2030 projection datasets.

TIME PERIOD	HISTORICAL DATASET	GCM – 2030 PROJECTION
1991-1995	4052.74	4738.86
1996-2000	3418.84	3814.50
2001-2005	3409.54	3563.64
2006-2010	3221.60	3750.60

Conclusion

The results of this study show that wheat production for Katanning and Merredin, and most likely the SW, WA wheat belt region, are expected to decrease at a high rate under a hot and dry (GFDL-CM3), high impact 2030 climate scenario; negatively affecting the total profit/Ha of wheat crop earned by SW, WA wheat farmers.

The greatest influencing factor to a decline in wheat production is the increase in the frequency of extreme climatic events during critical growth periods, which significantly impact the overall growth and grain production produced by each plant.

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