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Storytelling and participatory system dynamics modelling for water resources management in Lake Atitlán of Tz'olöj Ya' in Mayan Guatemala

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Participatory system dynamics modelling is a useful tool for sociohydrological systems management due to its inclusion of diverse viewpoints and incorporation of feedback dynamics and delays between the human and environmental spheres. We here present a case study from the Lake Atitlán watershed in Guatemala, which is unique due to its endorheic nature, very long retention time, and diversity of human societies around it (Kaqchikel, Tz'utujil and K'iche', as well as a Hispanic minority). The lake is under pressure from several sources and has become increasingly vulnerable to eutrophication in recent years. The lake is also central to the economy and ecology of the region, with diverse stakeholders including fishers, farmers, both traditional and youth-led Mayan organisations, NGOs, businesses, and municipalities and other levels of government.

While effectively all participating stakeholders agree that the lake is under threat, there exist very differing narratives regarding the most pressing threat (pollution, biodiversity, or water availability) and therefore appropriate policy options. These differences vary significantly according to the ecosystem services each stakeholder obtains from the lake, as well as their own personal experiences and worldviews. Indigenous voices have also unfortunately been historically marginalised and often excluded from decision-making in environmental management.

In this context, we applied a novel methodology incorporating storytelling and narratives coupled with causal loop diagrams to incorporate the points of view of all stakeholders, whether literate or not. The results from these individual interviews were used to compare visions and possible solutions, followed by the development of a coupled human-hydrological systems model as a decision support tool. In the coupled model development process, socioeconomic processes are represented in a system dynamics model, while hydrological processes are eventually "outsourced" to an external hydrological model (such as SWAT+). Using the Tinamït software package, these two models can then be simultaneously executed with data (e.g., land use and water quality) dynamically exchanged between both models at runtime.

While most studies conducted in or on Indigenous regions and their peoples are conducted in European languages that exclude these very people from meaningful decision-making, all team members (both national and international) in this research project were chosen to be functional in

at least one of the mutually intelligible Mayan languages spoken in the basin, and these languages were used as the official project language (while also providing services in Spanish for Hispanic stakeholders). This key aspect to our approach ensured that all stakeholders were equally included in the process, and that Indigenous students also had equal opportunities to be hired as part of the (decision-making) research team.

We discuss how this methodology led to unique contributions to the model throughout the research process, from problem definition to identification of key system processes and candidate policy scenarios, and improved the quality of both the participatory and the modelling processes.