Geophysical Research Abstracts
Vol. 21, EGU2019-11073, 2019
EGU General Assembly 2019

System Dynamics of Sustainable Rice Agriculture on the Mekong River Delta

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Large river deltas across the globe are under increasing economic and environmental pressure due to overpopulation, climate change, and rising sea levels. River catchment sediments and associated discharge feed delta systems providing nutrients that not only enable higher yields in rice production but also the potential for flooding. Indeed, rice production on the Mekong River Delta (MRD) plays a main role in achieving food security for Vietnam, and provides significant export income for the Vietnamese economy (1.16% of GDP in 2018). To sustain high levels of rice production, the Vietnamese government has invested in a system of canals, flood dykes and sluice gates to control flooding of rice paddies and thereby extend the number of growing seasons from two to three rice harvests per year. However, these flood control measures have an unintended consequence in that, rather than allowing paddies to fallow, the exclusion of water and sediments from rice compartments means that soil nutrients become depleted and thus require artificial fertilizers to maintain yields. Furthermore, maintaining high levels of rice production is increasingly difficult as a result of climate change altering flood cycles, upstream hydro dam emplacement reducing sediment supply, and salinity intrusion shrinking available crop areas. In the face of these pressures MRD policy makers are facing pressing decisions in the delta and need to navigate the complexities of deltaic systems and identify optimal and sustainable land use management practices.

In this work we present the outcome of the application of an integrated Systems Dynamic Model (SDM) which emulates the distribution of biophysical components for water, suspended sediment, and nutrients over the delta, delivering a calibrated amount to each flood compartment. Biophysical components were calibrated using water quality routing model INCA (Integrated Catchment model), and the engineering hydraulics model MIKE 11 (with the ECO lab module). Spatial elements of the delta, such as soil type and land systems, are coupled to the SDM through a geographic information system (GIS). Model outputs of recent events provide a baseline to develop and test the SDM.

Here we show the results of the use of the (SDM) to integrate floods, nutrient supply, environmental/climate change and crop yields to facilitate stakeholders in the production of plausible normative spatially explicit scenarios of the agricultural intensification of the delta, centring on how intensification will occur and who will benefit. We use the SDM to explore scenarios covering the intensification range from local cooperatives that already exist to internationally funded agro-business. The question of livelihoods and community benefits is addressed in the normative outcomes as well as in the potential alignment and deviation form stated policy aims of the Government of Vietnam on the Mekong Delta.

Keywords: system dynamics, sediment transport, nutrient cycling, sustainability, agriculture, water supply management, water policy