Using Seasonal Climate Forecasts For More Effective Grain-Cotton Production Systems

Summary

In discussions with stakeholders, the project team identified that in addition to El Nino-Southern Oscillation (ENSO)-based information, climate change and probabilistic forecasts for tactical decision-making at the two week to two months timescale were the most important climate related issues to be addressed to improve risk management in grain-cotton systems. As part of the project, research was conducted into the consequences and possible management options of climate variability at a wide range of timescales - from high frequency variability (weeks to two months), right up to climate change. Scientific results and practical outcomes were widely disseminated and discussed with growers and industry representatives.

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Conclusions
Climate is one of the many risk factors that managers of climate sensitive systems need to consider. In discussions with stakeholders, the project team identified that in addition to ENSO-based information, climate change information and probabilistic forecasts for tactical decision-making at the two week to two months timescale were the most important climate related issues to be addressed.

Low frequency variability (LF)
The project showed that the single most important cause of explainable, terrestrial rainfall variability resides within the El Nino-Southern Oscillation (ENSO) frequency domain (2.5 to eight years), followed by a slightly weaker decadal signal (nine to 13 years), with some evidence of lesser but significant rainfall variability at inter-decadal timescales (15 to 18 years). While LF signals at a decadal scale are dominant, the variability evident was ENSO-like in all the frequency domains considered. The extent to which such LF variability is (a) predictable and (b) either part of the overall ENSO variability or caused by independent processes remains, as yet, an unanswered question. Further progress can only be made through mechanistic studies using a variety of models.

However, knowledge of the existence of LF is critically important to industry, particularly when making long-term, strategic investment decisions. This project has quantified some of the economic and environmental consequences of LF climate variability and highlighted their importance when making investment decisions.

Climate change
The economic viability of agriculture could be at risk. The effects of climate change at a regional level need to be better understood and a range of possible responses investigated before making decisions about when, where and how individual producers and the industry as a whole need to adapt. This requires appropriate policy responses that are currently impaired by the lack of policy relevant scientific information at a regional level. There is a need to bridge this gap by providing quantitative information about the exposure to climate risk and the coping capacity of affected rural and water sectors.

A better understanding of climate change impacts at a regional level should be provided through consistent science-based messages to minimise the risk of inappropriate decisions and inconsistent planning due to climate change projections coming from various sources. This would increase the collective resilience to cope with climate extremes and climate change, as well as assist rural enterprises on the path to sustained economic growth.

Intra-seasonal climate variability
Better quantification and predictions of the onset, duration and termination of the northern Australian wet season would provide critically important information for better decision-making across the agricultural enterprises (grain, cotton, sugar, horticulture, grazing), as well as other sectors (health, infrastructure development, tourism). Similarly, in the southern regions, better quantification of wet and dry spell characteristics would improve tactical decisions (e.g. pest and disease control, planting and harvest operation, marketing). Building on existing forecast capabilities and new forecast capabilities such as the ones created by this project (e.g. the Madden-Julian Oscillation Index (MJO) and ENSO-based climate knowledge), further
research should target the specific needs of rural enterprises and develop mechanisms by which rural practitioners can gain ready access to such knowledge.

**Recommendations**

Further research and development (R&D) is required to investigate the dynamic linkages between weather and climate phenomena at intra-seasonal timescales with ENSO-related climate variability.

**Outcomes**

**Economic outcomes**

The project contributed to a better awareness of causes and consequences of climate variability and change on the grains industry. Economic outcomes of various management strategies in response to climate signals were quantified for the case study farms and results extrapolated to the regions. Outcomes provided individual growers, as well as the industry as a whole, with climate related information that can be incorporated into day-to-day risk management. This was achieved through newspaper articles, grower updates, scientific papers and the publication of a chapter in a major agricultural textbook for students and practitioners.

Project results highlighted that in addition to climate variability caused by ENSO (seasonal variability), two other timescales must be taken into account for better economic performance of cropping systems: 1) knowledge of variability at intra-seasonal timescale, i.e. the interface between weather and climate can lead to better tactical risk management (e.g. disease control, harvest operations, quality management, logistics) and 2) climate change needs to be considered when making strategic investments, particularly in environments that are already marginal.

**Environmental outcomes**

The project encouraged a holistic approach to crop management, with emphasis on the management of crop rotations. Issues such as runoff or drainage in response to surface management were quantified. The project quantified management impacts and highlighted that in most cases, sound environmental practice also increases the economic performance of cropping systems (e.g. appropriate cover during fallow periods reduces evaporation rates and increases infiltration rates).

**Social outcomes**

The project had significant social impact, in particular to climate change, by influencing policy e.g. project work influenced outcomes of a round table instigated by the Queensland Farmers Federation (QFF). Climate change is already impacting on production systems. Global temperatures have increased, with five of the hottest years on record occurring since 1998. Minimum winter temperatures across many parts of the world are on the rise. In many places, wheat is now sown earlier and maturity types have been adapted accordingly. Although these changes are rarely attributed to climate change, these autonomous adaptations in agricultural systems management are a consequence of a changing climate. Such autonomous adaptation should be supplemented by proactive adaptation to ensure that adaptive responses in cropping happen in a timely fashion. This requires policy frameworks that encourage proactive risk management strategies and farm managers who are willing to adapt. Proactive adaptation will be necessary to complement efforts to mitigate climate change. The project has quantified several such responses (e.g. frost risk in wheat).

**Achievements/Benefits**

The combined value of grain-cotton production in north-eastern Australia is approaching $2 billion per annum. Recent experience has shown considerable benefits and the future potential of seasonal forecasting in agricultural systems management (Hammer, 1997; Carberry et al., 1997; Meinke et al., 1998). Although these studies showed that cotton rotations can be intensified, profits increased and erosion risks reduced, the technology has not been rigorously applied and incorporated into the decision-making of grain-cotton systems. Some case studies show possible gross margin increases of 15% and a reduction in the erosion risk of 25% if climate risk information was incorporated into risk management practices. Consistent with GRDC’s aim to improve growers’ skills in managing production and price risks, this project enhanced and extended cropping systems management approaches that incorporate knowledge of climate variability and forecasting. Managing successfully in response to climate forecasting requires some understanding of the underlying principles by systems managers, as well as guidance in how to best apply forecast information. In response to demand by growers, grower groups and other rural enterprises, this project provided such information for the better management of dryland grain-cotton
Decadal scale climate variability (DCV) has encouraged expansion of crop production into normally drier areas, only for it to retreat when a series of good years came to an end. For example, peanut production, which developed in southern Queensland during the above-average summer rainfall conditions of the 1950s to 1970s, resulted in unrealistically high yield expectations for the changed climate patterns of the 1980s and 1990s. However, current cropping systems are generally resilient, that is, capable of absorbing some of that variability, without immediate disastrous results. A typical example is dryland winter and summer cropping in the north eastern cropping region of Australia (central New South Wales to central Queensland), where water is stored in the heavy clay soils over fallow periods. This water is then used by the next crop grown, and acts as a buffer against possible low in-season rainfall.

To remain economically viable in an internationally competitive market, Australian growers need to devise management options that can produce long-term, sustainable profits in such a variable environment. With declining prices and terms of trade, growers have had to increase productivity and the level of inputs, however, this has made them more vulnerable to losses in bad seasons. Hence, there is an increasing requirement for growers to have a sound understanding of the sources of rainfall variability, their degree of predictability, and objective tools to assess management options in agronomic, economic, and environmental terms. Demonstrating the effect of climate variability must not be confused with either the real or potential impact of a forecast. Effective applications of climate information, including climate forecasts, depend on factors such as the type of forecast provided and its suitability for influencing specific decisions.

This project outlined and documented the basics of Australian climate, including the physical causes and consequences of climate variability and its predictability. A chapter in the textbook, Principles of field crop production. Fourth Edition by J. Pratley (editor), Meinke et al. (2003) describes how growers, agribusiness, commodity traders, and policymakers can use this information to make better-informed decisions.

Several indicators of climate variability at a range of timescales were explored as part of this project:
* the Southern Oscillation Index (SOI) Phase Forecast System, which indexes the El Nino/Southern Oscillation (ENSO).
* an index representative of decadal climate variability at 9-13 years (9y 13y DCV, decadal correlation between sea surface temperature anomalies and mean sea level pressure).
* the Interdecadal Pacific Oscillation (IPO) - combining the Pacific low frequency sea surface temperature indices.
* interactions between ENSO and DCV.

As the project progressed, it became increasingly obvious that in addition to ENSO-type information, climate change and intra-seasonal variability were the issues that needed to be addressed in order to assist the grain and cotton industries to make better climate related decisions. This changed the emphasis of the work during the project’s final years considerably and resulted in many publications (scientific as well as newspaper articles and newsletters) that provided policy relevant background and information regarding climate change. At the intra-seasonal timescale, breakthrough research on the Madden-Julian Oscillation Index (MJO) resulted in a new prototype forecast system (Donald et al., 2006; www.apsru.gov.au/mjo).

The project demonstrated the whole-farm profitability and sustainability benefits of the adoption of opportunity cropping systems compared with monocultural systems in the Northern Grains Region. For instance, the economic and environmental performance of monoculture wheat, sorghum and cotton systems was investigated at three locations representing the geographic extent of the region (Breeza, Dalby and Emerald).

Following are some of the outcomes from the economic scenario analyses:

The effect of the SOI Phase on the performance of monoculture cropping systems differed between geographic locations and crops. For monoculture wheat, the SOI phase in April of the year of planting failed to discriminate between wheat cropping seasons at Breeza, although there was some separation in gross margins between SOI phases at planting at Dalby and Emerald - the negative SOI phase had a lower gross margin than the positive SOI phase. For monoculture sorghum, the SOI phase prior to planting affected its performance at Breeza and Emerald (a positive SOI improved returns) but not at Dalby where there is usually sufficient rain to successfully produce sorghum in most years. For monoculture cotton, a positive SOI phase prior to planting enhanced gross margins at all three locations. In opportunity sorghum-wheat systems, the SOI phase prior to planting affected performance at Dalby and Emerald, but had no effect at Breeza. In the opportunity cotton-sorghum system at Emerald, the performance of cotton was more reliable when the SOI phase was positive prior to planting.
The ENSO classification of years into La Nina or El Nino years showed:
* for wheat, the chance of a negative gross margin was increased in El Nino years at all three locations.
* for sorghum, the chance of a negative gross margin was increased in El Nino years at all three locations.
* cotton is less risky if planted in La Nina years, particularly at Emerald.
* the wheat-sorghum opportunity cropping system masks the effect of the ENSO classification on crop returns - the biggest impact of a El Nino year was greatest at Breeza with this cropping system.
* the opportunity cropping cotton-sorghum system at Emerald performed significantly better than monoculture sorghum in La Nina years.
* the opportunity cotton, sorghum and wheat system at Dalby was unaffected by the ENSO classification.

At the decadal timescale, the 9y 13y decadal climate variability (DCV) index showed that:
* a negative phase slightly reduced the risk of a negative gross margin for wheat at Breeza and Dalby (but had no effect at Emerald).
* a negative phase improved the performance of sorghum at Breeza and Emerald (but not at Dalby).
* a negative phase improved cotton returns at Breeza but had no effect at Dalby or Emerald.
* for the opportunity cropping cotton-sorghum and wheat at Emerald (had no effect elsewhere).
* for the opportunity cropping system at Dalby, a negative phase reduced the risk of a negative gross margin from 30% to 10% of years (compared to a positive index).

At a decadal/interdecadal scale, the IPO index showed:
* sorghum at Emerald, the chance of a negative gross margin increases from 10% in negative indices years to 17% in positive indices years.
* cotton at Breeza and Emerald, at Breeza the chance of a negative gross margin increased from 25% in negative indices years to 35% in positive indices years; at Emerald the chance of a negative gross margin increased from 35% in negative indices years to 50% in positive indices years.

The IPO index was not significant for opportunity cropping systems.

Initial research on the Madden-Julian Oscillation indicated substantial value for tactical decision-making at intra-seasonal timescales across the Northern Grains Region. Hence, the project concentrated heavily on MJO-based applications and the provision of relevant MJO information for the grain-cotton industries. This led to the establishment of a prototype web site (www.apsru.gov.au/mjo) and to a major publication on the global impact of the MJO (Donald et al., 2006).

The project had significant social impact, particularly climate change, by informing public and private policymakers (e.g. project work influenced outcomes of a round table instigated by QFF). Climate change is already impacting on production systems. Global temperatures have increased, with five of the hottest years on record occurring since 1998. Minimum winter temperatures across many parts of the world are on the rise. Queensland was identified as one of the areas with the largest recent increases in temperature. In many places wheat is now sown earlier and maturity types have been adapted accordingly. Although these changes are rarely attributed to climate change, these autonomous adaptations in agricultural systems management are a consequence of a changing climate. Such autonomous adaptation should be supplemented by proactive adaptation to ensure that adaptive responses in cropping happen in a timely fashion. This requires policy frameworks that encourage proactive risk management strategies and farm managers who are willing to adapt. Proactive adaptation will be necessary to complement climate change mitigation efforts. The project has quantified several such responses (e.g. frost risk in wheat).

Other research

The project led to the following on-going research and development (R&D) activities:
1) New project funded by Land and Water (L&W) Australia under its Managing Climate Variability (MCV) Program: Improving Prediction of the Northern Australian Wet Season.
2) Major input into the recently intensified debate about climate change and possible adaptive responses by rural industries (e.g. input into roundtable discussions with QFF).
3) Information and approaches developed by this project now provide significant input into several Farming Systems projects, particularly the Central and Western Farming Systems projects.

Intellectual property summary
Project outcomes and outputs are generic and valuable to rural industries as a whole. The information generated and the products developed based on this project are not suitable for commercialisation.