CelsiusPro

Weather Dependency of Wheat Yields in NSW, Australia

White Paper:

Hedging Wheat Yields with Weather Derivatives

CelsiusPro AG, January 2010

Wheat in Australia NSW

This document outlines the dependency of the wheat yield to cumulative rainfall during spring. Furthermore it shows how the financial risk of low yields due to low precipitation can be mitigated with weather derivatives.

Australia is one of the world's largest wheat producers and is the world's largest wheat exporter. New South Wales (NSW) and Western Australia (WA) are the largest contributing states with 25% and 38% of the national production respectively. NSW grows predominantly Australian Premium White and Hard Wheat and with Hard Wheat mainly grown in northern NSW.

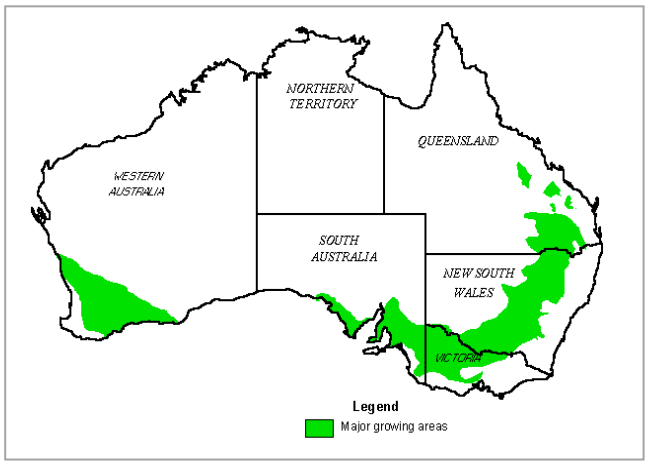
The Australian Bureau of Agricultural and Resource Economics reports an average production of 6'209kt for the past eleven years with the high of 8'602kt in 2008/09 and lows of 2'477kt in 2007/08 and 2'569kt in 2006/07. This translates in an average yield (t/ha) of 2.51 and lows of 0.62 and 0.71. Assuming an average price of AUD 290 per ton, NSW produces on average wheat for AUD 1'800bn but in a dry year only AUD 718bn. This earnings volatility is not only negatively affecting farmers but the Australian economy as a whole.

Given an increased impact of climate change in future, more extreme weather conditions such as extreme droughts and extreme heat are likely to further increase volatility of wheat production in Australia. Furthermore, given the global importance of this wheat as staple food, the impact of increased yield variability of the world's largest exporter will not go unnoticed.

The graph shows the winter wheat cropping belts in Australia.

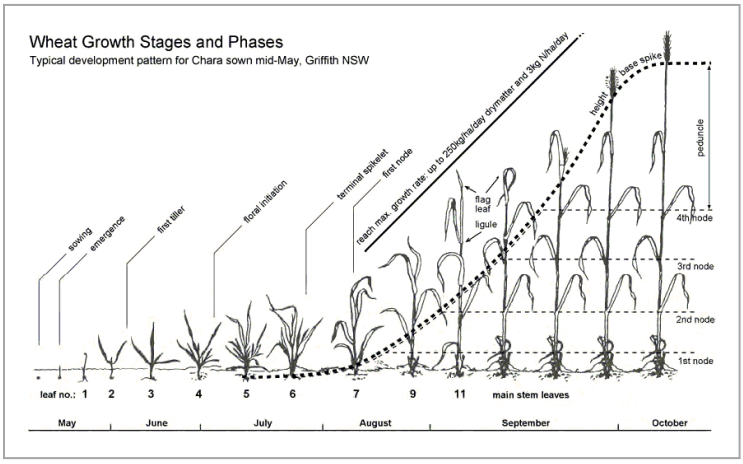
Wheat production per state a percentage of national total:

Western Australia	38%
New South Wales	25%
South Australia	16%
Victoria	12%
Queensland	9%



The graph shows the growth phases of wheat in NSW.

Clearly visible is the period from beginning of August to the end of October when the crop grows the most. The results from the quantitative analysis confirm that the precipitation during this period is essential for the crop yield.



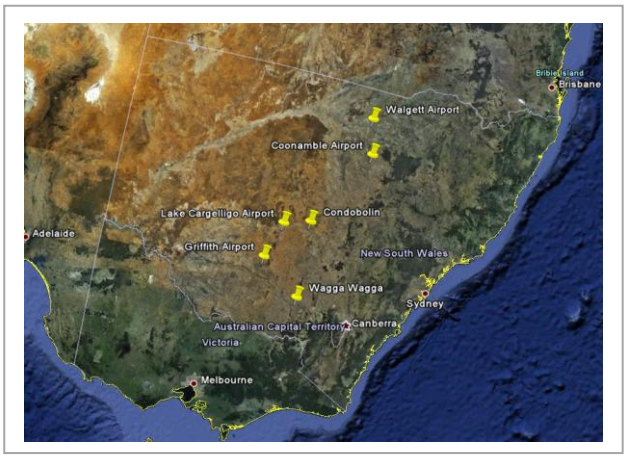
Graph Source: Crop Monitoring and Zadocks Growth Stages for Wheat, Dr. Maarten Stapper, CSIRO Plant Industry, Canberra,

Basket of Weather Stations and Yield Analysis

The basket used for this analysis consists of the average of the cumulative rainfall of six weather stations in the cropping belt. The cumulative rainfall is measured during the period from August 1st to September 30th by the Bureau of Meterology.

The graph shows the geographical spread of the weather stations in the basket.

Below outlined the detailed information about the stations used in the basket for the analysis.



Weather Station	*WMO Ref.*	*Lat.*	*Long.*
Wagga Wagga	*94910*	*-35.15*	*147.45*
Griffith Airport	*95704*	*-34.24*	*146.06*
Lake Cargelligo	*95707*	*-33.28*	*146.37*
Condobolin Res. Stn.	*94707*	*-33.06*	*147.22*
Coonamble Airport	*95718*	*-30.97*	*148.37*
Walgett Airport	*95713*	*-30.03*	*148.12*

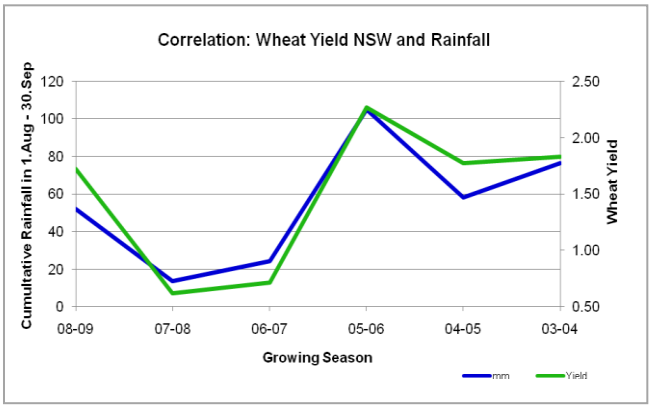
WMO Ref: Unique reference number of the World Meteorological Organisation

The graph below shows the correlation of the wheat yield (t/ha) in NSW to the cumulative rainfall in the area for August to September. The correlation of 0.95 or 95% of the last six years shows wheat's high dependency on rain.

The **correlation** shows the development of the rainfall and the NSW wheat yield for the growing seasons 2003/04 to 2008/09. The **correlation coefficient of 0.95** is very high.

Period: August 1st – September 30th
Weather Stations: Basket of stations in NSW
Average rainfall per period: 55mm
Maximum rainfall per period: 105mm
Minimum rainfall per period: 14mm

Source: The Australian Bureau of Agricultural and Resource Economics (ABARE)
The Bureau of Meteorology in Australia (BOM)

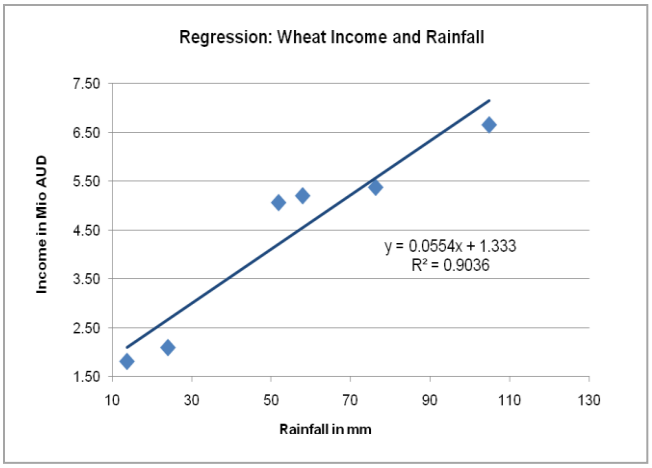


The graph below shows the regression of the wheat yield in NSW to the cumulative rainfall in the area. The high coefficient of determination (R^2) of 0.90 confirms that variation in the rainfall index explains 90% of the variation in wheat yield.

The **regression** shows the distribution of historical events. The blue trend line confirms the linear relationship between wheat yield and rainfall.

Y = 0.0188x + 0.4535
One mm (x) less cumulative rainfall result in 0.0188 yield (y) decrease.

R^2 = 0.90
90% of the variation in wheat yield is explained by variation in rainfall.



Hedging Wheat Yields with Weather Derivatives

We have seen the high correlation between cumulative rainfall as the independent variable and wheat yields in NSW as the dependent variable. Given that wheat yields cannot be hedged directly, a proxy hedge on cumulative rainfall can be used to secure the wheat yield.

Weather derivatives are risk management tools to mitigate or lower the risk of financial losses due to adverse weather. Key parameters of a **Dry Season Certificate**:

- Weather Station
- Period
- Strike in mm
- Payout per mm
- Maximum Payout
- Premium/Cost

Unlike insurance contracts, the payout is solely index based and not indemnity based. Hence no loss needs to be proven.

Dry Season Certificate

Aim: *Payout when there is below average rainfall (mm) during the period.*

Definition: *Under this Certificate, the Client will receive a fixed amount of [●Payout per mm●] for every mm that the cumulative Rainfall is below [●Strike●] up to a maximum of [●Maximum Payout●] during the period from [●Start Date●] until [●End Date●]. The Cumulative Daily Rainfall is defined as the Rainfall measured by the independent national meteorological station.*

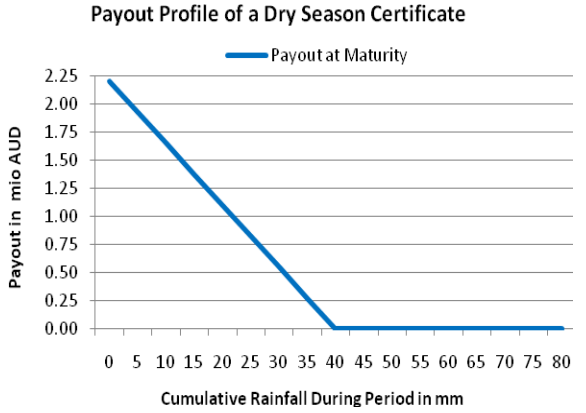
Conversion of Yield to AUD per mm Rain

The regression analysis has shown how much yield changes per mm rainfall (0.0188). This value can be converted to AUD as follows:

*Yield (ton/ha) * Area (ha) = tons (t)*
*Average price per ton (AUD) * ton = Earnings*

Assumption:
Area of 10'000ha and AUD 290 per ton.

The earnings variation per mm is AUD 54'520.
This value can be used as payout per mm.



The graph shows the improved risk profile of a wheat grower using a weather derivative to hedge yield fluctuation.

The blue bars show the original earnings variability given changes in rainfall.

The green bars show the payout of the Dry Season Certificate when cumulative rainfall is below the strike level of 40mm.