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Attributing climate change impacts on wheat yields in northern India during the heatwave year 2022

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Abstract

Extreme weather events are an increasingly important driver of crop yield losses worldwide. Wheat - central to India's food and nutrition security - is highly sensitive to terminal heat stress. In 2022, an early-onset heatwave affected wheat cultivation in its terminal growing phases in northern parts of India, leading to a substantial yield decrease, followed by an imposed export ban on wheat due to domestic food security concerns.

Attribution science is an emerging field that establishes a causal link between climate change and its consequences. While there is robust evidence that anthropogenic climate change has amplified weather extremes, few studies have explicitly attributed observed extreme event related crop losses to anthropogenic climate change. This lack of impact attribution studies limits the evidence base for risk management, adaptation planning, and climate policy.

This study investigates the impact of anthropogenic climate change on wheat yields during the heatwave in northern India in 2022 for the two major wheat-producing states, Punjab and Haryana. We apply a probabilistic climate impact attribution approach and compare simulated yield distributions under a factual (world with climate change), counterfactual (world without climate change) and future climate scenarios. We use downscaled and bias-adjusted CMIP6-based climate data from five climate models. Simulated yields are generated with a crop model ensemble (APSIMx, DSSAT and InfoCrop), allowing for a robust analysis and accounting for crop model uncertainty.

Preliminary results show that climate change did not significantly influence the probability of a low-yield event such as the 2022 yield event, because elevated CO_2 in the factual scenario compensates for the detrimental effects of increased heat stress. In future scenarios, however, increasing heat stress is expected to outweigh potential CO_2 fertilisation benefits, leading to an increased probability of low wheat yields in both the near and far future.

This study advances climate impact attribution by providing a probabilistic, model-based assessment of how anthropogenic climate change influences crop yield risks. By demonstrating that rising heat stress is likely to increase the probability of low wheat yields in the future, this study provides critical evidence to inform climate-resilient agricultural policy and adaptation planning.

Keywords: Apsim, climate impact attribution, heat, india, terminal heat stress, wheat

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