Inquiry into the impact of climate change on Queensland agricultural production

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THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Research and Innovation

22 August 2023

Ms Margaret Telford
Committee Secretary
State Development and Regional Industries Committee
Parliament House
George Street
Brisbane Qld 4000

Dear Ms Telford,

Following a site visit by the State Development and Regional Industries Committee to the UQ Long Pocket Precinct on 31 May 2023, The University of Queensland (UQ) welcomes the opportunity to provide additional input into the inquiry into the impacts of climate change on Queensland's agricultural production. Across all disciplines, UQ is one of Australia's top research-intensive universities, consistently ranking in the top-50 global universities year-on-year, and with 100% of research rated as at or above world standard in the 2018 Excellence in Research for Australia report. From the position as Australia's leading university in the field of agriculture, we offer the following comments in response to your consultation.

Climate change is and will continue to impact Queensland's agricultural production systems across scales including plants/animals, paddocks, farms, regions, industries, and sectors. Predicted changes in temperature, rainfall, extreme events, and carbon dioxide concentration result in a complex interplay of factors affecting distribution, yield, health, pests, and disease. There will be some gains, some losses, and a great deal of risk and uncertainty as the sector adapts to the changes.

Sector scale changes

The warming climate and more frequent extreme heat events will be one of many contributors to changes in the cropping systems present in a geographical region. Recent examples of regional cropping system changes include the expansion of the cotton growing region into Victoria and the transition from sugar to horticultural crops such as macadamia and avocado taking place around Bundaberg.

The development of greenhouse infrastructure is shifting some high value crops south, and the impact of climate change may make parts of Queensland unsuitable to grow some crops. For example, with increases in temperature and accelerated extreme weather events, species such as strawberries may be challenged. Indoor farming offers a solution where farmers can grow continuously year-round independently of external conditions and avoiding disease consequences. Investment in indoor and vertical farming is a risk mitigation response as well as an opportunity for Queensland to expand production into crops that don't grow in this climate.

Diversification is a key adaptation strategy. Drought in existing southern cotton production areas, new incursions of pest and disease, climate variability and emerging environmental markets are central drivers for diversification of North Queensland farming systems. Consultation with farmers in the region has led to research investigating 1) cotton as a pillar crop that is sufficiently profitable to justify funding of farm development needed to establish cropping, 2) rotation crops for local cattle feed markets and rehabilitating degraded soil to buffer dry spells during the following cotton crop rotation and 3) improving existing beef systems drought resilience, cattle market options and decreasing methane emissions with locally grown cattle feed that replace imported soybean meals required for existing feed supplements. This research is being undertaken through the Cooperative Research Centre for Developing Northern Australia.

Impacts on crops

UQ assesses climate impacts on crops through data analytics and computational modelling, glasshouse experiments and field trials. UQ is a founding member (as is the Queensland Government) of the APSIM initiative, which over 30 years has become a world-leading platform for the modelling of cropping systems. UQ is currently investing more than $80M in research infrastructure for the study of climate influences on crops including the Plant Growth Facility at St Lucia and new glasshouse facilities at Gatton. UQ has partnered with the Queensland Department of Agriculture and Fisheries to become a northern node of the Australian Plant Phenomics Facility (through Commonwealth NCRIS funds). This is in addition to the Queensland Department of Agriculture and Fisheries partnership supporting QAAFI, including in climate related research.

Impacts on crop adaptation

- There can be a significant loss of yield if crops are exposed to high temperatures at the wrong time. Drought has long been a focus of breeding and management research and farmer decision-making in northeast Australian grain cropping, given the high perceived costs of drought in this region. Our research shows that drought will continue to play an important role in the two main grain crops of the region (wheat and sorghum). Heat directly impacts the yield of these crops when it coincides with flowering and grain set, causing abortion of grains. There is some expectation that the combination of increasing CO_2 and associated climate changes is likely to gradually reduce the drought exposure. In contrast, the occurrence of temperatures high enough to impart significant direct damage to these crops is increasing. We estimate that aggregate yield impacts of direct heat stress by mid-century may equal drought impacts for wheat and be as much as half as important as drought for sorghum. These results indicate that efforts to adjust sorghum and wheat systems (including development of new varieties) to cope with (or escape) extreme heat will be an important part of agricultural adaptation to climate change in this region; a continued focus on drought will not be enough.[1]
- Warmer temperatures already reduce the life cycle of wheat and will cause flowering to be 2-3 weeks earlier by 2030. To allow earlier sowing to escape frost, heat, and terminal drought, and to maintain current growing period of early-sown wheat crops in the future, breeders will need to develop and/or introduce new genetic sources for later flowering, more so in the eastern part of the wheatbelt.[2]

Summary of selected key impacts of climate and adaptation in Grains

Climate change causes an increase in:	Which impacts crops (and systems) via:	With potential adaptation via:
Average daily temperature	Accelerating development with less time to photosynthesise (accelerating carbon breakdown in soil)	Genetic selection for 'slower' development; Adaptation of sowing date
Average minimum (night-time) temperature	Increased respiration - reduced net CO_2 assimilation	Genetic selection (though not large)
Frequency of temperature extremes (especially heat)	Increased tissue death, increased pollen sterility and grain abortion, decreased grain size	Genetic selection for heat (good prospects) and frost (less prospect) tolerance; shifting phenology
Frequency of extreme rainfall	Changes in drought patterns (increased erosion and runoff)	Modifying phenology and agronomy to adapt
Increased CO_2 concentration	Increased growth rate (risk of using water too fast) (accelerating carbon breakdown in soil)	In high rainfall, accept the benefits. In low rainfall, benefit of increased transpiration efficiency, but at risk of using too much water.

Crop adaptation requires breeding that keeps pace with climate change. Continued investment in plant breeding and exploration of novel genetic resources is essential to support the delivery of adapted varieties to growers. The spatial extent of potential impacts and the financial benefits of these investments can be modelled at farm and regional scales using approximations of future climate scenarios. These types of models are also routinely utilised to support decision-making within season and can be extrapolated to provide information about

[1] Lobell, D.B., Hammer, G.L., Chenu, K., Zheng, B., McLean, G. and Chapman, S.C. (2015), The shifting influence of drought and heat stress for crops in nor heast Australia. Glob Change Biol, 21: 4115-4127. https://doi.org/10.1111/gcb.13022

[2] Zheng, B., Chenu, K. and Chapman, S.C. (2016), Velocity of temperature and flowering time in wheat – assisting breeders to keep pace with climate change. Glob Change Biol, 22: 921-933. https://doi.org/10.1111/gcb.13118

likely impacts on the distribution of production, and consequences for local and international supply chains.

Impacts on crop disease

Many direct and modelling studies have been undertaken assessing the potential impact of climate change on plant-pathogen interactions both with regards to increasing CO_2 levels (e.g., using Free-Air Carbon dioxide Enrichment (FACE) experiments) and increasing temperature. The predictions are varied depending on the type of host-pathogen interactions (biotrophic versus necrotrophic) or whether it is an annual or perennial crop. These changing conditions will directly impact growth of the host plant in some cases increasing vigour and, in some cases, the contrary. The growth of the pathogen will also be affected and may in some cases lead to a reduction in disease and in other cases and increase in disease level associated with increased inoculum. As conditions change there will also be expected geographical shifts in cropping areas which will then expose crop plants to new pathogen populations to which they may have little protection. The changes in environmental conditions may also affect between season survival rate of pathogens, leading to increased inoculum at the start of the next season providing a jump start to an epidemic. Increasing temperate may lead to more cycles of the pathogen per year and with that increased genetic variants with abilities of overcoming genetic resistance in the crops or in developing resistance to fungicides. On the other hand, with increased temperature and CO_2, the crop may mature faster and then be in the field over a shorter period and so not as exposed to pathogen damage.

For broad acre cropping systems, screening germplasm versus potential pathogens using controlled environment systems (temperature and FACE) would allow selection and development of cultivars suited to the predicted warmer environment.

Impacts on livestock and poultry

Research shows that the impact of climate change is complex. There will be cascading effects of climate change across the domains of animal nutrition, animal behaviour, physiological changes, animal wellbeing, as well as on the sustainability of environment, economic, and human health and welfare. Climate change will impact further on water availability, pasture and forage availability and quality, and animal disease and pest distribution. There is also the likelihood of increased zoonotic diseases.

Heat load is an increasingly frequent problem, where higher temperatures experienced by animals are exacerbated by high solar radiation, high relative humidity, and low wind speed. Warmer temperatures overnight don't allow the animals relief from the conditions, so strategies for heat abatement at night especially for dairy cows may be useful. Heat stress in dairy cows can reduce milk production by up to 35% as well as reduce immune function, reproductive efficiency and calf health. [3] Poultry are particularly vulnerable to heat stress as they have limited capacity for heat regulation. Just four days of hot conditions resulted in higher cases of necrosis in chickens – reducing their quality of life and meat.[3]

Climate variability is impacting reproduction efficiency of livestock in the grazing sector through lower rates of conception, failed pregnancies, and lower survival rates of calves. In addition to this challenge, the grazing sector is vulnerable to climate impacts on pasture and forage availability and quality. There are many variables that are poorly understood, including the behaviour of grazing animals themselves which make it difficult to provide useful advice for graziers to adapt to the changing climate.

Adaptation strategies include adjusting the environment (e.g., sunshades, sprinklers), nutritional manipulation, new pasture varieties, selective breeding for tolerance, and changing geographical distribution of species.[4] The grazing sector is particularly vulnerable as environmental controls are not always feasible. For example, planting trees for shade can cause additional problems if the trees that will grow in that location are not native and have potential to become weeds.

[3] Joseph, Joe; Charalambous, Renae; Pahuja, Harsh; Fox, Dylan; Jeon, Jiwoo; Ko, Ning-Yuan; Rao, Nishit; Wang, Zhiheng; Nerurkar, Sneh; Sherekar, Sharvari; Yang, Yifei; Dutton-Regester, Kate; Narayan, Edward, 'Impacts of climate change on animal welfare,' CABI Reviews, 21 July (2023). DOI: 10.1079/cabireviews.2023.0020

[4] Gaughan, John B., Sejian, Veerasamy, Mader, Terry L. and Dunshea, Frank R. (2019). Adaptation strategies: ruminants. Animal Frontiers, 9 (1), 47-53. doi: 10.1093/af/vfy029

Rapid dissemination of superior genetics that will allow the breeding of livestock tolerate to changing environmental conditions is the key to adaptation. Selecting animals that are more tolerant usually comes at a cost of lower productivity. It is important to identify genetic capacity in livestock that will be productive in harsh conditions as this will improve economic viability and overall sustainability in changing environmental conditions. Supporting commercial deployment of rapid evaluation of animal genetics for breeding is needed so graziers can make quick changes to their herd.

Transition to net zero

Impacts of the transition to net zero carbon emissions will be felt by the agriculture sector as a result of their own abatement activities, as well as mitigation efforts from other sectors and the resulting competition for land. The Net Zero Australia[5] project undertaken by UQ with the University of Melbourne, Princeton University and Nous Group shows that abatement in land sector will be essential, with the modelling suggesting that the land sector would require offsets, not become a source of them. “Farming areas face many impacts from decarbonisation.

- Afforestation as an abatement measure will affect many farms, as will converting to farm machinery, household appliances, vehicles that use clean energy, and managing animal waste.
- Many farms in Renewable Energy Zones (REZs) will host wind or solar farms or transmission lines. The impact of renewable infrastructure on farming varies from minor to significant, depending on the type of infrastructure and farm.
- Farm communities in REZs will compete for labour with companies developing clean energy projects and will share roads with large loads during construction. Some farms may need to reduce enteric emissions.
- Divisions between regional and urban areas may compound as regions face disproportionate impacts from the transition and climate change.
- Rental payments for hosting infrastructure will give landowners an independent and stable income, and revegetation can provide wider benefits to farm production. Global decarbonisation and reduced climate variability should reduce long-run risks to farm viability.”[5]

UQ is a lead organisation in the Zero Net Emissions Agriculture (ZNE-Ag) CRC[6] bid, which is a multi-stakeholder approach to transitioning Australian agriculture to net-zero, healthy, resilient, and profitable food systems by 2040. ZNE-Ag CRC will create large scale action through integrated frameworks to accelerate industry-led research, development, adoption and commercialisation of science and technology-based solutions at scale. Mitigation solutions will focus on low-emissions plants, towards methane-free cattle and sheep, whole-farm and mixed enterprise systems analysis, and delivering value from net zero.

Another example of the diverse sources of emissions in the land sector that will need to be reduced, large, artificial water bodies currently accounts for 5% of global anthropogenic methane emissions.[7] In contrast, the role of small artificial water bodies (stock watering dams and ring tanks) is very poorly studied but highly relevant to the Queensland agricultural sector given its dependence on surface water storages for stock watering and irrigation. Ongoing research at UQ has shown small artificial water bodies in Queensland alone emit over 1.6 Mt CO_2 equivalent per year, representing 10% of the state's entire land use, land use change and forestry sector emissions[8] and this is likely to be over 30% when larger water bodies are included. Emissions from flooded land is predicted to increase based on the construction of new reservoirs as well as from the twin threats of climate change and eutrophication.[9]

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[5] https://www.netzeroaustralia.net.au/ “How to make net zero happen”, Mobilisation report, July 2023
[6] https://zneagcrc.com.au/
[7] Beaulieu, J.J., DelSontro, T. & Downing, J.A. Eutrophication will increase methane emissions from lakes and impoundments during the 21st century. Nat Commun 10, 1375 (2019). https://doi.org/10.1038/s41467-019-09100-5
[8] Grinham, A., Albert, S., Deering, N., Dunbabin, M., Bastviken, D., Sherman, B., Lovelock, C. E., and Evans, C. D. The importance of small artificial water bodies as sources of methane emissions in Queensland, Australi. Hydrol. Earth Syst. Sci., 22, 5281–5298 (2018). https://doi.org/10.5194/hess-22-5281-2018
[9] Soued, C., Harrison, J.A., Mercier-Blais, S. et al. Reservoir CO_2 and CH_4 emissions and their climate impact over the period 1900–2060. Nat. Geosci. 15, 700–705 (2022). https://doi.org/10.1038/s41561-022-01004-2

Farmers will require support to overcome challenges and benefit from the opportunities of decarbonisation. The Net Zero Australia project recommends the following actions in the land sector by 2030: [5]

- **Research and develop plans for land sector abatement, including technologies, farm practices, and policy mechanisms.**
- **Begin scaling up prospective abatement pathways, particularly revegetation, by expanding advisory and nursery services to farmers.**
- **Plan net zero transitions for all sectors on the expectation that the land sector will be a net purchaser of offsets**

Thank you again for the opportunity to comment as part of this inquiry.

Yours sincerely

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