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Looking ahead to 2100: Modeling Groundwater Management Scenarios under Climate Change Using the Stakeholder-Assisted Socio-Hydrological Modeling tool Tinamït

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Climate change impacts on environmental sustainability have shifted the focus of modern research and have resulted in the development of state-of-the-art integrated modeling tools that can support climate change assessment. This research introduces an open source modeling tool, Tinamït, that couples a participatory group-built system dynamics and a physically based model to evaluate stakeholder preferred adaptation strategies for limiting adverse impacts of climate change. Tinamït allows for the connection of system dynamics and physically-based models through either a graphical user interface or an application programming interface and has functionalities that allow for the rapid automation of simulation runs with various policy combinations under different climate change scenarios. The latter is facilitated by the new Python package Taqdir, which is integrated into Tinamït and supports the one-way linking of weather variables generated from the MarkSim software to either the system dynamics or the physically-based model.

We use a case study of a stakeholder-built system dynamics model from the Rechna Doab region of Punjab, Pakistan where the rate of groundwater exploitation is high and salinity problems have persisted despite efforts to implement remediation policies. The system dynamics model of farmer socioeconomics was coupled with the comprehensive distributed hydrological (soil salinity) model SAHYSMOD using Tinamït, and CMIP5 climate change predictions were incorporated into the SAHYSMOD model inputs for distinct RCP scenario runs. This approach ensures bi-directional feedback between both models, where the system dynamics model provides management decisions as inputs to the hydrological model, which in turn provides environmental conditions and constraints (groundwater quality) back to the former. The results of the model suggest that under conditions of climate change no one single policy is capable of halting groundwater resource degradation in the region and that combinations of socially and environmentally-oriented policies, likely with governmental subsidies, will have to be adopted.