A software coupling approach to assess alternative soil conservation strategies for highland agriculture in Vietnam

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Soil degradation is largely caused by the activities of land use decision-makers, and has substantial feedback effects on both human and environmental systems. To capture these feedback effects and the resulting human-environment interactions, we used an agent-based modeling approach to couple two software packages that simulate soil, water and plant dynamics (LUCIA) and farm decision-making (MP-MAS) as shown in Figure 1 (Schreinemachers and Berger 2011; Marohn 2011; Ayanu et al.).

We show that such a software coupling approach has advantages over hard-coded model integration as applied by most other comparable studies as it allows combining increasingly sophisticated individual models and achieving a well-balanced representation of agricultural systems. We show the challenges in model coupling, calibration and partial validation.

We apply the coupled model to a 30 km2 mountainous watershed in northwest Vietnam that comprises 471 farm households in five villages. Farmers in the area grow paddy rice in the watershed's valley and maize and cassava on the mountain slopes. The intensive cultivation of mountain slopes leads to substantial erosion and a downward pressure on maize and cassava yields. Although farmers are aware of the

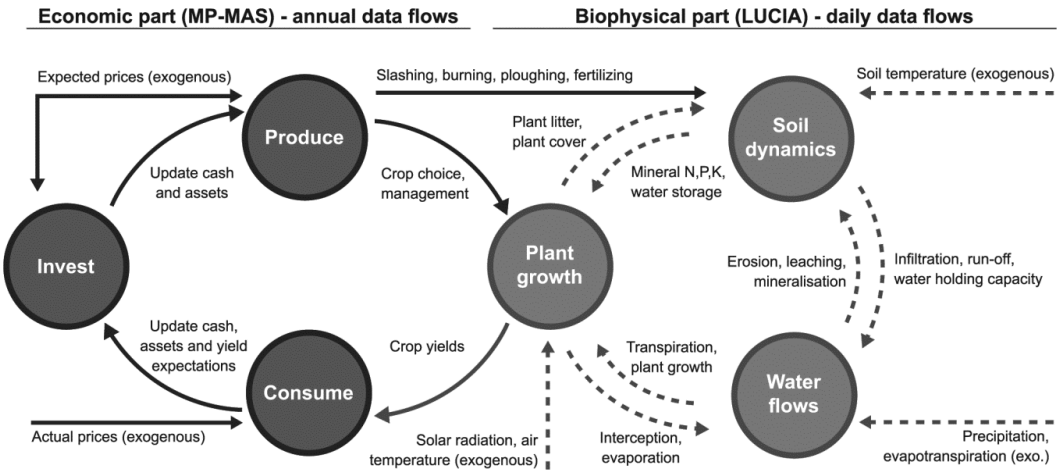

Figure 1. Human-environment interactions and dynamics in the coupled model

problem, the adoption of soil conservation techniques has been low.

Results of the baseline, the scenario that best represents current conditions and current dynamics, show maize yields to gradually decline from 6.5 Mg ha-1 in year 3 to 4.3 Mg ha-1 over 24 years. Initially, all agents used average amounts of fertilizer, yet over time agents tend to switch to either using no fertilizers or using high levels of fertilizer with the average level of fertilizer use gradually declining.

Scenario analysis was used to ex-ante test the effect of introducing three low-cost soil conservation techniques as an alternative to the conventional practice of maize cultivation in which farmers burn vegetation and plow their fields: Zero tillage without a cover crop, zero tillage with a cover crop, and a cover crop that is plowed into the soil. Each of these innovations assumes the absence of burning, but each also assumes higher labor requirements than the conventional practice.

Simulation results show that no-tillage alone would have very limited impact on soil erosion, maize productivity and household incomes in the catchment under current conditions, while introduction of legume cover crops led to a small but steady increase in yields after the first five to ten years. Simulation results were highly sensitive to the price of mineral fertilizers. If fertilizer prices were lower, maize yields would increase and the use of soil conservation would decrease. We discuss the implications of this model sensitivity with respect to the coupling approach taken. We further highlight spatial variability of the model outputs and ways to interpret the data.

References

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