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The role of crop and farm system modelling in supporting agricultural resilience and sustainability in sub-Saharan Africa: A systematic review

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Abstract

Agricultural systems in Sub-Saharan Africa (SSA) are increasingly challenged by climate variability, soil degradation, and resource constraints—factors that threaten food security and rural livelihoods. Crop and farm system modelling has emerged as a valuable tool to assess these challenges and to support scientific explorations of climate change adaptation options, climate risk management, on-farm nutrient management, and sustainable resource use. However, the extent to which these modelling efforts drive tangible, positive change remains insufficiently explored. This systematic literature review analysed 54 studies using the search terms “system model,” “positive change,” and “Sub-Saharan Africa” and their synonyms, on the application of crop and farm system models in SSA, focusing on their role in addressing climate risks, adaptation strategies, and broader sustainability goals, including soil health, water management, and farm productivity. The review highlighted that climate change adaptation was the most frequently addressed issue, particularly for cropping systems. While nearly half of the studies involved some form of non-scientist participation, only 20% reported direct engagement with decision-making stakeholders. Although most studies aimed to predict and forecast agricultural responses to climatic conditions, a deeper understanding of SSA’s agricultural systems often emerged as the primary contribution. Studies incorporating stakeholder engagement tended to focus more explicitly on decision support, underscoring the importance of participatory approaches for informing policy and practice. The findings suggest that while system modelling enhances understanding of complex agricultural dynamics, its real-world impact depends on critical factors such as accessibility, integration with local knowledge, and alignment with decision-making processes. These insights highlight the urgent need for interdisciplinary and transdisciplinary participatory modelling approaches to allow science to effectively support resilient and sustainable agricultural development in SSA.

Keywords: Agricultural system modelling, climate adaptation, nutrient management, participatory approaches, Sub-Saharan Africa, sustainable agriculture