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# Assessment of agricultural land-use change for helping sustainable land management and landscape development

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**Abstract:** Agriculture is nowadays expected to adopt “multifunctional” land use practice as a contribution to sustainable development of rural areas. We started a participatory research study in the Coteaux de Gascogne (France) to prospect local paths for agricultural systems contribution to land-use sustainability. The area considered is a study-site of the Long term Ecosystem Research network. Our first common objective is to understand how family-farm dynamics contribute to land-use change at the landscape level. We started therefore a spatially-explicit and exhaustive study of agricultural land use and its change since the 1950s at a reference area of limited size (4 villages). The method consists in survey at every farmer using land in the area using both a semi-directive questionnaire and farmland maps and the building up of a Geographic Information System (GIS). We present here the first results of our assessment of the variety in family-farms and their land use practice (56 farms). We discuss our perspectives for using these results and helping local land use development.

**Keywords:** participatory research, land-use change, farmers’ land-management strategy, GIS, sustainable development

## Introduction

In the ‘Coteaux de Gascogne’ region by Toulouse (France), agriculture stakeholders are very concerned about its future. It is a hilly region where agricultural landscapes associate cultivated land, grassland and small forest elements, due to a mixed crop-livestock orientation of agricultural systems. Farmer population is ageing, farm numbers declining rapidly, and farm size enlarging continuously. The huge changes in production system and land-use practice at the farm level since a few decades are being impacting visibly on local landscape character. At the same time development of local agriculture is challenged by (i) rural urbanization and tourism, which become important pillars of local economy and (ii) the changes in the natural and the socio-economic environment from the local to the global scale (public policies, climate). Farmers and additional stakeholders of the agricultural sector are wondering about way(s) to strengthen local production systems, economic viability and liveability of farms without neglecting environmental and social functions currently expected, such as preservation of biodiversity and environment, and maintenance of landscape cultural identity and amenity. They built up with our research group in 2006-2007 a research-development (R/D) project for supporting their search for sound pathways for a sustainable development of local agriculture.

## Research Questions and Posture

We assume that (i) research results are all the easier to use by actors than they participate into their production and (ii) R/D for sustainable management of natural resources requires the ‘co-construction’ of decision-support tools (e.g. ComMod, 2005). Indeed, the classical view of the role of research, in which researchers supply society with references and indicators to be used in development actions, appears nowadays of limited value due to the growing awareness of the complexity of the ecological and social processes, and the multiplicity of rural development stakeholders (Kates *et al.*, 2005).

Therefore our research group established communication with development stakeholders and set up a participatory Research & Development project (2007-2010). All along its course, municipalities and agriculture advisory services are to be involved into the research studies from their beginning.

We agreed starting the project studying how family-farm dynamics contribute to land use change at the landscape level.

## Methodology

We rely on scientific principles and frameworks of international research trends on socio-ecological systems (Berkes & Folkes, 1998) and land-use (Bousquet & Le Page, 2004) for developing a spatio-temporal address of the interrelationships between agricultural land-use, landscape structure and functions and their changes. We selected therefore a study site of limited size "representative" of the Coteaux de Gascogne area (4 adjoining villages) where we can carry on a spatially- explicit and exhaustive study of agricultural land-use and their change over the last decades, according to a method inspired by Mottet *et al.* (2006). Data collection is based on a 2 steps survey at every farmer using land in the study site. Farmers are interviewed about their current farm structure, function and land-management practice and their change over the last 50 years, using both a semi-directive questionnaire and farmland maps. A GIS and associated data-bases are built up for data handling and analysis. We categorise current farm-types using a series of selected indicators from a multivariate analysis and clustering in R® software.

## First results

The 56 farmers interviewed work 93% of the agricultural land of the 4 villages. The farm typology we built from the data collected stresses out the coexistence of 6 main types of family-farms (table 1). Farm collapse rate has been high over the past 20 years, especially in t1 - t2. Although mixed crop-livestock farming, which roots local landscape identity, still prevails (t2, t3, t5), agriculture modernization has favoured farm enlargement, and specialisation towards dairy (t4) or crop (t1, t6). Intensification, land consolidation and irrigation have markedly impacted landscape composition over the period. Today farm transfer at the farmer retirement time appears increasingly problematical, while new pressures on production systems cropping patterns (climate change, global food and energy crisis) challenge the economical orientations for sustainable farm development in every farm type.

Table 1. Some characteristics of the farm types (mean)

Types	Nb farms	Agricultural Area (AA)	Age (years)	Workers (AWU)	AA (ha)
t1. Small crop family-farms based on pluriactivity	4	1,4%	53	0,2	19
t2. Crop-livestock farms in a cessation process	12	9,9%	56	1,0	44
t3. Crop-livestock farms in a farm restructuring process	17	32,1%	41	1,3	100
t4. Big dairy farms managed by young farmers	5	10,7%	42	2,6	113
t5. Crop/livestock farms in a "steady state" with a familial transfer farm perspective	11	34,3%	55	2,8	165
t6. Large crop farms	4	11,7%	51	1,3	155

## Ongoing research

We are currently analysing the variety in the layout and the use of farmland at the individual family-farms in relation with the above farm-types and the related family strategy for farm development over the past decades. The next steps of our R/D project will consist in using the typologies' results for building scenarios of future behaviour of farm families according to types under assumed modified pressures from the local and global environment. We will develop sets of rules mimicing their modified land-use strategies and use maps of individual farmlands as starting points for building a Multi-agent system model that can simulate the related land-use and landscape change.

## Conclusions

An important direction for sustainable agricultural development at the local scale is the enhancement of the capacity of local agriculture and rural stakeholders to face to change and uncertainty. The actual challenges attached to multifunctional land-use can be enlightened from an improved understanding of the interrelationships between agricultural land-use and landscape character; anticipation of their future changes according to plausible scenarios and communication with other rural development stakeholders. We consider our research study as an illustration of the contribution research can make to the understanding of the conditions for sustainable rural development, when linking a socio-

ecological systems approach, with technologies such as GIS, and computer simulation methods suited for the modelling of spatio-temporal processes from the plot to the landscape scale.

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