EGU21-6766, updated on 27 Jan 2022
https://doi.org/10.5194/egusphere-egu21-6766
EGU General Assembly 2021

Hierarchical Bayesian inference and spatial validation of socio-ecological system dynamics models: participatory modelling for Indigenous smallholder agriculture and food security in Guatemala

Julien Malard[1], Jan Adamowski[1], Héctor Tuy[2], and Hugo Melgar-Quiñonez[3]
[1]Université McGill, Génie des bioressources, Sainte-Anne-de-Bellevue, Canada (julien.malard@mail.mcgill.ca)
[2]IARNA, Universidad Rafael Landívar, Armita', Iximulew (Guatemala, Guatemala), C.A.
[3]Margaret A. Gilliam Institute for Global Food Security, McGill University, Sainte-Anne-de-Bellevue, Canada

Systems dynamics modelling is often used as a participatory modelling tool to model the long-term dynamics of socio-ecological systems, as well as to help in developing integrated policy decisions that take into account the unexpected and complex system behaviours that are often caused by the dynamic feedbacks between ecology and society. Actual use of these models in decision-making is, however, hindered by the frequent lack of high-quality temporal data on many key socioeconomic (and environmental) variables, which makes the application of traditional system dynamics model evaluation techniques difficult. This situation is particularly pronounced in the context of many Indigenous communities around the world, regions where improved access to decision support tools such as system dynamics modelling could be of particular use for supporting communities in their quest to make (and have implemented) their own resource management decisions. In the absence of rigorous quantification methods, however, these models are difficult to build and trust.

In this research, we present a novel methodology for calibrating hard-to-quantify relationships between socioeconomic variables of systems dynamics models. Based on hierarchical Bayesian inference, the methodology allows for the use of spatially explicit (but temporally poor) datasets to infer the quantitative, numerical relationships between socioeconomic variables, even when data in the precise region of interest is very scarce. We present, as a case study, a system dynamics model of small-scale agricultural systems and food security in two different regions of Guatemala (Tz'olöj Ya' and K'iche'), and analyse the impacts of different proposed policies in the face of socioeconomic shocks and water stress due to projected climate change. The hierarchical Bayesian inference calibration method allowed for the inference of key socioeconomic parameter values in a spatially explicit context to compensate for data scarcity, while spatial validation indicated which regions of the country the model was appropriate for.

Such a methodology, once incorporated into user-friendly system dynamics software, has the potential to facilitate participatory sociohydrological modelling even in quite data-scarce regions where modellers, up until now, have had to rely on educated guesses for the majority of the model's calibration.