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Editorial: Addressing climate change in agriculture and natural resources with a focus on adaptation and extreme events

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Editorial on the Research Topic

Addressing climate change in agriculture and natural resources with a focus on adaptation and extreme events

Introduction

As climate change accelerates, agriculture and natural resources face growing threats, not merely from gradual shifts in temperature and precipitation, but also from more frequent and intense extreme events, variability, and compounded stresses. Addressing these challenges requires more than technical fixes; it requires region- and crop-specific strategies, innovative management practices, and attention to social and institutional dimensions of resilience.

The Frontiers Research Topic “*Addressing Climate Change in Agriculture and Natural Resources with a Focus on Adaptation and Extreme Events*” brought together insights from climate projection, field-based assessments, farmer perceptions, and institutional decision-making. The five accepted articles highlight the diverse ways climate risks manifest and the adaptive response being developed across different contexts.

The first article, *Simulating Future Climate Changes in Ghana’s Black Volta Basin* (Kabo-Bah et al.), demonstrated the effectiveness of bias-corrected CMIP6 projections under four SSP scenarios. It revealed significant warming and seasonal rainfall decline by mid-century, with severe implications for agriculture, water resources, and hydropower. The study recommends drought-resistant crops, improved water management, and climate-resilient infrastructure to buffer these risks.

In China, *Assessment of Extreme Climate Stress across Maize Harvest Regions* (Chen et al.) showed that bias-corrected CMIP6 ensembles effectively capture the intensity and frequency of extreme heat and precipitation. Heat stress is projected to increase

consistently, particularly under high-emission scenarios, highlighting the need for localized adaptive management strategies. Complementing this, *Effects of Sand-Dust Weather on Cotton Fields* (Gao et al.) quantified microclimatic impacts of dust storms, revealing significant wind fluctuations that affect crop stress and soil loss, offering guidance for hazard mitigation.

The social and institutional dimensions are addressed by two articles. *Factors Influencing Urban Farmers' Intention to Adapt in Addis Ababa* (Getu et al.) applied Protection Motivation Theory, showing that perceptions of climate risks, incentives, self-efficacy, and social norms strongly drive adaptation behaviors. The study recommends strengthening institutions, farmer training, early warning systems, extension services, and financial access. Meanwhile, *Advancing Decision Support for Climate Adaptation in California* (Ikendi et al.) surveyed technical service providers, identifying gaps in data translation, visualization, community engagement, and equitable deployment of decision tools, emphasizing the need for context-sensitive support systems.

Together, these contributions reflect a balanced mix of climate modeling, field observation, behavioral analysis, and institutional analysis, spanning geographies (Ghana, Ethiopia, California, China), scales (from local field to basin to institutional), and methods (quantitative modeling, survey, field observation, qualitative discussions).

Gaps and under-addressed areas

Despite these advances, several gaps constrain actionable adaptation. First, the capacity to predict seasonal and interannual variability remains limited: many systems lose skill beyond one to 2 weeks, leaving little actionable guidance for managing droughts, heatwaves, or wildfires beyond those 2 weeks. Operational skill in the 2-week to monthly (seasonal) period remains weak in many regions, particularly for precipitation forecasts (Robertson et al., 2020; Yin et al., 2023). Moreover, most climate modeling works remain narrowly sectoral and rarely incorporate cross-sectoral dynamics. Consequently, advances in climate modeling seldom translate into actionable farm-level decision support, limiting adoption. This gap is further reinforced by institutional tendencies to prioritize technical specialists over boundary spanners, professionals who can bridge research, facilitation, and decision-making (Bednarek et al., 2018; Cross et al., 2022; England et al., 2018).

Second, compound and cascading events, such as drought followed by heat and wildfire, or flood combined with pest outbreaks, are still underexplored, even though they pose growing real-world risks (Ebi, 2025; Haqiqi et al., 2021; Schillerberg and Tian, 2024; Tripathy et al., 2023; Walden et al., 2023).

Third, scale and heterogeneity constrain adaptation, as local lessons are difficult to generalize, and cross-scale dynamics are often missing (Berger et al., 2019; Fossa et al., 2021; Holman et al., 2019; Maciejewski et al., 2015).

Fourth, while governance framework and equity are frequently discussed but less often operationalized, with insufficient emphasis on implementation that addresses the needs of marginalized groups,

women, and small-holder farmers (Araos et al., 2021; Cannon et al., 2024; Chu and Cannon, 2021).

Fifth, monitoring, evaluation, and adaptive learning need to be improved across scales, to learn from failures, and build cumulative knowledge (Dupuits et al., 2024; Goodwin and Olazabal, 2025; Sparkes and Werners, 2023; UCFCCC, 2023).

Implications and way forward

To enhance impact, research and practice should prioritize developing integrated climate-extreme forecasting tools spanning sub-seasonal to decadal time scales, directly linking to practical agricultural decisions such as planting schedules, irrigation planning, and insect-pest control. Analyses of compound and cascading events are necessary to develop multi-risk adaptation strategies that mirror real-world conditions. To bridge research and practice, professionals are needed who combine data and scientific expertise with facilitation skills to work with farmers, translating research into actions. Equity and vulnerability assessment must explicitly identify and document who benefits and who is left behind. Monitoring and feedback systems should be strengthened to support continuous learning and cross-site knowledge exchange. Finally, effective policies, innovative institutions, and accessible technologies are critical to convert research into practical, scalable, and socially inclusive adaptation.

Conclusion

The five articles collectively demonstrate the breadth and depth of climate change adaptation research, from projections in Ghana and China to social and institutional studies in Ethiopia and California. They reveal progress in modeling, field measurements, behavioral understanding, and decision support, while also highlighting persistent gaps in extremes prediction, compound stress integration, scalability, and equity. Addressing these gaps requires bridging robust climate science with participatory, inclusive, cross-sectoral, and adaptive approaches. Agricultural and natural resource systems can achieve long-term resilience to climate change only by connecting predictive models, local knowledge, governance, and practical decision support.

Author contributions

PJ (First author): Formal Analysis, Project administration, Funding acquisition, Supervision, Validation, Writing – review and editing, Methodology, Visualization, Data curation, Software, Investigation, Writing – original draft, Conceptualization, Resources. PJ (Second author): Writing – review and editing. SM: Writing – review and editing. SN: Writing – review and editing.

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