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▶ To cite this version:

Pierre Chopin, Jean-Marc Blazy, Loic Guinde, Thierry Doré. Designing innovative agricultural land systems in the Caribbean: application to Guadeloupe. 51st conference of the Caribbean Food Crop Society, Jul 2015, Paramaribo, Suriname. hal-02739925

HAL Id: hal-02739925

https://hal.inrae.fr/hal-02739925v1

Submitted on 2 Jun 2020

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DESIGNING INNOVATIVE AGRICULTURAL LAND SYSTEMS IN THE CARIBBEAN: APPLICATION TO GUADELOUPE

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Abstract

Farming system design needs to adopt a landscape perspective in order to better respond to sustainability issues at the regional scale. Thus, we built a method at the regional scale to design agricultural land systems accounting for field characteristics and farm diversity, current farming systems and cropping systems, and the ecological processes (e.g. pollution of water bodies) at the regional scale. This method encompasses the definition of a farm typology to approach farmer's decision processes in term of cropping system choice. This farm typology is integrated within a regional bioeconomic model that produces new agricultural land systems by simulating farmers' decision processes in term of cropping system choices at plot scale, within the entire region. These new agricultural land systems are assessed with a set of indicators to provide information on their response to sustainability issues. This model coupled to the indicators are used within a scenario route to provide information on the relevance of combination of agronomic, economic, social and environmental levers to improve the contribution of agriculture to sustainable development. The method is applied in Guadeloupe for prototyping agricultural land systems that improve the response of agriculture to economic, social and environmental challenges with levers such as "agro ecological crop-gardening cropping systems", "energy crop", "changes in crop subsidies" and "availability of experienced workforce in farms". This method could be used in the Caribbean islands to help decision-makers improve the response of agriculture to sustainability challenges such as reaching food self-sufficiency, increasing employment and decreasing environmental impacts of agriculture. Coupling this approach to land use change study could provide a way of designing future sustainable islands.

Introduction

Agricultural is actively involved in the provision of a wide range of ecosystem services from local to global scales. The "Farming system design" discipline has mainly been focused on designing cropping systems at field scale and farming systems at farm scale. But the design of these innovative agricultural systems has shown some limits in addressing regional and global issues. For instance at the field scale, some cropping systems may fail to reach the objectives defined at the regional scale due to the low scaling integration and the spatial heterogeneity in the region. Agronomists then need to integrate a landscape perspective for the design of new agricultural systems adapted to local contexts and addressing sustainability challenges at regional scale. We here present a method to prototype innovative agricultural land systems accounting for field characteristics and farm diversity, current farming systems and cropping systems, and the ecological processes (e.g. pollution of water bodies) at the regional scale.

Materials and methods

The method starts with a farm typology that groups farmers based on the similarity of their decision-process in term of cropping system choice. This farm typology is realized with a classification tree which allows the classification of farmers in types based on crop acreage thresholds. A regional bioeconomic model called MOSAICA has been designed in order to prototype agricultural land systems by optimizing the cropping system composition and organization on farmer's plots all over a region. This optimization at regional scale produces new agricultural land systems that are assessed with a set of regional indicators. These indicators use the information on cropping systems allocated to plots and field characteristics, which are up-scaled based on different scaling procedures, to provide an assessment of ecosystem services provision through a score. Furthermore, the variability of response of cropping systems to sustainability issues is assessed by spatializing these indicators. The farm typology, the bioeconomic model and the regional indicators are used through a scenario route in order to test the impact of several agronomic, economic, social and environmental levers of change on the organization of cropping systems at the regional scale and the consequences of these new agricultural land systems on the provision of ecosystem services. Through this framework, relevant levers are selected based on their ability to respond to a given issue and they are combined in a "Go Sustainable" scenario to improve the entire contribution of agriculture to regional sustainable development.

Results and discussion

We applied this method in Guadeloupe based on a geographical field database with 25 057 fields and 5336 farms. Biophysical and farm structure information was added to this database through geographical information system and regional statistics. The farm typology, realized from this database, is composed of eight farm types: arboriculturists, banana growers, specialized cane growers, crop-gardeners, breeders, diversified cane growers, mixed sugarcane-breeders and diversified producers (Chopin et al., 2015). The bioeconomic model MOSAICA is used with 36 activities describing local cropping systems that can be allocated on farmers' plots. The model is considered as valid since the similarity of crop areas between the initial mosaic and the simulated one at regional, sub-regional and field scales were respectively 90%, 84% and 77% and farm type similarity at farm scale was close to 81%. We then used the model in the framework and we selected several levers, that increase the contribution of agriculture to the response of several sustainability issues, that were combined in a "Go sustainable" scenario among which: "introduction of agro ecological crop-gardening cropping systems", "introduction of crop energy", "increase of subsidies for local food crops", "a deletion of subsidies for sugarcane" and "the ban of food crops on polluted soils". These levers combined increased the level food self-sufficiency by 160%, the production of biomass for energy by 10%, the overall agricultural added value by 120% and decreased the pollution of water bodies by 15% and the risk of food crop contamination by 100 % compared to the initial situation.

Conclusion

The mechanistic modeling of the evolution of agricultural land system helps integrate knowledge from the determinants of cropping system location, cropping system performance, the decision-process of farmers and impacts of farming practices at the regional scale. This method helps visualize the change in cropping system composition and organization at the regional scale and their impact on the societies in a spatially explicit way. This modeling method makes it possible to generate knowledge on the relevance of levers to improve the contribution of agricultural land systems to sustainable development of islands. The method and tools developed here are then particularly useful to help decision-makers improve the contribution of agriculture to sustainable development. Coupling this approach with land use study could help provide new land systems composed of urban, forest and agricultural use but with a wider diversity of agricultural uses associated to cropping systems in order to better assess the entire contribution of land system to sustainable development of societies. This land system architecture process to be built could help governments of islands build sustainable future islands.

Acknowledgments

The authors would like to thank all the agricultural institutions in Guadeloupe which provided geographical data and all the experts for their help in the cropping system definition phase. This research was funded by the "Région Guadeloupe" and the INRA "Environnement et Agronomie" Division.