FINAL REPORT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

CSA00053

Impacts of climate on low rainfall and marginal areas

PROJECT DETAILS

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PROJECT TITLE:	IMPACTS OF CLIMATE ON LOW RAINFALL AND MARGINAL AREAS
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SUPERVISOR:	STEVEN CRIMP
ORGANISATION:	CSIRO
CONTACT NAME:	STEVEN CRIMP

Summary

Climate change predictions suggest that the scale and rate of change will alter agricultural production in many parts of Australia, particularly the low rainfall agro-ecological zones (LRZ) where projected changes of warmer temperatures, shifting and more variable rainfall patterns are likely to occur.

For this reason GRDC supported:

1. The review of knowledge products used to manage seasonal climate conditions.

2. How leading growers are maintaining viability under variable climatic conditions.

3. Available crop genetic material with superior performance in low rainfall and high stress environments.

The project has successfully delivered reviews across all these knowledge domains.

Report Disclaimer

Conclusions

All grain farming in Australia is risky. Compared to medium and high rainfall zones, low rainfall farming tends to have higher year to year volatility. Few growers in the LRZ would argue that their region was 'reliable'. However, unreliable does not mean unviable; rather it requires different approaches to agronomy and farm business management.

The consistent message is that there are farm businesses that have not just coped with erratic and low rainfall, but are viable and growing. Due to lower costs and the efficiency of scale, low rainfall farming can be highly profitable in good seasons. This is not to overlook the challenges for growers, farm businesses and rural communities in difficult seasons. In some regions, these tough conditions are ongoing or growers are dealing with the legacy of recent clusters of bad years.

The growers and agronomists who were spoken to were quick to point out that there was no simple recipe for success. A common theme was the skill of the farm business operator with an emphasis on 'not what you do, but doing things well'. This applied to both good agronomy and sound business management and recognising when to seek external assistance.

In terms of seasonal climate forecast (SCF) use as a way to improve resilience and responsiveness to climate variability, a number of clear recommendations based on the literature, surveys and interviews have been made. The most important of these include:
o A standardised approach to evaluating the economic returns for SCF use be attempted. This would allow improved inter-comparisons of SCFs, as well as allowing the development of a database of economic evaluation across multiple locations and enterprises.
o More effective integration of climate and statistical sciences is required to produce skilful forecasts on seasonal and sub-seasonal timescales.

Projected changes in temperature and rainfall in 2030 and 2050 are likely to reduce gains made via genetic selection. If, from current wheat National Variety Trial (NVT) data, the relative performance of varieties shows that the yield advantage of the best three varieties is typically in the range of 5% to 20%, this would suggest that additional warming may have significant effects on even genetically resilient crop lines.

Increasingly in the future, genetic material that will provide resilience to future conditions may need to be sourced outside of Australia.

Recommendations

The results of these reviews have identified a number of recommendations. These are:

o Need to address changing climate by moving from the notion of 'drought as a crisis' to acknowledging the variable availability of water - multi-year droughts should be expected and may increase.
o As well as focusing studies on successful farm businesses combating climate variability or change, also study families who have chosen to leave farming and invest elsewhere. Related to this could be a study on the strategies and characteristics of businesses which were forced to leave agriculture.
o Is a key issue on climate change being avoided? Is it possible to identify regions which have a high likelihood of failure of current farming systems under reasonable projections of climate change?
o Thresholds for minimum community resources for farms to remain viable or can farms survive without a local community? If so, how? How valuable is the social dimension provided by organisations such as farming systems groups to maintaining mental resilience of growers during difficult periods?

A number of knowledge gaps were identified regarding the development and maintenance of resilient farming systems for LRZ environments. These include:
o Need for more analysis on system change and its impact on farm finances. This will involve partnerships between GRDC, Australian Wool Innovation Limited (AWI) and Meat and Livestock Australia (MLA).
o Complementary vs antagonistic components of livestock in cropping systems.
o Lack of skills in livestock husbandry amongst younger generations.
o Understanding the cause of yield gaps in low rainfall cropping systems and consideration of the costs of addressing these gaps. This is being addressed under current GRDC investments, but a low rainfall business perspective needs to be continually applied to the improved agronomy.
o Appropriate fertiliser strategies for low rainfall districts. Does the practice of cutting back on applications during difficult periods have long term implications on productivity and/or profitability?
o Appropriate weed management strategies in low rainfall farming districts. Is the use of more expensive herbicide options valid for longer term weed management?
o Effect of scale on profitability across different seasons, and, in particular, different runs of seasonal phases (e.g. wetter or drier).
o Improved knowledge of the benefits and cost of zone management of soil constraints, nutrition and weeds using precision agricultural (PA) techniques.
o Whole farm system analysis of the effect of different farm plans on long term profitability. This has been attempted with moderate results.
o Improved methodology for incorporating uncertain seasonal forecasts into current risk management and tactical management decisions.
o Improved systems to identify opportunity cropping potential in marginal districts.
o Extension of best practice yield potential assessment systems (e.g. Yield Prophet®).
o The impact of clusters of poor seasons on debt and equity raise the question of understanding the cause and predictability of persistence in climate at the two year to 10 year timespan.
o Given the vulnerability that a grains business has during an expansion phase, there may be a special role for multi-peril insurance.

Outcomes

This project was established to deliver a set of reviews relating to SCF tools and services, farm business structures and genetic material of relevance for the LRZ. For this reason, the direct value of this project to GRDC will be realised through effective assimilation and response to the recommendations contained in the report. For this reason, only the indirect benefits of the implementation of the recommendations are discussed. These benefits are centred on both enhanced economic outcomes and environmental outcomes.

Economic Outcomes
Recent estimates by the Centre for International Economics (2014) suggest the potential annual value of the SCF for Australian agriculture is $1,587 million per annum, a value add of 7.3%. Supporting the recommendations outlined in the Technical Report as well as broadening out the current areas of GRDC research investment as outlined in the reviews will result in further economic benefits to Australian cereal growers. While it is difficult to quantify these benefits, some estimates

suggest that improved adoption and integration of seasonal climate information could result in sustained benefits of between 2% and 7%. The review of LRZ relevant genetic material indicated that effective adoption of these traits could deliver 5% to 12% improvement in productivity and hence value. The indirect benefits of implementing these recommendations are thus estimated to improve the potential annual value of cereal production by between 2% and 19%. As projected changes in climate are realised, these indirect benefits are likely to be more conservative.

Environmental Outcomes
The information regarding future projections, the determination of suitable genetic material and effective adaptive management practices for the LRZ will provide insights into possible future operating conditions and industry options. Effectively utilised by growers, this could result in more robust production systems that are less likely to deliver negative environmental outcomes.

Achievements/Benefits

This project has successfully undertaken research activities that include:
1. The development of historical (past 30 years) and future (next 30 years) climate fact sheet summaries that outline change in both mean and extreme temperature, rainfall, evaporation, and solar radiation at both seasonal and annual timescales.

2. A review of existing SCF tools and services, as well as their use in applications. It will include an assessment of gaps and potential for expanding and updating or improving the range of tools available, as well as collate modelling studies that have examined the economic returns and risk associated with utilising the SCF information. A national survey will also be undertaken to explore the current levels of SCF use, perceived value and to understand some of the limitations of SCF use.

3. A review of existing literature along with current and recently completed projects that explore how farm business structures in LRZ can be adapted to climate variability and change. The review has included an examination of what leading growers in the LRZ are doing to profitably manage climate risk in their businesses.

4. A broad literature review undertaken to identify new or under-utilised genetic material in current and past NVT trials. This review has included a discussion of identified traits and associated management regimes that could improve yields under more variable climate conditions.

The key findings from this series of reviews and surveys are:

Climate change assessment
The regional analysis highlights that the greatest increase in extreme maximum temperatures (i.e. 90th percentile values) are likely to occur in the north eastern agroecological zones (AEZ), with temperature increases of up to 1.6°C likely by 2030 and up to 2.4°C by 2050. This would mean that the 90th percentile annual maximum temperature at 2030 for a location like Caringle could be in excess of 39°C and by 2050 could be 40°C. Warming maximum temperature extremes in the southern AEZs are likely to be more modest than in the east, with 90th percentile temperatures warming by 0.8°C to 1°C by 2030 and 1.6°C to 2.2°C by 2050.

The regional analyses highlight the potential for large increases in extreme daily and weekly rainfall across the New South Wales north west (NSW NW), Queensland south west (QLD SW) and QLD central AEZs of between 10% to 20% by 2030 and up to 50% by 2050. Across all the other locations, extreme daily and weekly rainfall is likely to decline by 10% by 2030 and up to 25% by 2050.

Across the whole LRZ, extreme warming is likely to increase by 0.5°C to 2°C by 2030 and by up to 2.5°C by 2050. The LRZ of the southern AEZs is likely to experience both declines in rainfall and increases in temperature, making these zones extremely challenging environments in which to remain profitable and resilient in the future.

SCF review
The review found that the Bureau of Meteorology (BoM), as well as a range of state government agencies and organisations, offer 21 operational SCF tools. A number of these include rainfall and temperature forecasts, as well as forecasts of secondary variables such as soil moisture, frost severity and plant available water.

A number of observations were made about ongoing knowledge gaps and improvements that could be made to improve SCF uptake and the range of knowledge products that incorporate seasonal climate conditions. The most significant barriers

to use of SCF remain:
o Perceived lack of local or regional relevance.
o Perceived lack of sufficient lead time.
o Perceived lack of skill and accuracy during periods when critical farm level decisions and period of time during which the SCF has perceived skill.
o Context relevant knowledge products.
o Perceived lack of application to understanding how SCFs translate to measurable improvements in farm profitability.

Resilient LRZ business structures
For most low rainfall operators, the long term effects of climate change remain an uncertainty. This is reflected in the survey results and general feedback that information on climate change projections in the medium or longer term are not regarded as a high priority by growers in the LRZ or their advisers. The focus remains on adapting to current variability as a means of coping with longer term change. Some of the strategies being used by growers in the LRZ include:
o Getting the Enterprise Mix Right - Successful cropping businesses in low rainfall areas usually have some clearly defined strategies involving alternative sources of income to cope with either a single or run of poorer type seasons. Inclusion of livestock in the mix is a common response, but there are many other ways to diversify income.
o Productive Systems - Water is the most limiting resource in these systems and success is linked to capturing and storing rainfall over the fallow, monitoring the amount of stored soil water and then using the water in a productive way.
o Lean Cost Structures - The lean cost structure of LRZ farming is evident in the low level of fixed costs achieved through scale and low variable costs achieved through minimum inputs.
o Appropriate Flexibility - Compared to medium rainfall zones, a farm business in the LRZ tends to make a greater portion of its profit in a few good seasons. It follows that flexibility in response to these high production years has many advantages. However, while there are gains in flexibility, there are also associated costs and some growers advocate a less responsive, fixed approach.
o Wise Use of Debt - The sensible management of debt is seen as an important requirement for resilient low rainfall farming businesses. The majority of farms in the LRZ remain multi-generational family owned businesses.
o People Management - In recent years there has been increasing recognition of the human cost of drought and the complexity of motivation for farming generally and for low rainfall farming in particular. Growers in the LRZ will often point out that resilience at the farm level (scale, efficiency, less labour) is a driver of de-population which can lead to less resilient communities.

Identifying useful NVT genetic traits
Many of the genes that control flowering time through response to vernalisation and photoperiod have been identified in model species and several crop species, but the genetic control of response to temperature as such is not nearly as well understood. At present, it is also slow and difficult to screen genotypes for tolerance to high temperature in either vegetative or reproductive stages of growth.

GRDC research relevant to the development and adoption of improved germplasm is grouped under Theme 2: Improving Crop Yields. The portfolio had nine oilseed, 23 pulse, four summer cereal and 70 winter cereal crop type projects. The dominant crops within each of these crop types are canola (6 projects), lupins (15 including general pulse projects), sorghum (2) and wheat (54), with barley involved in 24 projects. The majority of projects (33) specified drought as a priority with many of the 62 'multiple stress' projects also likely including drought. Frost, heat and salt were targeted by 5, 25 and 2 projects, not including the multiple stress projects. Frost tolerance can be also considered as a 'heat' trait - earlier sowing of frost-tolerant cereals would assist them to 'escape' heat and drought at the end of the season, as shown by Zheng et al., (2015). There are few projects targeting heat in oilseeds and none in summer cereals, with a large number of projects in pulse (8 plus some of the 'Multiple' stress projects) and winter cereals (13 plus 'Multiple' stress projects).

A question that was commonly raised in discussions for this report is whether the LRZs are as well served by wheat breeders as are other zones. The NVT site lists all of the commercial lines for the winter crops that were under test in the latest season (http://www.nvtonline.com.au/commercial-varieties-in-nvt/). Inspection of the latest list for the 2015 trials indicates that for barley, bread wheat, durum wheat, triticale, canola and faba beans, there was at least one variety for any given AEZ.

The evidence from the analysis of the NVT trials is that heat during the reproductive (stage 2) and grain filling (stage 3) growth periods is particularly associated with reduced yield per unit of rainfall in South Australian (SA) and Western Australian (WA) environments. Impacts occur in the northern environments, but tend to be less frequent, associated with earlier flowering

and grain filling due to milder winter temperatures. This would suggest that projected changes in temperature and rainfall in 2030 and 2050 are likely to reduce gains made via genetic selection. If, from current wheat NVT trial data, the relative performance of varieties shows that the yield advantage of the best three varieties is typically in the range of 5% to 20%, this would suggest that additional warming may have significant effects on even genetically resilient crop lines.

Other research

Both the review and survey activities have served to articulate the importance of understanding the changing nature of climate extremes. Internal CSIRO support has been provided to explore the range of climate extremes that have direct relevance to Australian agricultural industries and to understand the impacts these extremes may have had in the past. As part of this activity, there is an aim to determine the degree of current and future exposure to these events through the development of a flexible Climate Extremes Index (fCEI), as well as assess the ability of industries to respond and adapt to these changes. Rural industries willing to partner in this activity are being sought, so that knowledge products can be tailored for their needs.

Intellectual property summary

Given the targeted reviews are publically available, the project intellectual property (IP) generated has no commercial value. The climate projection information for the LRZ has been developed using background IP owned by CSIRO. A royalty free, non-exclusive licence to use the background IP exists for the term of the project and the report. Replication and dissemination of the graphics and maps associated with these projections are not subject to background IP constraints and so could be made freely available to those interested.

Additional information

This project has undertaken a series of targeted reviews around farm business structure and climate risk, identification of genetic traits from existing trials, and climate prediction services. In addition, two national surveys were undertaken to gauge the current ways of managing climate risk with an emphasis on the range of use of existing SCF services, perceptions of accuracy, consistency, relevance, value and barriers to use. These reviews have not been converted into journal publications at this time.