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Title: Modeling climate resilience in smallholder agricultural systems: an agent-based approach



While many definitions of resilience have been explored in agricultural development contexts, resilience is seldom assessed in quantitative modeling applications. Given the great risk that climate variability and shocks pose to smallholder farming systems, quantifying and identifying potential enhancements to future resilience is a priority. In this study we present and demonstrate a method for quantifying resilience in a smallholder agricultural system. Resilience is conceptualized as the extent to which region-wide food security is compromised by exposure to climatic shocks (vulnerability) and how quickly it recovers (rapidity). Through the use of an agent-based model, we quantify resilience of an Ethiopian smallholder farming system, and explore the resilience-enhancing capacity of selected development strategies, including access to seasonal weather forecasts, increased urban job availability, and access to irrigation. Agent-based modeling allows us to explore future resilience with explicit consideration of household-level behavioral feedbacks and inter-household heterogeneity, as well as explicit notions of risk and uncertainty, which are central when considering the effects of stochastic shocks on agricultural systems. Through this context-specific application, we show how the overall approach can be used to evaluate and prioritize policy interventions with respect to their effect on resilience. This is a critically-needed competency for a wide range of systems threatened by climate change and other external stressors. Our approach can ultimately be used by researchers and policymakers to (1) quantify current levels of resilience of agricultural systems, and (2) quantify the relative effects of development interventions on this resilience. As climate change threatens to increase the exposure of human-natural systems to climatic extremes, this necessitates a greater understanding of the effects of variability on these systems, as well as how this vulnerability can be reduced. Quantitative resilience assessment can help to complement the traditional focus on poverty reduction in agricultural development, and our approach works to bridge this gap.