

# INTEGRATING FIELD, FARM AND TERRITORY SCALES IN THE DESIGN OF AGRICULTURAL SYSTEMS

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## 1 Introduction

In order to cope with several actual and future major issues like climate change, natural resources depletion, protection of biodiversity, ensuring food security, innovative agricultural systems have to be developed. These systems have to satisfy a set of objectives at the field, the farm and the territory scales and their design has to take into account explicitly the interactions between these scales (Veldkamp & Lambin, 2001). We propose a simple framework to this end and apply it to two questions in Guadeloupe: 1) the *ex ante* assessment of low-input innovative cropping system and their potential of adoption by heterogeneous farmers and 2) the design of new mosaics of cropping systems satisfying several sustainability goals at the territorial level and taking into account farms' constraints.

## 2 Materials and Methods

The framework presented in Fig. 1 shows how the nature of the innovations that have to be implemented into current cropping systems (field scale) can be orientated by the farm and the territory scales. Firstly the innovations at field scale can perform differently in the territory, because farms are heterogeneous in terms of biophysical situation and socio-economic resources. Secondly the effective implementation of innovations at field level is conditional upon farmers' decision of adoption which can be influenced by the three levels. Finally reaching sustainability goals at territorial scale requires an optimal combination of innovative cropping systems at field scale while taking into account farm level constraints.

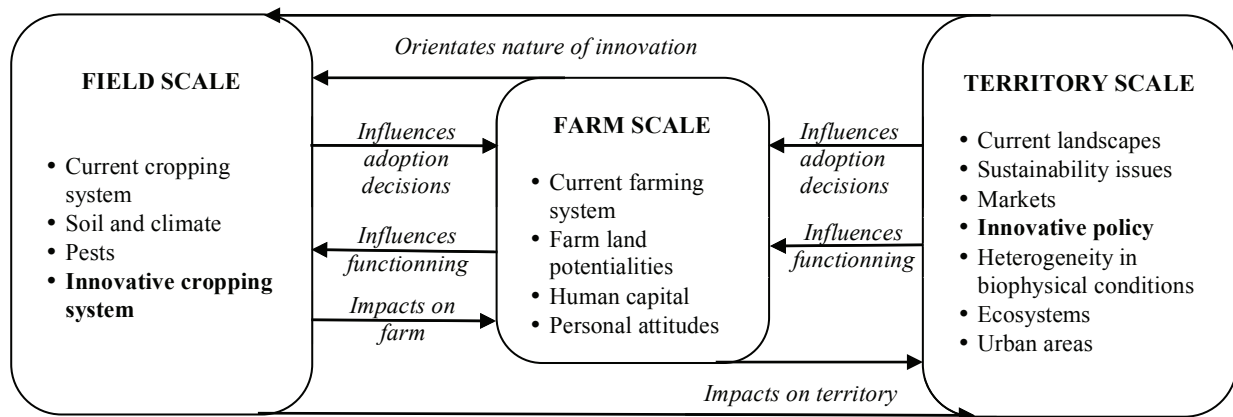


Fig. 1. Framework of interrelationships between field, farm and territory scales in the design of agricultural systems

From a practical point of view, the framework is aimed at building an architecture of models to design and assess new agricultural systems emerging from innovations at several spatial scales. It could also serve to assess trade-offs between sustainability goals and across scales. The use of a combination of tools is required to implement the framework. We tested three types of tools combinations: 1) quantifying the impacts of innovation on cropping system performances at field scale with a biophysical model parameterized with a regional typology of farms, 2) modelling farmers' decision of adoption of new cropping systems as a function of cropping system performance, farmers individual characteristics and economic incentives and 3) integrating information from field and farm scales into a bio-economic multi-criteria regional model to prototype mosaic of cropping systems satisfying several sustainability goals.

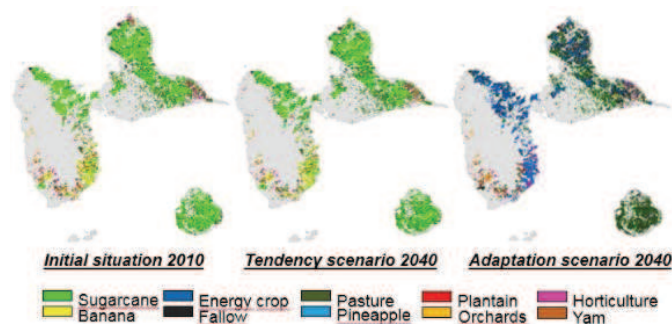
### 3 Results - Discussion

First we present in Table 1 the *ex ante* assessment of the introduction of new intercropping techniques in banana cropping systems in Guadeloupe and Martinique (Blazy *et al.*, 2010). Our results show that performance of the innovative cropping systems are clearly influenced by the farm type. Then the willingness to adopt is also different according to the farm type and depends upon the performances of the system (size of workforce seems to be crucial for adoption) and the territorial context (compare Guadeloupe and Martinique islands). This verify the hypotheses that effective increase of the sustainability at the territorial scale requires accounting for adoption constraints and heterogeneity at the field and farm scale.

**Table 1.** Ex ante assessment of two innovative banana cropping systems based on intercropping for two farm types.

Farm type	Highlands smallholders		Flatlands industrial farms	
	<i>Canavalia ensiformis</i>	<i>Impatiens sp</i>	<i>Canavalia ensiformis</i>	<i>Impatiens sp</i>
Innovations (service crop intercropping)				
Banana yield (t ha <sup>-1</sup> yr <sup>-1</sup> )	+15.9	0.0	+4.4	+0.4
Work (days ha <sup>-1</sup> yr <sup>-1</sup> )	+75.4	+10.4	+42.0	+16.8
Net income (€ ha <sup>-1</sup> yr <sup>-1</sup> )	+3472.1	-426.4	-830.9	-1390.5
Willingness to adopt in Guadeloupe (%)	58%	81%	46%	54%
Willingness to adopt in Martinique (%)	16%	47%	35%	54%

Then we present the results of the design and assessment of a multi-objective mosaic of cropping systems satisfying the principles of climate-smart agriculture (Lipper *et al.*, 2014). To this end, the bioeconomic model MOSAICA (Chopin *et al.*, in press) was used by i) optimizing the satisfaction of the objectives of “an adaptation scenario” made of innovations at the farm and policy levels (introducing energy crop, organic fertilization and environmental incentives) and ii) taking into account spatial heterogeneity, resources availability and risk attitudes of the diverse farm types of the island. The results showed that the landscape evolves greatly under the “adaptation scenario” (Fig. 2) and that the objective of reducing by 10% all GHG emissions of Guadeloupe could be achieved while also increasing other sustainability indicators (Table 2).



**Fig. 2.** Prototyping climate-smart mosaic of cropping systems.

**Table 2.** Assessment of mosaics of cropping systems.

Indicators	Units	Initial situation	Adaptation Scenario
Mean farmers' income	€ ha <sup>-1</sup> yr <sup>-1</sup>	3510	4940
Energy self-sufficiency from energy crop	%	3%	13%
Food self-sufficiency	%	15%	17%
Proportion of rivers potentially polluted	%	39%	8%
Total amount of subsidies	M€ yr <sup>-1</sup>	75	61

### 4 Conclusions

Our framework provides a conceptual representation of the interrelationships between the field, the farm and the territory scales. The application of the framework in Guadeloupe through two different combination of models confirmed that taking into account the complexity of these interrelationships is crucial for the design of new agricultural systems. Innovations at field scale have to target heterogeneous farmers' objectives and constraints for adoption. Policy can be an efficient way to impulse and promote the adoption of these innovations. Bio-economic models are necessary for building new optimal agricultural landscape because of the complexity in hierarchical organization. The results that agronomist can obtain with such approaches offer promising perspective in designing scenarios of transition of agricultural systems toward a higher sustainability level, which is of interest for helping decision making of policy makers.

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