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Coupled crop-system dynamics modelling for climate resiliency of agriculture in Guatemala

Julien Malard (1), Jan Adamowski (1), Azhar Inam (1), Héctor Tuy (2), Hugo Melgar-Quiñonez (3), and Xingyu Peng (1)

(1) Université McGill, Génie des bioressources, Sainte-Anne-de-Bellevue, Canada (julien.malard@mail.mcgill.ca), (2) IARNA, Universidad Rafael Landívar, Guatemala, Guatemala, (3) McGill Institute for Global Food Security, Sainte-Anne-de-Bellevue, Canada

Smalholder agricultural systems worldwide, and the food systems they support, face increasing pressures from climate change and socioeconomic transformations. Climate change, in particular, has serious potential to deal both unexpected shocks as well as longer-term trends to smallholder farmers, and, as such, the concept of resilience to these threats is gaining importance as a method of measuring and ensuring sufficient adaptation.
System dynamics (SD) modelling can be a powerful tool to address the complex socioeconomic feedbacks that determine resilience in coupled human-environmental systems, and participatory SD model building in particular has shown strong potential to inclusively incorporate stakeholders in environmental management decision-making. More recently, the coupling of socioeconomic SD to physically-based environmental process models has allowed for the further (and stakeholder-friendly) incorporation of such processes as hydrology and climate change into the SD modelling framework, which had previously been very limited in terms of options to represent such complex environmental processes.
However, little research to date has used SD in the context of evaluating the resilience of smallholder agriculture production and food systems to climatic threats, nor how policy decisions' impacts may contribute to or detract from this resilience in the short and long term. Given the critical situation of many smallholder farming systems today in the face of climate change, such research could significantly contribute to the development of better informed adaptation policy decisions in a stakeholder-inclusive manner.
In this research, we use a case study from western Guatemala where a stakeholder-built socioeconomic SD model of smallholder farming communities was coupled with the cropping model DSSAT. Here rainfed and irrigated agriculture are both important by region and climate change-induced droughts are already exacting a heavy toll on agricultural production in several regions, many of whom also have persistently very high levels of food insecurity and child malnutrition (70% and higher).
We use Tinamït software to couple the models and also developed Taqdir, a Python package that allows seamless integration of stochastic current future weather scenarios generated by MarkSim from CMIP5 model outputs, to integrate future climatic trends and shocks from various RCP scenarios into the coupled model. Defining resilience in our context as the ability of smallholder farming and economic systems to ensure stable food security to the entirety of the region's population, we then use this approach to quantity 1) the resilience of smallholder farming systems in western Guatemala to expected climatic shocks and trends over the current century, 2) the potential of various stakeholder-identified policies to increase this resilience, and 3) differences in (1) and (2) across nearby farming communities employing different agricultural technologies and crops.