Cotton under a future climate

Dr Iain Hume[1], Dr James Lawson[2] and Dr Daowei Sun[3]

[1] NSW DPI, Wagga Wagga
[2] NSW DPI, Ourimbah
[3] NSW DPI, Narrabri

Key findings

- Preliminary projections for NSW suggest a warmer future climate that would be more suited to growing irrigated cotton if water was not limiting.
- More irrigation water will be needed to realise the potential of the future climate.

Keywords cotton, southern, climate, water, future

Introduction

The Vulnerability Assessment (VA) project is part of the NSW Primary Industries Climate Change Research Strategy (CCRS; https://www.dpi.nsw.gov.au/dpi/climate/about-dpi-climate/climate-change-research-strategy). The project assesses the relative impacts of climate change on 5 industry sectors: Extensive livestock, broadacre cropping, horticulture and viticulture, fisheries, and forestry. Several commodities are assessed in each sector; irrigated cotton is one of the 9 broadacre crops being examined. We chose irrigated cotton as the focus of this paper because it is grown throughout NSW, makes a significant contribution to the value of agricultural production and is likely to be sensitive to changes in climate. Irrigation water is more available in the south of the state and this combined with the release of longer season varieties has led to the increase in the area of cotton grown in southern NSW.

This paper examines the consequences of climate change for the production and water demand of irrigated cotton and compares its performance throughout NSW.

Site details

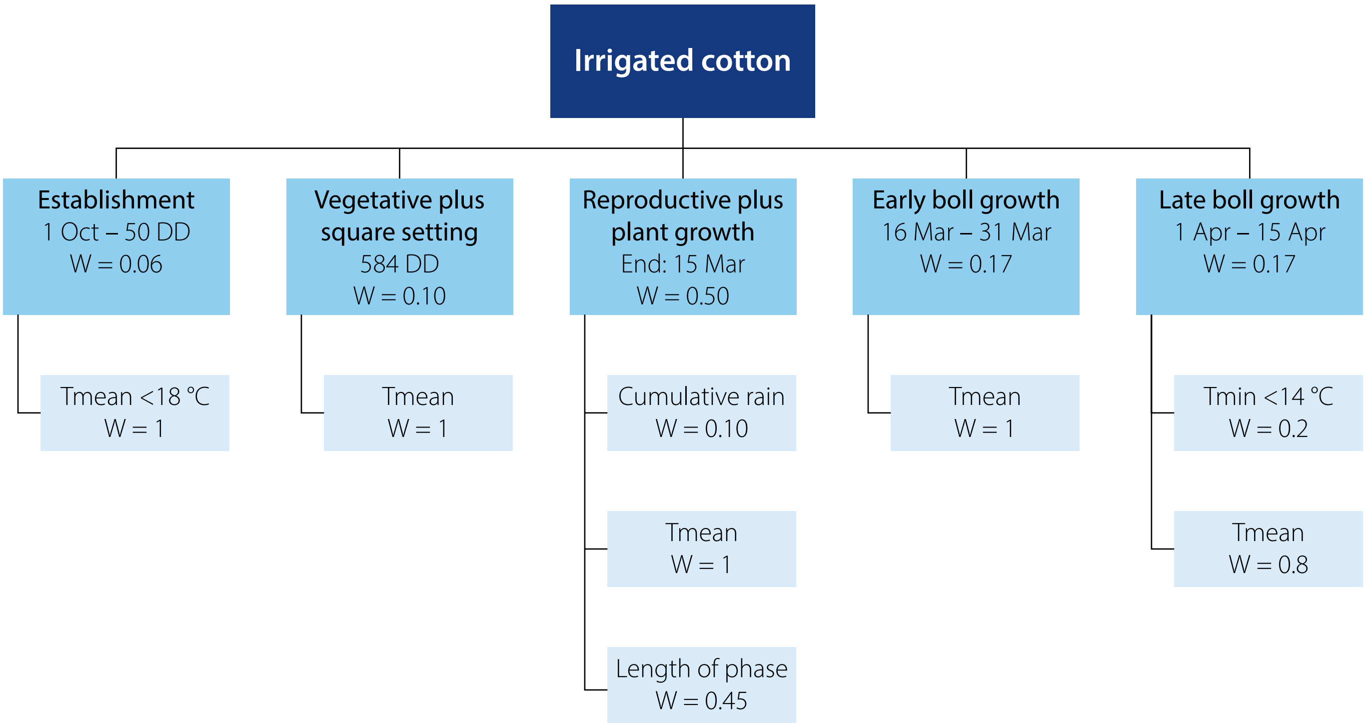
Location

The project assesses the impact of climate change throughout NSW.

Treatments

Multi criteria analysis model

A standard assessment method was applied to all commodities in the VA project so they could be compared. Multi criteria analysis (MCA) (Saaty 1990) was used because it is a decision-making analysis tool that evaluates multiple (conflicting) criteria to reach decisions. It focuses on what is important, is logical and is consistent. A hierarchical MCA model was developed that set out the key climate variables for each phase of irrigated cotton production. The MCA approach used an expert panel, or focus group, to critique the MCA design and to set the variable weightings in the model through a standard analytic hierarchy process (AHP) (Saaty 1990). The final model had 5 phases, fixed planting and harvest dates and a dynamic phenology driven by thermal time (Figure 1).



Note: Five phases and their duration either in degree days (DD) or chronological time are shown. The weight (W) or importance of each phase is indicated. The climate variables driving suitability during each phase are shown below the phase; where more than one variable is considered they are weighted according to their importance.

Figure 1 The MCA model of irrigated cotton.

Water demand

We modelled crop irrigation demand as the difference between effective rainfall and crop evapotranspiration. Thirty percent (30%) of rain falling in the fallow period of 15 April–1 October was carried over to growing season rainfall; 15% during establishment and 15% during vegetative plus square setting. During the growing season, 30% of effective rainfall (75% of total rain) during a phase was added to the rain falling during the subsequent phase.

Water supply

We have not explicitly considered water availability in this analysis, but the consensus is that climate change is expected to decrease irrigation water availability in southern NSW. Twelve NSW regional water strategies (https://water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies) are addressing this issue, the Lachlan, Murrumbidgee and Murray regional water strategies are well advanced and will be exhibited for community feedback during 2022.

Climate data

The MCA model was run using CSIRO climate change for Australia: Application ready data (CSIRO 2015). An historic baseline period (1981–2010) and future climate (2036–2065) were used. The future climate was predicted using 2 representative concentration pathways (RCPs). The first (RCP 4.5) predicts emissions will decline from 2040, the second (RCP 8.5) assumes emissions continue to rise. The median of 8 global circulation models that represent a range of plausible future climates was used.

Results

Climate suitability

Historically the climate of the western cotton growing region (Bourke) was highly suited to growing cotton, as was the western half of the northern region (Moree and Narrabri). The eastern portion of the northern region and the central valleys were also highly suitable for cotton growing, but the southern

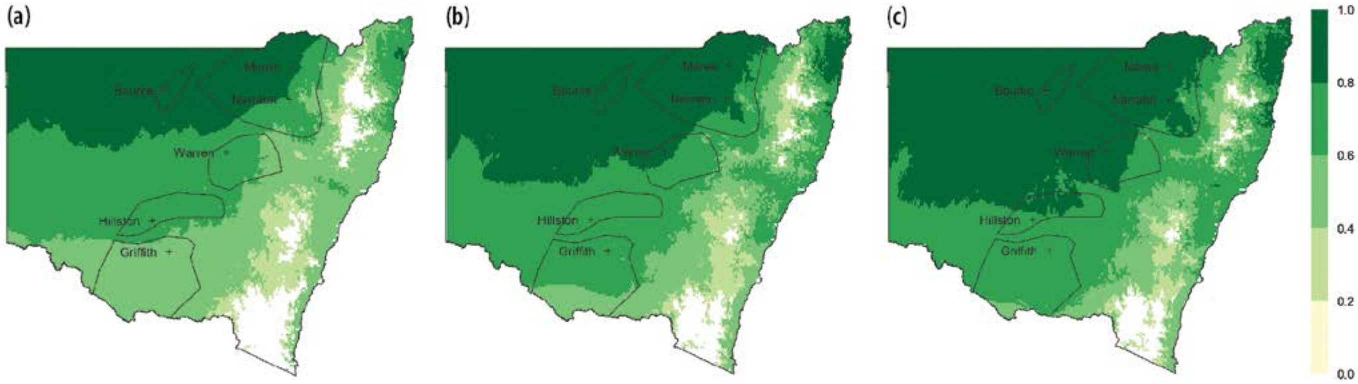


Figure 2 Preliminary maps showing the NSW climate suitability for growing cotton under (a) historic, and (b) RCP 4.5 and (c) RCP 8.5 predicted future climates.

Under both emissions scenarios, the suitability of all regions increased with a greater increase under the RCP 8.5 emissions scenario (figures 2b and 2c).

Each of the 8 global circulation models represents the future climate differently. This will result in a range of suitability scenarios predicted by the MCA model and is known as the uncertainty in our predicted suitability and will vary from place to place. In northern NSW increases in the suitability of the climate for cotton were smaller than in southern NSW (Figure 3). We have high confidence in these projections.

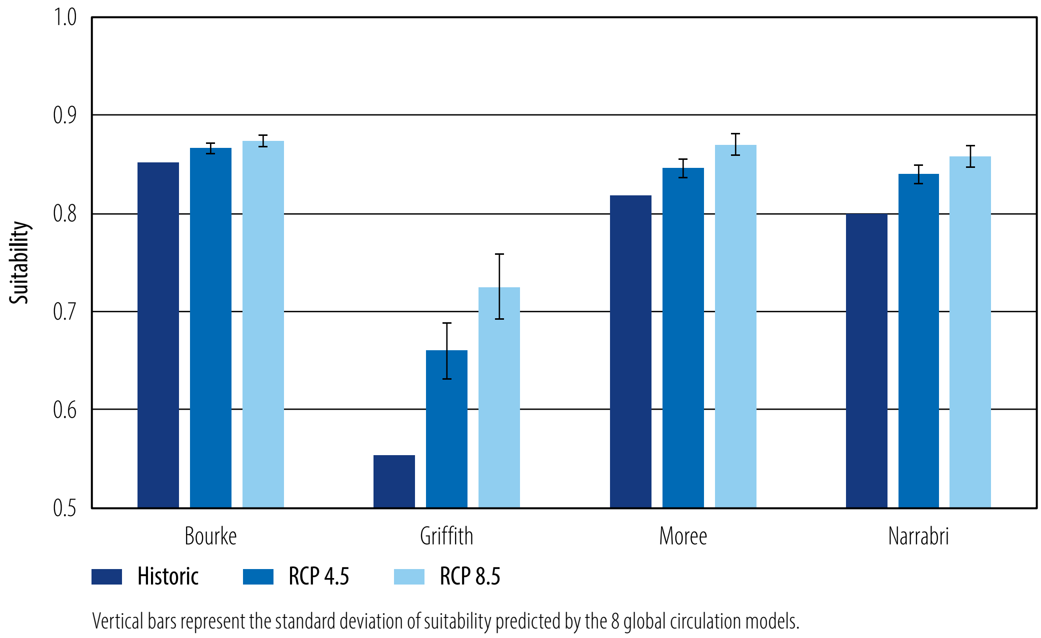
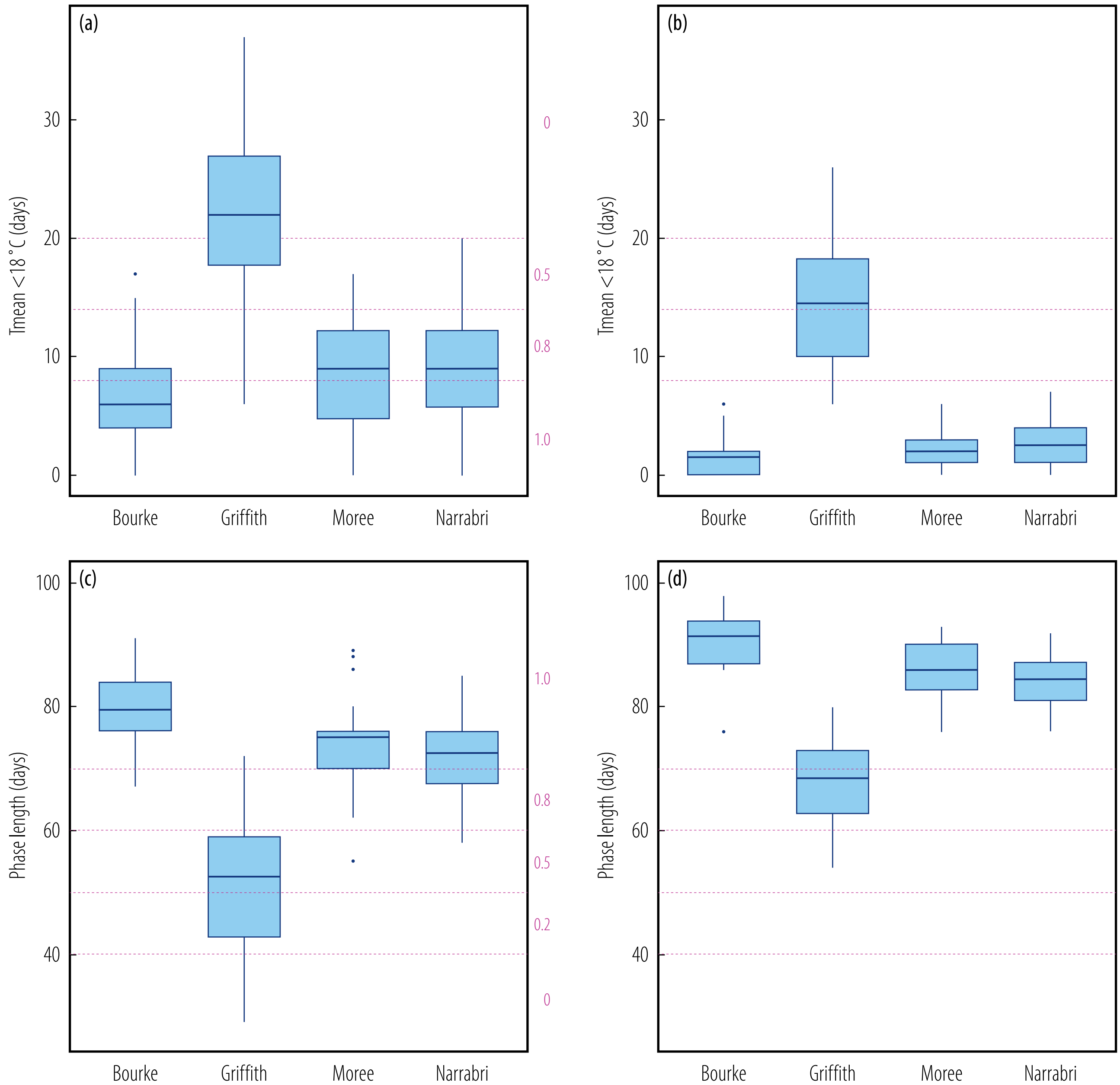


Figure 3 The suitability of the test locations under historic climate and that predicted under RCP 4.5 and RCP 8.5.

Increased temperature and more rapid crop development drive these improvements in suitability under future climates. This leads to earlier emergence due to fewer cold days during establishment and a longer period of reproductive growth when the plants set their yield potential (Figure 4). These changes are greater at Griffith leading to a larger change in suitability (Figure 3).



The pink numbers and dashed lines indicate the suitability classes.

Figure 4 The number of cold days during establishment at 4 key cotton growing locations under, a) historic and b) future climate projected under RCP 8.5; and reproductive phase length under, c) historic and d) future climate projected under RCP 8.5.

Water demand

Water demand increased under both future emissions scenarios (Figure 5). At all 4 test locations the increased water demand under RCP 4.5 was less than 1 ML/ha, but exceeded 1 ML/ha under RCP 8.5. Bourke had the highest water demand and the smallest change while Griffith had the lowest water demand but the greatest change in the future (Figure 5).

The uncertainty in water demand predicted by the 8 global circulation models was quite high at the 4 key cotton growing locations (Figure 6). The uncertainty was greater under RCP 8.5, the high emissions scenario.

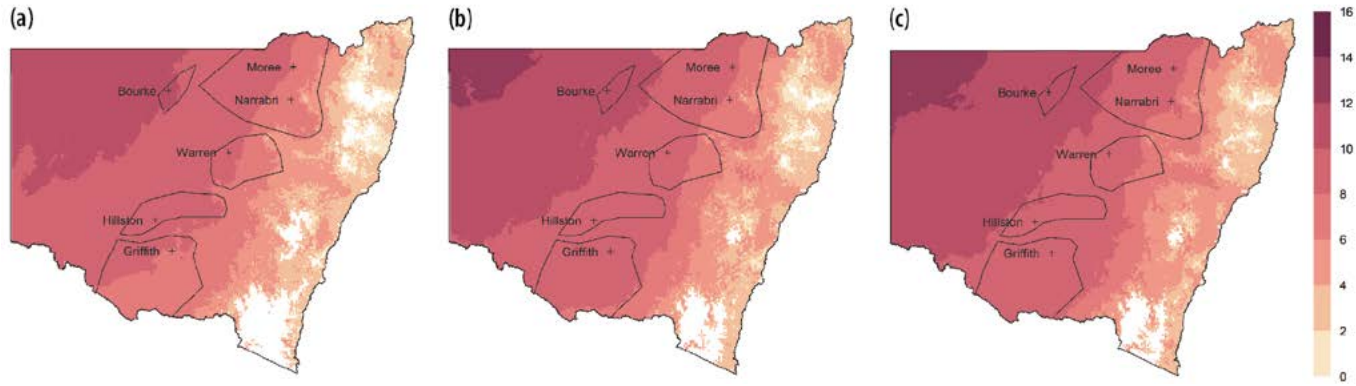
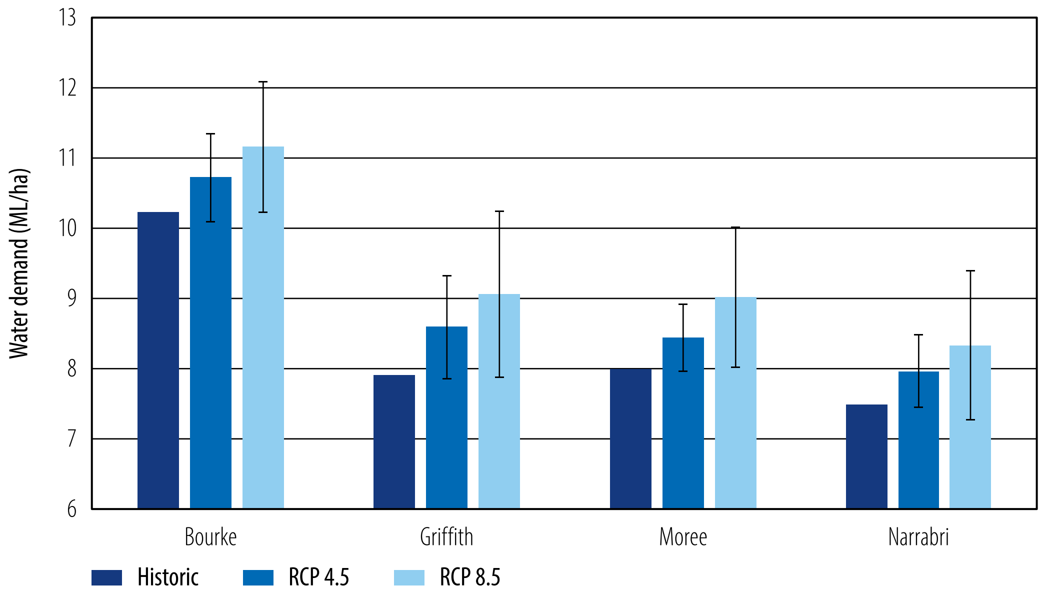


Figure 5 Preliminary maps showing the water demand (ML/ha) under (a) historic, and (b) RCP 4.5 and (c) RCP 8.5 predicted future climates.



Vertical bars represent the standard deviation in the water demand predicted by our MCA model under the 8 global circulation models.

Figure 6 The projected change in water demand at 4 key cotton growing locations.

Summary

The future NSW climate is projected to become more suitable to grow irrigated cotton under both RCP 4.5 and RCP 8.5 emissions scenarios. This change will be greatest in the south of the state. However, to realise these improvements irrigation water will be needed with more than 1 ML/ha additionally required under the RCP 8.5 scenario.

References

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Contact

Dr Iain Hume, Wagga Wagga Agricultural Research Institute, Wagga Wagga
iain.hume@nsw.dpi.gov.au
0419125308