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Abstracts

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Keywords

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Abstract

Nutrient recycling plays a key role in the functioning of agro-sylvo-pastoral systems (ASPS). In West African ASPS, livestock-driven nutrient flows are the main sources of soil and crop fertilization. Livestock mobility organizes spatial transfer of nutrients within the landscape. During daytime, livestock eats natural resources in rangelands while at night, it is paddocked in harvested fields. Livestock effluent are thus concentrated on the cultivated fields. However, farming systems transitions tend toward an expansion of croplands onto rangelands and a shift from these traditional "extensive" systems to more “intensive” systems based on in-barn livestock fattening. In these new systems, farmers use an increased quantity of feed concentrates and crop residues and livestock effluent are stored in barns and manually spread on fields. In order to study the consequences of such changes on nutrient transfers and, thus, on soil fertility, we built a spatially-explicit agent-based model, the TERROIR model — TERRoir level Organic matter Interactions and Recycling model.

The purpose of the model is to provide realistic estimations of the nutrient flows structure of a typical West African ASPS at different levels: land plot, herd, household and village. It is built to compare different agro-ecosystems, depending on input parameters concerning i) the structure of the landscape such as proportion of land units, i.e. homogeneous part of the landscape in terms of land use and management practices; and ii) crop-livestock systems diversity, linked to a typology of households. The model simulates the exchanges of biomasses between dozens of households with different strategies and practices, on a daily and weekly basis. It includes spatial transfers of biomasses between several hundred plots orchestrated by dozens of herds moving independently. These flows are analyzed through a set of indicators from two methods of analysis (Ecological Network Analysis and System Gate Balance) to describe the structure, functioning and sustainability of the agroecosystem, in terms of productivity, efficiency, autonomy, recycling, spatial transfers and nutrient balance.

The model was designed and configured with available data on savannah agroecosystems in West Africa. It focuses on processes related to nitrogen (N), a key limiting resource for both plant and animal production. It was implemented with Gama (v1.8). Model evaluation was based on field-data from two villages of the Groundnut Basin in Senegal, where agro-pastoralists have contrasted farming practices. It showed that the model reproduces the differences between an “extensive” and an “intensive” system.

In a context where historical quantitative data on nutrient flows are lacking, the model was used to explore past agro-ecosystems functioning and performances regarding N flows. Simulations highlighted bottlenecks along the N cycle like accumulation of N in manure heaps and housing areas, reducing N recycling efficiency, especially in “intensive” systems. Two major properties appeared to be outlasting the transition: i) independence towards external inputs, based on crop-livestock integration; ii) spatial heterogeneity due to nutrient transfers from peripheral land units to core land units, mainly through livestock. This model can be further used to explore improved agro-sylvo-pastoral landscapes. Processes related to carbon sequestration can also be implemented.

Additional material

- Repositories: https://github.com/MyriamGrillot/TerroirModel ; https://www.comses.net/codebases/5608/releases/2.0.0/
- Full model description: Grillot M., Guerrin F., Gaudou B., Masse D., Vayssières J., 2018. Multi-level analysis of nutrient cycling within agro-sylvo-pastoral landscapes in West Africa using an agent-based model. Environmental Modelling & Software 107, 267-280. https://doi.org/10.1016/j.envsoft.2018.05.003