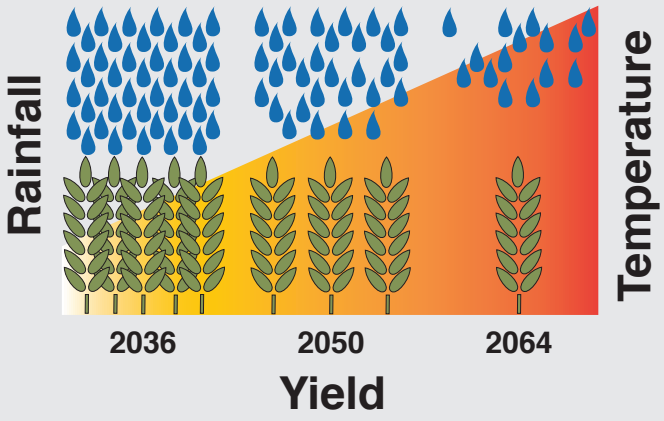
MONASH University

MONASH BUSINESS SCHOOL

Research Bulletin

The key grain producing region of Northwest Victoria is certainly no stranger to hot and dry seasonal conditions with 2019 being one of the driest years on record for the region. This new record combined with a series of tough years has encouraged growers and researchers to pose a much broader question. What climatic conditions are in store for the region over the next few decades? This question sparked a Department of Environment Land Water and Planning sponsored project with Monash University, ORM, and Climate Comms. The project explored the impacts of extreme temperatures on wheat yields and farm profitability in Northwest Victoria by generating yield predictions under ten different climate change scenarios.

Figure 1: Rainfall & yield decline corresponding with rising temperatures for 2036-2064.



A visual representation of rainfall and yield decline corresponding with a rise in temperature for both vegetative & reproductive phases within the Mallee & Wimmera region.

YIELD RESPONSE

The research utilised actual historic (1993-2018) data on farm-level yield and weather (temperature and rainfall) for 37 farms within the Wimmera and Mallee regions. For the wheat growing cycle 1 April - 31 Dec, the analysis of this historical farm data indicated that exposure to freezing temperatures (≤0°C) during the vegetative and the reproductive phases, and exposure to extreme temperature during the grain filling phase (>32°C) had significant negative effects on yields.

The reproductive season is the most sensitive to temperature extremes. The magnitude of these effects differed significantly between the Wimmera and Mallee regions.

Within the Wimmera region frost had a stronger negative effect on yield than the Mallee while heat stress (in the grain filling phase) had a stronger negative impact in Mallee when compared with the Wimmera. In both locations the adverse effects of frost and heat stress on yield was either fully or partially offset by increased rainfall.

The project explored the likely impact of ten different climate change scenarios, based on three global climate models (Warmer and Slightly Wetter, Warmer and Wetter, Hotter and Drier), and two emission pathways (RCP4.5 & RCP8.5) over short (2016-2045) and medium (2035-2065). Each of these ten models provided climatic projections of future temperature and rainfall patterns that crops are likely to be exposed to over the next 45 years.

These climate change projections, with respect to (1993-2018) averages, indicate the following:

- In *every climate change scenario:*
  (a) crop exposure to freezing days falls in the vegetative and reproductive phases; **(b)** exposure to low and moderate temperatures increases in all three phases; and **(c)** rainfall declines during the fallow period.
- Under the *hotter and drier scenarios,* there is a significant increase in extremely hot temperatures.
  - 45% increase within the Mallee and 41% within the Wimmera region.
- A decline in rainfall, especially during the reproductive phase.
  - Within Wimmera, rainfall decreases by 39% during the

fallow period and by 29% in the grain filling phase. The corresponding effects for Mallee are 42% and 29% declines respectively.

POTENTIAL IMPACTS ON FUTURE WHEAT YIELDS

The predictive modelling indicates that future yields will largely depend on which climate change scenario eventuates.

In the 'Hotter and Drier' scenarios, the increasing level of exposure to high temperatures and low rainfall could negatively impact yield. This combined with the changes to the annual pattern of temperature and rainfall, would result in a decline in the long-term average yield as well as a greater level of volatility from year to year. Within the Wimmera region the yield decline is less severe initially in contrast to Mallee but gradually declines over time.

Within the 'Warmer and Slightly Wetter' and the 'Warmer and Wetter' scenarios, wheat yields are not so badly affected as a result of a variety of favourable conditions such as fewer freezing days, warmer temperatures, and better rainfall effectively offsetting the effects of exposure to higher temperatures.

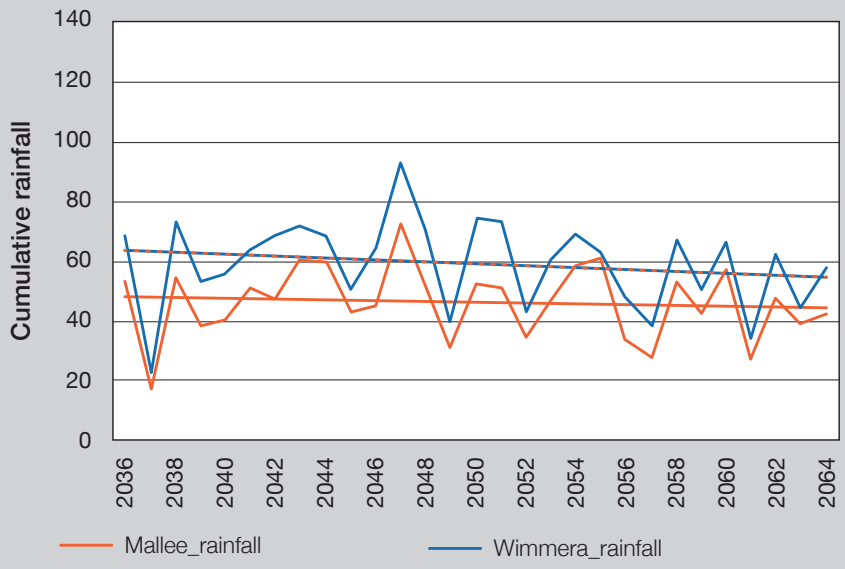
These contrasting outcomes under the two scenarios, raise the important question of which climate scenario is the most likely to eventuate over the coming decades. Are we more likely to see a 'Warmer and Wetter' scenario, or a 'Hotter and Drier' scenario? Climatic projections in the recently released **IPCC (2021)** Australasia Factsheet indicate that a Hotter and Drier scenario is more likely to eventuate for Mallee and Wimmera. The negative impacts of the 'Hotter and Drier' scenario will be felt more in the Mallee than in the Wimmera. Yields may fall by up to 30% within the Mallee compared with a 11% fall in the Wimmera region.

IMPACTS ON FARM PROFITABILITY AND THE REGIONAL ECONOMY

Future economic impacts will be determined largely by the ability of farmers to adapt to climate change.

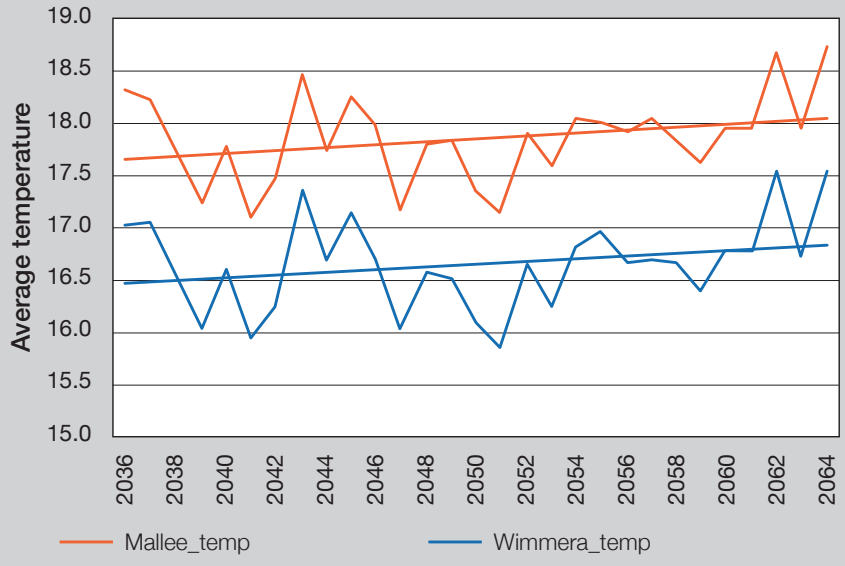
Hotter and drier scenario

Figure 2: Cumulative rainfall projections for 2036-2064.



Projected cumulative rainfall under a Hotter and Drier scenario for the Wimmera and Mallee region.

Figure 3: Average temperatures projections for 2036-2064.



Projected average temperatures under a Hotter and Drier scenario for the Wimmera and Mallee region.

Within the Wimmera and Mallee regions, it is typical for farms to diversify across a number of crops and enterprises. On average, farms within the Wimmera region earn around 30% of their income from wheat and about 20% from livestock compared to over 40% from wheat within the Mallee region, where livestock accounts for less than 5% of farm income. In Mallee, the share of non-wheat income increased significantly during 1993-2018. This indicates that farmers are diversifying revenue streams to increase farm resilience.

The impact of annual temperature and rainfall on farm profitability under climate change scenarios was also analysed drawing upon an analysis of historical records from 33 farms in Northwest Victoria for the period of 1993-2018 that incorporated farmers adaptive responses to

various weather shocks. The predicted impact of most weather variables on future farm profitability was similar to wheat yields, although farm profits tend to be more stable than wheat yields because of the diversified nature of farming systems. Non-wheat profits in the business partially offset the negative impacts of wheat yield decline.

The impact on the regional economy also depends on which climatic scenario eventuates and how effectively farmers can adapt to, and cope with, the effects of climate change. Without ongoing adaptation, a reduction in the average wheat yield under the 'Hotter and Drier' scenarios can be quite large, reducing annual regional GDP by up to 0.7-2.8%.

Historical data has shown that farmers in Northwest Victoria are very dynamic, adaptable, and innovative. The research results emphasise the need for continued R & D efforts and complementary measures to help farmers develop adaptation strategies to cope with climate.

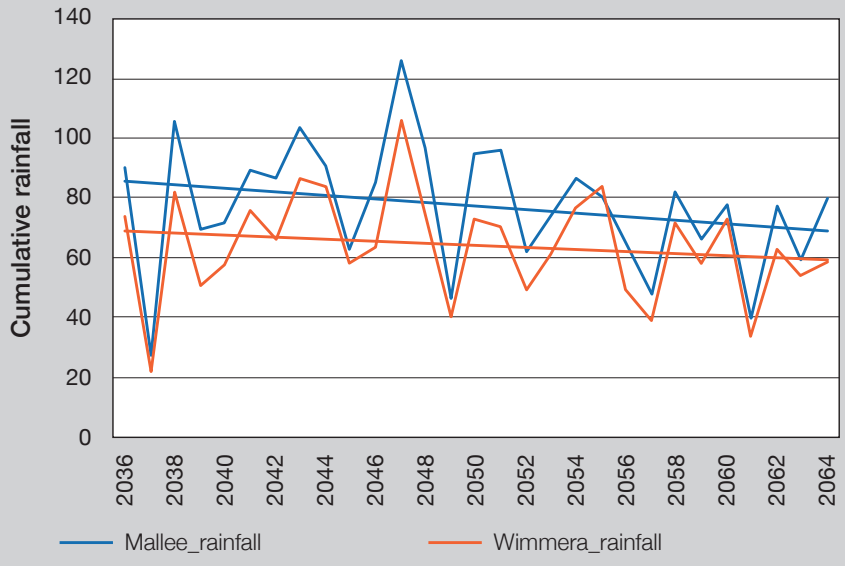
Farm adaptation strategies may include the following:

- Adopting new varieties, new cultivation practices and crop management strategies that are better suited to the new climatic conditions.
- Diversifying into other enterprises by reallocating farm resources to minimise the impacts of climatic variation.
- Accessing farm finance products and services to cope with increased levels of volatility.

Agronomic modelling has indicated that shortening the growing season to allow for faster crop development under more favourable conditions may be a potential adaptation option. In response to requests at a project workshop in March 2021, the project team used statistical models to assess the impact of changing sowing and harvesting dates. The results suggested that changing the wheat growing period from the 1st of May to the 15th of Nov may improve yields in the Mallee but not in the Wimmera region. These results will need to be confirmed by field trials and future R & D at a local level.

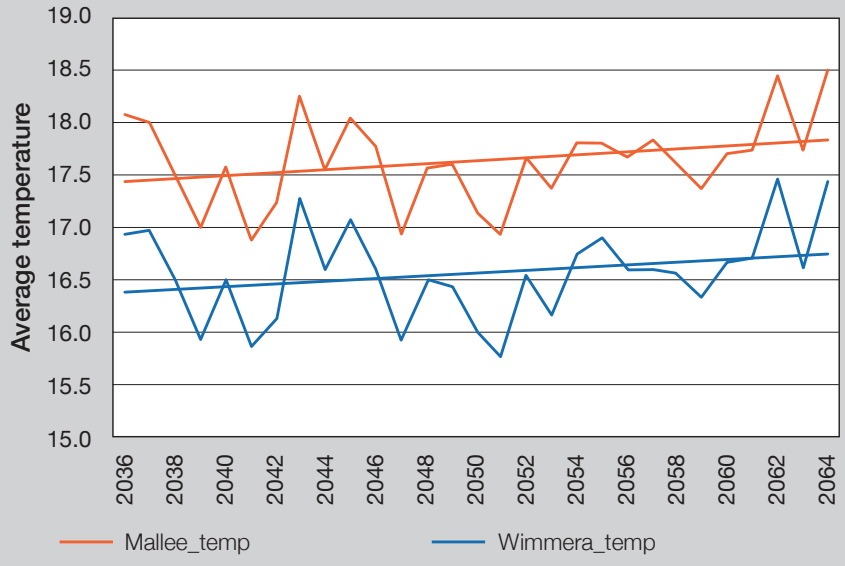
Warmer and slightly wetter scenario

Figure 4: Cumulative rainfall projections for 2036-2064



Projected cumulative rainfall under a Warmer and Slightly Wetter scenario for the Wimmera and Mallee region.

Figure 5: Average temperatures projections for 2036-2064.



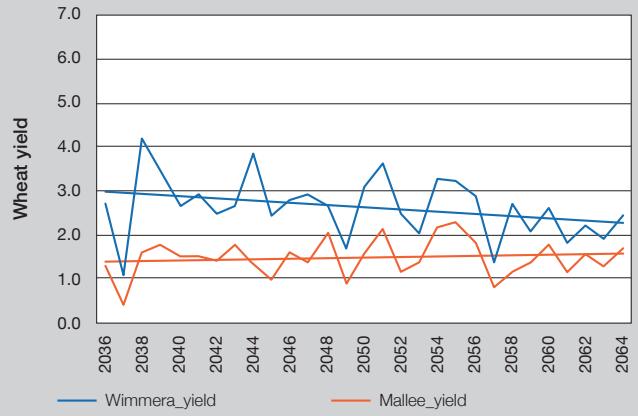
Projected average temperatures under a Warmer and Slightly Wetter scenario for the Wimmera and Mallee region.

Further crop diversification is another option. In the past, legumes were grown primarily for improving soil nutrition and pest control. But in recent years farms in Northwest Victoria, particularly in the Mallee region, have diversified by incorporating pulses (and other crops) into cropping rotations to target new markets, including export markets.

In conclusion, this research emphasises the need to prepare for declining future wheat yields and higher yield volatility in Northwest Victoria under a Hotter and Drier climatic scenario. There is every reason to be optimistic about the future of farming in Northwest Victoria, but it is important to plan for managing farm production within an increasingly volatile climate. History has shown that

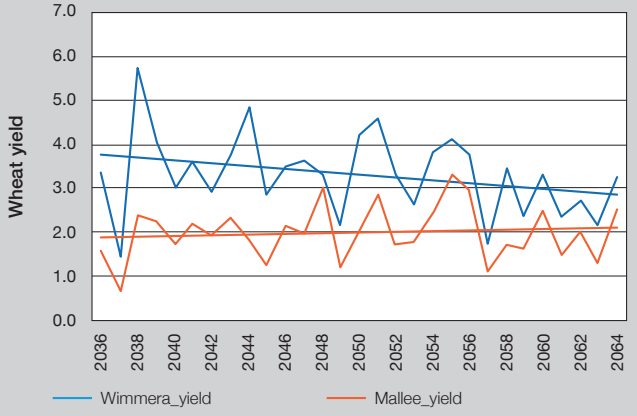
Yield projections for 2036-2064

Figure 6: Yield predictions under a Hotter and Drier scenario.



A combination of higher temperatures and low rainfall would result in a yield decline under a Hotter and Drier scenario.

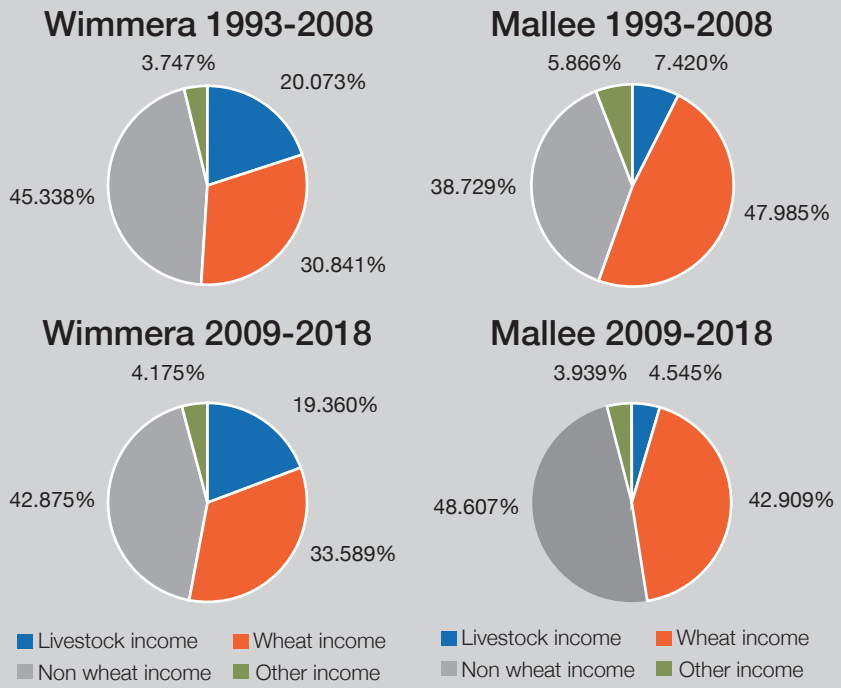
Figure 7: Yield predictions under a Warmer and Slightly Wetter scenario.



Under a Warmer and Slightly Wetter scenario yields are not so badly affected due to fewer freezing days, warmer temperatures, and better rainfall.

farmers have the ability to respond to changing climatic conditions and challenges, provided they can access more climate suited technologies to optimise production by managing risks. What is needed is a coordinated response from government, the scientific community, financial institutions, and the agricultural industry to ensure that farming communities can meet the challenge of a changing climate head on.

Figure 8: Revenue distributions for Mallee and Wimmera farmers from 1993-2018.



The shifting revenue distributions of Wimmera and Mallee farmers possibly due to adaptation.

CONTACT DETAILS

Professor Param Silvapulle
(General inquiries)
+61 3 99032237
param.silvapulle@monash.edu

Dr. Natalia Bailey
(Methodology)
+61 3 9905 9111
Natalia.Bailey@monash.edu

Associate Professor Anke Leroux
(Climate change & Farm Profitability)
+61 3 99034710
anke.leroux@monash.edu

LINKS

A). For methodology and analysis: https://www.monash.edu/business/ebs/research/publications/ebs/wp18-2020.pdf
B). For the technical report: https://www.monash.edu/business/cdes/our-research/climate-change-and-sustainability/_nocache

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