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Impact of climate change on paddy yield in rainfed agriculture system

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Abstract

Climate change poses several risks to agriculture in India, which is vital to food security and the livelihoods of more than half of India's people. Odisha, a coastal rice-producing state in eastern India with high climate fluctuation and considerable physiographic diversity consisting of coastal plains, central plateaus, hilly areas and western undulating uplands, is heavily reliant on the monsoon. Bridging the research gap, the study provides the relative importance of moisture persistence, temperature extremes and their spatio-temporal interconnections with paddy productivity at subdistrict scales in Odisha.

The climate-yield connections for paddy across Odisha, India is quantified using annual block level yields (1995–2023) together with rainfall and temperature indices. Rainfall and temperature indices were calculated from daily India Meteorological Department (IMD) gridded data based on regular IMD operating thresholds and ETCCDI definitions. Detrended and standardised yield series were used to extract climate-driven variability. Climate impacts were assessed through lag diagnostics, two-way fixed-effects panel regression, non-linear threshold modelling, and rolling-window estimation. Spatial risk was summarised by a Composite Climate Vulnerability Index (CCVI).

The results suggest that, despite long-term high yield growth, paddy production has been highly sensitive to climate variability and extremes. The climate-driven fluctuations remain substantial, with detrended anomalies frequently exceeding ±50 %. Drought-year yield losses are strongly spatially structured, exceeding 9–10 % in interior plateau and undulating zones but limited to 2–4 % in coastal plains, reflecting contrasts in irrigation access and soil-moisture buffering. CCVI results identify persistent vulnerability hotspots in western and interior tableland zones, whereas coastal regions remain comparatively buffered. This work demonstrates that there is a high degree of regional variability in vulnerability, suggesting that state-wide uniform approaches to adaptation are unlikely to be beneficial. Instead, adaptation should be regionalised in terms of combinations of climate exposure-yield sensitivity. These findings highlight the necessity for region-specific climate-smart adaptation measures in rainfed agricultural systems to achieve climate resilient agriculture.

Keywords: Agricultural vulnerability, climate change, climate change adaptation, climate vulnerability index, paddy yield vulnerability, rainfed agriculture

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