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Understanding how farmers last over the long term : a typology of trajectories of change in farming systems. A French case-study.

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ABSTRACT

In the current context of market fluctuation on agricultural products prices, European agriculture is endangered. In hilly areas, the orientation of CAP policy promoting specialization added to an always increasing lack of work forces challenges the future of farms. Nevertheless, farmers found how to adapt to local context to last on the long term. In this study, we try to assess the diversity of the adaptative strategies developed by farmers to last in analyzing their trajectories of change. Our study aims to understand the variety in trajectories of farms from 1950 up to now. We applied an integrated approach to the farm population of a case-study site, in the Coteaux de Gascogne. In this hilly region of south-western France, agriculture maintained with a limited specialization of production. We made a survey of the history of every farms working land in an area of about 4000 ha. We used a two steps-analysis including : (i) a manual assessment of the trajectory of each farm and (ii) a typology of farm trajectories build on a combination of multivariate analysis on a set of data composed by 20 variables for 50 farms on 10-year steps. The interpretation of the types was based on the results of the manual assessment. The resulting 6 types of trajectories reflect different objectives and strategies. Farmers found different "paths to last" in a same local context (environmental, political and economic). In two types of trajectories, farmers became specialized, in the other ones, farmers maintained more traditional systems, based on a crop-livestock association. This typology was validated by local farmers. Our results stress out the importance to understand the systemic functioning of farms to study local change in agricultural systems. In a next step of our study these results will be used in a participatory future process with local stakeholders, through co-constructed prospective scenarios.

INTRODUCTION

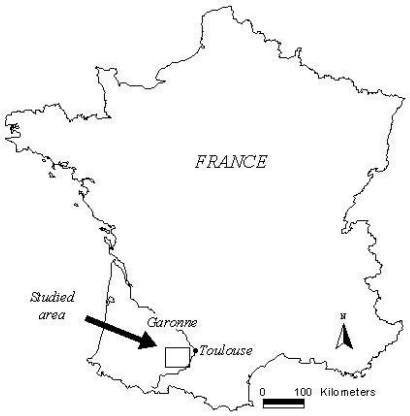
In the actual context of market fluctuation on agricultural products prices, European agriculture is endangered. In European marginal areas in particular, the past orientation of CAP favouring specialization of production systems and enlargement of farm size led to a continuously increasing lack of work forces, worrying for the future of farmers. Since 1950, European agriculture experienced major changes which accelerated since 1970 in relation to the modernisation and intensification of agriculture (Antrop, 2005). In accordance with Garcia-Martinez *et al.*(2009) and Gibon *et al.* (2010), we assume that the assessment of the variety in the historical paths of change in individual farms can (i) enlighten the adaptative strategies farmers developed to maintain their farm up to now and (ii) support the enhancement of farmers' capacity to face current challenges for the sustainable development of their farms. On our case study, we assess the variety in the past trajectories of socio-technical change in farms from 1950 up to now within the whole farm population of a reference area in South-Western France uplands. The assessment and understanding of the overall variety in the evolution patterns of farming systems should permit us to understand how local farmers have adapted to changes In a first section of the paper, we present the study area and the method we used to build a typology of farm trajectories of change amongst farms of our case-study site. In a second part, where we present our results, we give focus both to the general trend of change in local agriculture and the variety in the individual farm trajectories. We will finally discuss our results.

1. MATERIAL AND METHODS

1.1. Case-study area and research context

The case-study area is part of the 'Coteaux de Gascogne' region in South-western France. This upland area is characterised by sloppy hills and plains. As illustrated in Figure 1, farm numbers in the area were steadily decreasing since 1970, as well as animal numbers in pig and dairy production. This region with dry summers experienced a limited specialization of agricultural production (Choisis *et al.*, 2010). 47 % of the today farms have a mixed cash crop-livestock production system, mostly based on suckling or dairy cattle. They may include complementary

livestock production (*i.e.* force-feeding ducks, fattening pigs...). Remaining farms are specialized either in cash crop (14%) or cattle production (39%)(Ryschawy J. *et al.*, 2010).



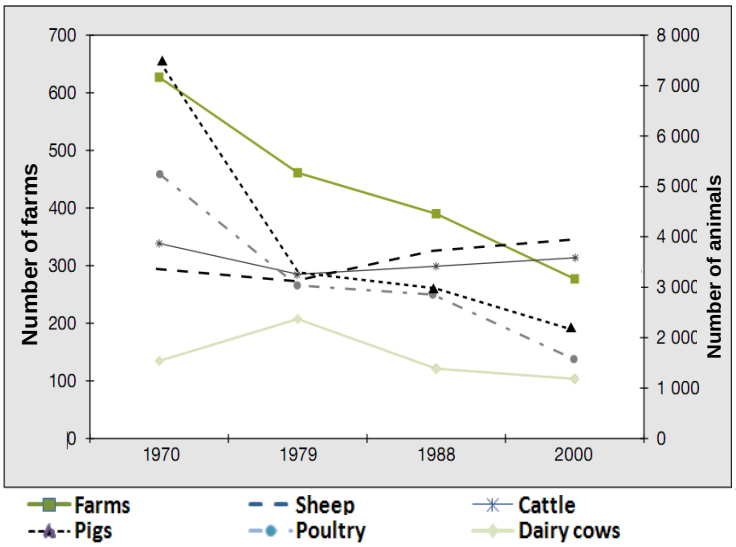


Figure 1: Localisation of the study area (Aurignac canton) and change in its farm and animals numbers between 1970 and 2000. (source: Choisis et al., 2010)

1.2. Methodology

1.2.1.Farm population studied and data collection

We considered in the study the whole farm population of a reference area of about 4000 ha. We adapted the survey method for an integrated and 'spatially-explicit' assessment of socio-technological change since 1950 (Mottet A. *et al.*,2006). Data on the structure, function and evolution of the 56 farms working land in the study site was collected in 2006-2007 Data collated were put into a relational and georeferenced database from the parcel up to the farm level (DYNAFARM-COTO®) The database includes farmers explanations as regards changes in their farm since 1950.

1.2.2. Data elaboration depicting the temporal patterns of farm change

A major methodological challenge when addressing the variety in the trajectories of change of a set of farms is to select a sound time step and suitable indicators for depicting their individual patterns of change (Cialdella, 2009; Rueff and Gibon, 2010). We used a 10-year time step to describe the successive states of the farm structure and operations from 1950 to 2005. We used a set of 30 indicators addressing five dimensions of the farming system and their evolution: the farm land, the livestock and crop farming sub-systems, the working forces and farm investments. We also developed a graphical method to describe the individual history of every farm during the studied period (Choisis and Ryschawy, in Prep.). A summary of major changes in the farm characteristics and farmers' objectives over the period goes with each diagram. After discarding a few farms with missing data, 50 farm cases were available for analysis.

1.2.3. Data analysis

We applied a two–step method for assessing the variety in the individual trajectories of change amongst farms and building a typology: (i) a visual comparison of the resemblances and differences of the 50 synoptic diagrams and (ii) the application of a series of multivariate analyses and automatic clustering of individual farm-trajectory data inspired from Rueff and Gibon (2010). To assess similarities and differences in the individual profiles of temporal change among the farm population, we applied the Dolédec and Chessel's method (1987) to the set of data tables describing each farm at each of the 6 time-steps considered. We selected an appropriate set of 20 quantitative and qualitative indicators within the 30 indicators available in the database (Table 1). We submitted the statistical individuals to an Hill and Smith analysis and used their coordinates on the four first factors to perform a Principal Component Analysis (PCA). Information was thus summarized for each farm during the whole period into a single statistical individual. To build farm groups of a similar temporal profile, we submitted the 50 farms' coordinates on the four first PCA factors to a Hierarchical Ascendant Classification (HAC). We strengthened the results gained by a k-means classification based on the barycentres of the HAC clusters. All the statistical analyses were made in the R® 2.12.0 software. The elucidation of the cluster groups into farm-trajectory types was

supported by the comparison with individual graphical analysis and discussions with local farmers and their advisor (12 *ad hoc* farmer interviews and a collective meeting).

Table 1. *Indicators and variables coding applied for the multivariate analyses and automatic clustering of the individual trajectories of change of the farms in the study-site population*

Class	Indicator of	Criteria used in each decade	Variables coding
Areas	Total size of the farms	Total Utilized Agricultural Area	UAA (q)
	Tenant farming	Percentage of UAA in tenant farming	TF (q)
Working Collective	Working force needed on the farm	Total Work Units	WU (q)
	Changing generation	Setting up of a new generation	NG (Q) = *0 or 1*
	Generations working together	Number of generation working	NbG (q)
Production Units	Bovine production orientation	Presence of cattle beef	Beef (Q) = *0 or 1*
	Bovine production orientation	Presence of dairy cows	Dairy (Q) = *0 or 1*
	Auto-consumption of crops	Presence of cash crops	Crop (Q) = *0 or 1*
	On-farm diversification	Total number of production units	PU (q)
Livestock subsystem	Size of herd	Nb of adult bovine Units	Ncow (q)
	Orientation of bovine production	Major breed of the bovine herd	Breed (Q) *Code : B = Beef; M = Milk; D = Dual purpose L = Local ; U =Unknown;*
Crop subsystem	Herd feeding orientation	Presence of maize areas	Maize (Q) = *0 or 1*
	Innovation if herd feeding	Presence of maize silage	Msil (Q) = *0 or 1*
	Innovation in grassland management	Presence of grass silage	Gsil (Q) = *0 or 1*
	Use of grasslands	Presence of temporary grasslands	TG (Q) = *0 or 1*
	Adaptation to new crop orientations	Nb of new crop types adopted (soya,...)	NewC (Q)
Investments	Crop system landscaping	Drainage done	Drain (Q) = *0 or 1*
	Crop management	Use of irrigation	Irr (Q) = *0 or 1*
	Investment in sheds and outhouses	Nb of buildings present on the farm	Build (q)
	Total investments on farm	Investments	Inv (Q) = *0 or 1*

Legend*: the nature of the variables is designated with a letter in brackets in column 3 of the table: (q) for quantitative variables; (Q) for qualitative multimodal variables. For binary variables, 0 and 1 for respectively a negative or an affirmative response.*

2. RESULTS

2.1. The general trend of change in the farm population studied

The four first factors of Hill and Smith's analysis explained 57,6% of the total variance between the farm-date statistical individuals. They allowed us to highlight the general evolutions since 1950 of the local farm population which maintained up to 200. In the period 1950 to 1970, all these farms were diversified and had 2 to 4 production orientations: they all produced veal calves with a local breed, and also for most of them pork and poultry. They mainly produced cereals and other crops mainly used for family subsistence and farm's livestock feeding. The year 1970 marked the beginning of the specialization and modernisation of local agriculture. Most of the farmers adopted innovative techniques such as the use of maize silage and soya production. During this period, farms tended to abandon small livestock species in favour of a specialization on cattle meat or milk production. Farmers also intensified their production system to produce more cash crops and livestock products for sale. Since 1990, there was a large tendency to farm enlargement while specialization process in cash crop or livestock production continued. A lack of working force with regard to the increasing size of farms began to appear, which became an increasingly large preoccupation of farmers up to now. To face this constraint, farmers searched in the last decade new orientations of production and ways to simplify their farming system, through the adoption of e.g. simplified or no-tillage practices or increased use of grasslands in cattle feeding.

2.2.A large variety in the individual farm trajectories of change

There is however a large diversity of the individual trajectories of change since 1950 in the farm population studied. The classification through our statistical analysis led us to bring out 6 different types of trajectory of farm change (Table 2), which correspond to different adaptative strategies of local farmers.

Table 2 : *Main changes in farm characteristics according to their types of trajectory of change since 1950.*

	Type 1	**Type 2**	**Type 3**	**Type 4**	**Subtype 5_1**	**Subtype 5_2**
Number of farms	*13*	*5*	*8*	*6*	*10*	*8*
UAA 1955 (ha)	24,1±8,2	26,4 ± 3,4	25,6 ±10,8	52,5 ±60,7	25,6 ±12,3	29,8 ±12,7
UAA 2005 (ha)	68,1±34,7	123,2±19,7	55,3 ±53,5	179,8 ±53,0	110,7±87,0	21,5 ±14,3
PU 1955	1,4 ±0,8	2,0± 0,0	2,6 ± 0,7	2,2 ± 0,4	2,7±0,6	2,1 ±1,1
PU 2005	1,5±0,7	2,0 ±0,7	1,6 ±0,7	1,7 ±0,5	2,2±0,0	1,0 ±0,0
WU 1955	1,8 ±0,6	2,2 ±0,3	2,6 ±1,1	2,4 ±0,8	2,0 ±0,5	1,6 ±0,7
WU 2005	1,2±0,6	2,2 ±0,8	1,7 ±0,8	2,3 ±1,1	1,2 ±0,5	0,5 ±0,3
Ncow (Breed) 1955	13,0±3,4(L)	17,6±4,3(U)	13,9±7,1(L)	19 ,2±8,6(L)	14,6±5,4(L)	15,9 ±8,6(U)
Ncow (Breed) 2005	36,8±22,3(B)	68,0±14,2(M)	45,0± 21,8(B)	80,3± 44,6(B)	40,8 ± 23,5(B)	39,8± 16,6(B)
Beef 1955/2005 (%)	85 / 77	100 / 0	100 / 50	100 / 83	100 / 90	100 / 38
Dairy 1955 / 2005 (%)	15 / 33	0 / 80	0 / 13	17 / 0	0 / 0	0 /0
Irri 1955 / 2005 (%)	0 / 0	0 / 80	0 / 13	0 / 67	0 / 0	0 / 0
Msil 1955 / 2005 (%)	0 / 31	0 / 40	0 / 50	0 / 0	0 / 0	0 / 0

For the quantitative variables, we give "mean of the given date ±standard deviation", for the qualitative one the % of presence.

Type 1 corresponds to farmers with a family-tradition based strategy, who selected a beef-cattle orientation but maintained an objective of maximising farm autonomy. During the period studied they strived to find the best land-use combination to maximise the interactions between livestock and crops. Type 2 are farmers who specialized since 1970 in dairy production to insure the economic viability of their farm. They strongly invested in mechanization and enlarging farm acreage and herd size. Type 3 corresponds to farmers attached to the objective in local society tradition to insure the long-term permanence of the 'house', i.e. the conservation over generations of the inherited family-farm: their strategy was to go on with a diversified farming system from 1950 up to now, minimising as far as possible farm enlargement and investments. Farms in Type 4 specialized in beef cattle production. Farmers secured their farm through a large increase in capital, buying land and cows. Type 5 corresponds to another tradition-based strategy of farm-families, who aimed to maintain on-farm employment for all the familial work forces In subtype 5_1, where there was a large availability in family workers, farmers adapted gradually to changes in the economic environment, making progressive investments and maximising the farming-system diversity. In subtype 5_2, the lack of family workers was a limiting factor in the application of this strategy.

3.DISCUSSION

3.1 The difficulty of the assessment of long term change in farming systems

We choose to study farm trajectories since 1950 because of both scientific and methodological argues : (i) 1950 corresponds to the beginning of modernisation tendency of farms in Europe, also of change in their trajectories (Antrop, 2005) and (ii) a time lag of 50 years up to now is the limit of the human memory in retrospective collection of data (Cialdella, 2009). The definition of variables is often limited by the precision of the information given during surveys. As an example, actual farmers have memory of the presence or absence of maize in a past decade but not of the surface of maize cultivated. Nevertheless, discussions with farmers permitted us to precise our interpretation.

In our assessment of farm socio-technological change, a large place is given to the interpretation of data, which includes a part of subjectivity. Nevertheless, computer-processing methods limit this subjectivity (Mulaik S.A., 1993). Indeed our method associated a statistical analysis of variables chosen in reference to both conceptual and empirical considerations for bringing out the trends of changes in the farm trajectories and strategies of farmers on the long term. The validation of our results by local actors also secured our interpretation

3.2. Some factors of the local variety in the trajectories of farm change The evolution trends during the 1950-2005 period in the farm population evidenced in our study can be partly explained by the pressure of the CAP policy. In many places, the year 1970 marked the beginning of the general process of specialization and modernisation of local agricultures under its influence (Chatellier V. and Guyomard H., 2008). Since 1990, the CAP policy maintains its large influence,

in particular through regulations and compulsory norms. Most of the farmers in the population studied chose to maintain crop-livestock farming systems in a farm-development strategy rooted in local tradition, e.g. employing on-farm all the familial working force, maximising farm autonomy and diversity,... Farms in subtype 5_2 which are collapsing, show the failure in this strategy when there is a lack of family work forces devoted to the farm. In trajectory types 2 and 4, farmers adopted the conventional strategy for farm-development supported by the CAP : they selected one production to specialize and intensified their system. They also enlarged the size of their production unit. The variety in the strategies to last that the 50 farmers of the population study developed since 1950 appears to result from substantial differences in the farm condition at the beginning of the study period, whilst they all had a traditionally diversified mixed crop-livestock farming system. Indeed similar types of farm and farming systems of the present days appear to result from different « paths to last ». This is probably one of the main origins of the currently large variability intra-systems we pointed out in a previous study (Ryschawy *et al.*, 2010).

3.3.Participatory research with local actors

This study provides an illustration of the interest of participatory research with farmers and other local stakeholders in livestock farming research. Indeed it appears as a particularly valuable approach for enhancing the understanding of change in farming systems and also of natural resource management at the local scale (Etienne *et al*., 2010). The typology reported here, was submitted to the farmers and their adviser. Local actors have not only validated it, but also contributed to the explanation of the trends observed.

CONCLUSION

This work provides a first insight in the various strategies that farmers developed in the study area. It also contributes in giving some information of topical interest for the understanding of the farmer rationales in maintaining their farming systems on the long term in upland conditions of Southern Europe. Our elucidation of the variety in the "paths to last" local farmers found in a same, environmental, political and economic context also illustrates both the interest to consider sustainability as a direction to guide constructive change in Livestock Farming Systems and the potential of crop-livestock association for sustainable agriculture in European conditions.

In spite of their heaviness and methodological difficulty, integrated assessments of the variety in trajectories of farm change in local farm populations appear indeed as an important research orientation for the understanding of long-term management challenges in livestock production and helping the farmers and other stakeholders to face the currently large changes and uncertainty in the local and global environment

This work therefore offers a useful material for the design and assessment of prospective scenarios for change. This analysis of the variety in trajectories of change is indeed a first step in our study where we want (i) to test a participatory building and assessment of prospective scenarios with local farmers and stakeholders of the Coteaux de Gascogne area and (ii) to test the interest of mixed crop-livestock farming for local farming sustainability.

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