How can collective organization and the search for autonomy lead to an agroecological transition? The example of farm machinery cooperatives in France

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Abstract: *Mainly motivated by their search for autonomy (self-sufficiency an self-reliance), farmers interacting in farm machinery cooperatives (CUMA) in France develop new patterns of cooperation beyond the joint use of equipment and human resources. This work, supported by the interdisciplinary project CAPACCITA, aims at understanding to what extent farmers' quest for autonomy in the CUMA network can be a key factor in the development of agro-ecological practices and production systems.*

The research is based on the agronomic and sociological study of 3 CUMA groups in France. It combines together three methodological approaches: (i) a comprehensive analysis of the technical changes operated by the farmers, their rationale and the consequences of such changes on the global farm functioning (ii) a characterization of the level of agroecologization of practices and trajectories based on the Efficiency-Substitution-Redesign approach (iii) an impact assessment of these changes on sustainability and autonomy, derived from the IDEA method.

Results showed a great diversity of pathways of practices change, between groups and within each group. We showed a co-evolution of the ecologization of agricultural practices between different cultivation techniques. This dynamic approach made it possible to identify the key stages and levers of the agro-ecological transition, at the individual and collectives levels. The impact assessment revealed that farmers have gained more control in decision-making, more use of internal and territorial resources, but very few farmers have gained more economic autonomy. Thus, identifying levers and patterns of practices design to gain autonomy in CUMA groups brings very useful knowledge to support agroecological transition at territorial scale.

Keywords: *agroecology, autonomy, sustainability, assessment, ESR*

Introduction

Whereas agricultural practices contributing to agroecological transition are struggling to develop, the collective and local organization between farmers appears to be a lever for innovation and significant change, including amongst farmers who are not familiar with the ecological transition (Duru et al., 2015; Piraux et al., 2010). Mainly motivated by their search for autonomy (self-sufficiency an self-reliance), farmers interacting in farm machinery cooperatives (CUMA) in France develop new patterns of cooperation beyond the joint use of equipment and human resources (Lucas et al., 2014).

These new "agricultural solidarities" (Guillou et al., 2013) or "territorialized agroecological systems" (Duru et al., 2014) appear likely to favour innovation and the emergence of new practices that, even if they do not claim to refer to agroecology, correspond to forms of greening practices (Barbier and Goulet, 2013). In particular, it aims to contribute to the development of agricultural complementarities and synergies (between stockbreeders and grain farmers, for example), to facilitate the management of agroecological infrastructures or to enhance the use of ecological processes in agro-ecosystems through technical changes: development of no-till techniques, introduction of fodder legumes and cover crops into cropping systems etc.

Better understanding this phenomenon of reconfiguration of the collective action and evolution of the practices is a key issue to accompany this agroecological transition.

The objective of the Capaccita project (UMR Innovation - FNCUMA) is to combine the work of agronomists, sociologists and practitioners to understand this phenomenon of collective innovations facilitating the implementation of agroecological practices, to evaluate their impacts and to identify levers to support its development. A first step, presented in this article, is to combine a comprehensive approach of the pathways of practices change with an evaluative approach to assess their level of agroecology and their contribution to sustainable development.

Material and methods

The research combines together three methodological approaches: (Courty, 2016; Martel, 2016) :

1. A comprehensive analysis of the technical changes operated by the farmers, their rationale and the consequences of such changes on the global farm functioning. The objective is to finely analyse farmers' practices and their evolution over time to understand the drivers and the technical constraints of the change process in which they are engaged. We focus in particular on the place and the role of the key objects involved in this process (legumes, cover crops, material suitable for direct seeding, etc.), their uses to mobilize ecological processes within the agrosystems, the level of redesign of technical systems induced by these changes in practices, the corpus of agronomic knowledge mobilized in this transition. We use the concepts and approaches of practices analysis, at the interface between agronomy (Milleville, 1987) and sociology (Brives et al., 2015; Darré et al., 2006)
2. A qualification of their level of greening from the ESR approach (Hill and MacRae, 1996; Lamine, 2011; Tittonell, 2014) and the frameworks for analyzing the principles of agroecology by combining agronomic (Altieri, 1995) and sociologic (Stassart et al., 2013) approaches. The 'ESR' framework distinguishes between eco-efficiency (E), input substitution by organic inputs (S), and ecologically intensified systemic redesign (R). Efficiency remains in the realm of performance, input optimization and technology-based agriculture. Substitution is the replacement of synthetic inputs with biological inputs; at this level there may be a real break or a simple continuity with conventional agriculture. The last level of ecologically intensified systemic redesign is based on a redesign of the agro-ecosystem to mobilize ecological processes (intercropping, agroforestry, etc.).
3. A multicriteria analysis that aims to assess (1) the degree of autonomy reached in the management of the farm, (2) the effects of these orientations on others criterias of farm sustainability. About autonomy, we based our analysis on the empirical framework of van der Ploeg (2014) who emphasizes the mechanisms facilitating farmers' autonomy and to derive concrete indicators we mainly used the IDEA (Version 4) methodology (Zham et al, 2015). In the new IDEA approach, autonomy has a very broad meaning; it considers (1) the reduced use of different kind of inputs usually bought outside of the farm (favouring complementarities and internal fluxes within the farm or in between neighbouring farms); later we call it "input autonomy", (2) less dependency to public subsidies, (3) financial independence, in relation with the amount of loans and external capital that carry weight in the economical performance of the farm, (4) decisional autonomy (free decision capabilities for choosing farming practices and future orientations and high diversity of sources of

advice). Finally we consider 30 indicators, 17 dealing with the autonomy dimension. The final set of indicators was selected according to two major set of constraints and objectives (1) the feasibility of collecting the required information in a short period of time through farmers' enquiries (2) the possibility of measuring the time evolution of the values of several indicators. In this way, we were able to represent and compare the results (between farms) on a thematic tree, displaying diachronic and static indicators without using any ponderation and aggregation methods.

This methodological approach was implemented in 3 CUMAs of 6-7 farmers, in the North-East, in the centre and in the south of France. None of these CUMA claims an agroecological approach but they are engaged in technical changes that could lead to an agroecological transition: introduction of legumes, tillage reduction, use of service plants. All farmers in these three CUMAs were contacted to conduct the interview. The vast majority responded positively: 19 investigations were conducted. Each investigation lasted 2 to 3 hours. The interview started with an open-ended question inviting the farmer to tell the story of his change of practices (for example: "Can you tell us how the introduction of legumes on your farm came about?") and not a closed question about the characteristics of his farm (for example: "What are your cropping and farming systems?"). Information on the farm (size, type of crop, etc.) was then requested, as the interview was conducted, to refine the grower's account of the story.

Results and discussion

For each farmer encountered, the pathway of practices change since their installation were represented by linking: i. the farm's characteristics (significant events, surface area ...), ii. changes that have occurred on the farm (in terms of production systems, equipment used, technical changes, organizational changes), iii. the networks and discussion groups to which the farmer belongs, as well as the most important background elements (results not shown).

Levels of greening of farmers' practices have been represented on graphs to locate each farmer and to chart his evolution pathway. Each axis represents a management object. It is subdivided into different modalities corresponding to conventional, efficiency, substitution or redesign oriented practices. These modalities have been positioned along the axis according to their level of greening. As farmers often implement several of the reference practices listed on the axes simultaneously, they have been positioned on the graph at the level of their practice with the most advanced degree of greening.

Figure 1 shows that there is a correlation between the greening of tillage practices and weed management: some do not evolve independently of the others. Two farmers (in the green circle) are in a situation of sub-system redesign regarding both weed and tillage managements: they stopped using any herbicides and they both do direct drilling into a permanent cover. Eight farmers (in the blue circle) are already at a stage of redesign regarding tillage management because they do strip-tilling together with a variety of other reduced tillage practices. They are all dependent to glyphosate for cover crop destruction. Four farmers (in the brown circle) are in a high level of substitution regarding weed management: they don't use glyphosate for destroying cover crops although they still use it as herbicide for weed control, while being at different levels of substitution regarding tillage management. Four farmers (in the pink circle) rely on occasional ploughing so that they are only very partially substituting mechanics with biology, while being at different levels of substitution of herbicides with biology. These are livestock farmers and they say it will be challenging for them to quit ploughing because their soils are too much compacted by mowing machines for fodder production. Two farmers (in the orange circle) are at an advanced level of substitution for both reduced tillage and weed management, although they don't give up on glyphosate. One farmer (in the red circle) sticks to a stage of eco-efficiency because he has not introduced any cover crop in his cropping system yet and his crop protection management strictly relies on a doses reduction.

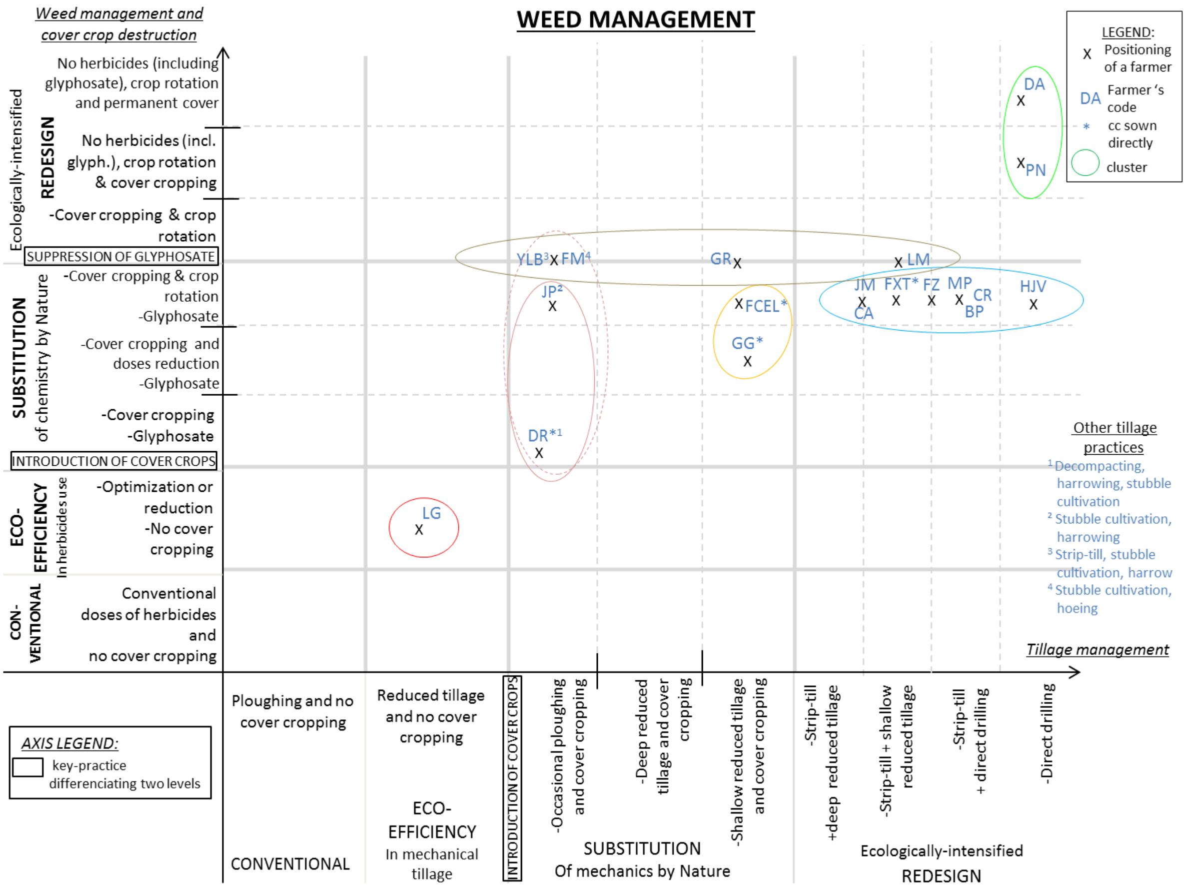

Figure 1. Actual farmers' weed and cover crop management according to tillage management, along the ESR scale

Now looking at the types of pathways that were undertaken by the farmers according to the ESR framework over time, five different types of evolutionary pathways have been outlined (Figure 2). The most common pathway in light green was to gradually substitute mechanics and chemistry with biology and reaching a redesign stage regarding tillage management. However, farmers who undertook this pathway will have difficulties in switching to sub-system redesign as long as they depend on glyphosate. The dashed light green arrow corresponds to the last step to reach sub-system redesign that only DA managed to reach because he recently switched to organic farming so that he gave up with any chemistry. The pathway represented by the light blue arrows show farmers who tried to give up with mechanics too fast with a switch from reduced tillage and no cover cropping to direct drilling into cover cropping and had go back to reduced tillage. The pathway in orange represents livestock farmers who tried to give up ploughing and to switch to reduced tillage before they realized they could not easily go without occasional ploughing because of their compacted soils. The pink arrow illustrates an interesting pathway, the one from farmers who chose first to introduce cover crops before switching to reduced tillage. Thus, there is a breakthrough with the introduction of cover cropping so that tillage can be easily reduced in depth, to reach direct drilling. Finally the dark green arrow represents the unique pathway undertook by Jan Co, who was a long time ago into an organic system in which he would make no use of herbicides before he decides to evolve with his tillage practice and switch directly to direct drilling.

Drawn from this set of pathways along the ESR framework, it seems that it is easier to reach a stage of sub-system redesign when starting to introduce cover cropping in the first place. The pathways of practices change hardly ever come under a radical transition but rather a step-by-step evolution. These trajectories highlight key steps and lock-in (such as the removal of glyphosate). There are also knock-on effects related to the modalities of animation of the CUMA group or to the proximity between farmers of the group. For example between 'Max' and 'Jan' who have come to a deep redesign of their system with different trajectories: Max has managed to suppress the use of glyphosate in his no-till plots and Jan to simplify tillage in organic farming. This was made possible through cross-learning and arrangements within the group (Jan's sheep graze Max's cereal plots at certain times of the year).

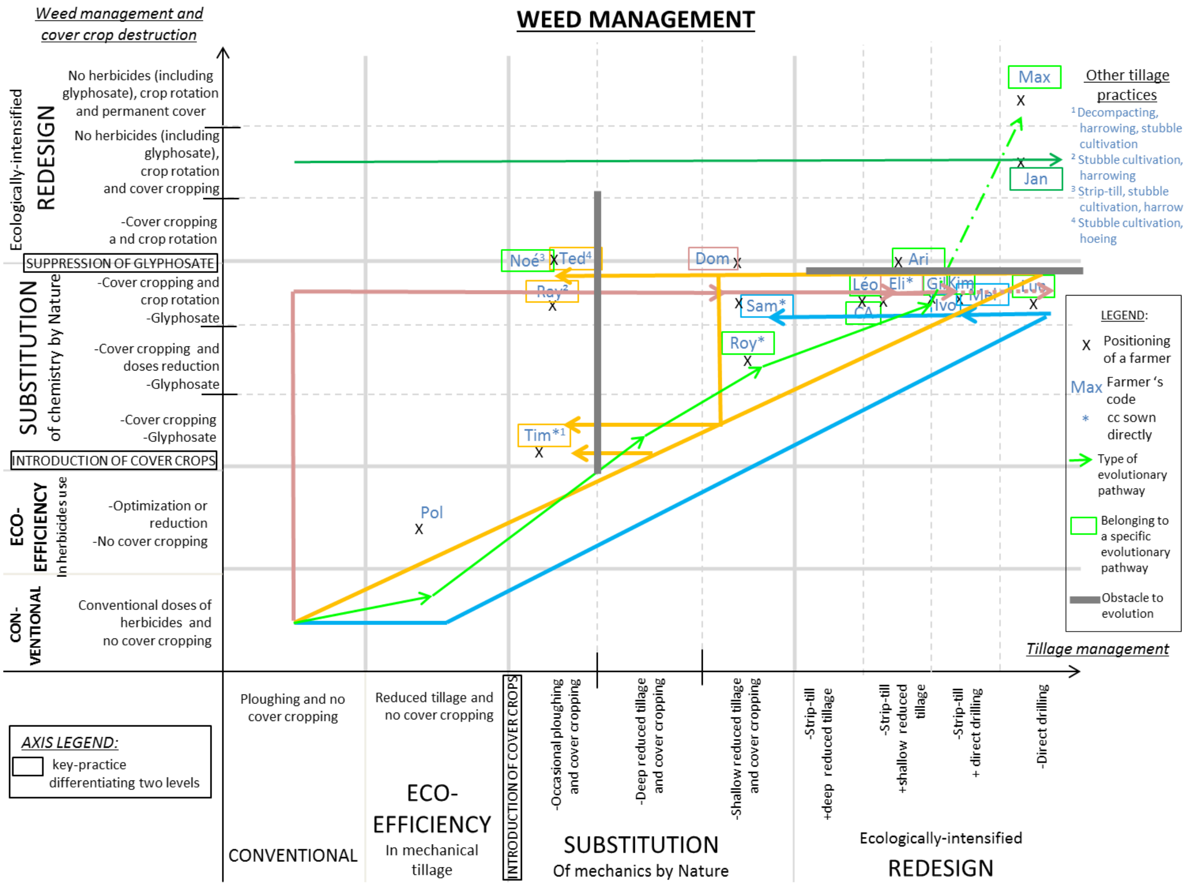

Figure 2. Farmers' pathways of practices change along the ESR scale

As a whole, the multicriteria assessment reveals very contrasted situations, with gains in input and decisional autonomy but sometimes reductions in financial independence (Figure 3). We also observe serious obstacles for the reduction of the use of specific herbicides (glyphosate) and nitrogen fertilizers.

About input autonomy, we observe very little variation in time (considering the same arable surface of he farm) of nitrogen fertilizers used and bought outside the farm, despite the development of leguminous crops like alfalfa. As a justification, farmers argue with agronomical considerations and also explain that they wait for a stabilization of the new cropping system before taking the risk of reducing fertilizer applications. In the same way, we observe a very weak diminution of the dependency to phytosanitary products. In details, there is an increase in glyphosate use (linked with the development of the no-till technology) and a decrease for the other herbicides. The gains in input autonomy concerns animal feeding, with an increase in farm production of forages and proteins. We also notice a reduction in energy consumption due to the application of no-till technology. For all farmers, we found a substantial intensification of equipment sharing (favoured by the CUMA structure, but not only) and also of the sharing of other strategic resources like seeds for multi-species pastures or cover-crops.

About decisional autonomy, we observe that farmers mobilize a very large number of sources of information and seek for diminishing their dependency to the "traditional institutions" in charge of technical and organisational advice to farmers. On the opposite, farmers strongly develop their commitment in (local) groups of peers and regional/national networks. Also, it exists a high level of exchanges of services between farmers (work sharing for example), indeed inside the CUMA structure, but also in the many other forms of collective action developed by farmers.

On the environmental point of view, we already mentioned a less dependency to fossil fuel, due to the implementation of technologies that reduce sol tilling. However, we also notice that several new agricultural practices (introduction of temporal or permanent multi-species pastures, no-till technology) are likely to contribute to C02 captation into the soils. Sharing equipment and reducing the purchase of animal feed also contribute to lower the indirect GHG emission (production and transportation). On the other hand, the farmers' reluctance to lower nitrogen fertilizer use doesn't allow us to foresee a rapid decrease of the contribution to N20 emission and fossil energy used to produce it. In the same way, we did not notice significant evolutions concerning the implementation of agroecological infrastructures like hedges, agroforestry…

			CUMA name		Pel-et-Der						Couffouleux						Charnizay						
		#	Qualitative indicator	Modality	Ari	Dom	Eli	Gil	Guy	Ivo	Jan	Kim	Léo	Luc	Max	Mel	Noé	Pol	Ray	Roy	Sam	Ted	Tim
AUTONOMY	Technical autonomy	1	Dependency on external fertilizers *(CCM)	-1/0/1	0	0	0	0	0	0	1	0	0	-1	0	0	0	0	0	0	0	0	0
		2	Dependency on external pesticides *(CCM)	-1/0/1	0	-1	0	0	0	0	1	0	0	0	1	0	0	1	-1	1	0	1	0
		3	Dependency on veterinary treatments	-1/0/1	NA	NS	NA	NA	NA	1	NA	NS	NA	NA	NA	NA	NS	NS	NS	NA	NS	NS	NS
		4	Dependency on external fossil energies *(CCM)	-1/0/1	1	NR	0	0	1	1	0	1	1	1	1	1	0	1	1	1	0	0	0
		5	Dependency on external fodder	-1/0/1	NA	1	1	NA	NA	1	NA	1	NA	NA	1	NA	1	1	1	1	1	1	1
		6	Dependency on external protein feed (fodder and concentrates) *(CCM)	-1/0/1	N/A	1	1	NS	NA	1	NA	1	NA	NA	1	NA	1	0	1	0	1	1	1
		7	Production of farm seeds	0/1/2	2	2	1	1	1	1	1	2	1	2	1	1	2	0	0	0	1	NA	1
	Decision-making autonomy	8	Diversity and Type of sources of information	0/1/2	2	2	2	2	2	2	2	2	1	2	2	2	2	0	2	1	2	2	2
		9	Farmers group(s) or network membership	0/1/2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2	2
		10	Taking back some tasks that used to be delegated	0/1/2	NA	NS	1	NS	0	NA	NA	2	0	NA	NA	NA	NS	0	1	1	1	NA	2
	Economic and financial autonomy	11	Equipping linked to technical change	-1/0/1	1	-1	-1	-1	-1	-1	1	1	-1	-1	1	1	1	-1	-1	-1	-1	-1	0
		12	Degree of capitalization concerning own machinery and recent infrastructures	0/1/2	1	1	1	1	1	1	0	1	0	2	1	1	2	0	0	0	1	2	1
		13	Side-activity or other income sources that can secure the investment	0/1/2	1	1	0	1	2	0	1	0	1	0	1	0	2	0	0	0	0	0	0
		14	Diversification in market sources (linked to farming productions)	0/1/2	1	2	2	0	0	0	2	1	1	1	1	1	2	0	0	0	1	1	0
	Territorial autonom	15	Exchanges of productive resources (seeds, fodder, straw, etc.)	-1/0/1	1	1	1	1	1	1	1	1	1	1	1	1	NS	0	0	0	1	0	0
		16	Mutualization of equipments and machinery *(CCM)	-1/0/1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		17	Exchanges of services (labor)	0/1/2	1	2	2	2	2	2	1	1	1	1	1	1	NS	2	1	2	1	1	2
SOCIA ASPECT		18	Workload variation	-1/0/1	NA	0	NA	0	1	0	0	1	1	0	NA	1	NS	0	NS	1	0	-1	NS
		19	System favoring employment	0/1/2	0	2	1	0	0	0	2	2	0	1	0	0	2	0	0	0	0	2	2
ENVIRONMENTAL ASPECTS		20	Diversification in crops in the cropping system	-1/0/1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
		21	Mixed farming system	0/1/2	0	2	1	0	0	2	0	1	0	0	1	0	1	1	1	1	1	1	1
		22	Way of covering the soil *(CCM)	0/1/2	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
		23	Reduction of suppression of ploughing *(CCM)	0/1/2	1	1	1	1	1	2	1	2	1	2	2	1	1	1	1	1	1	1	1
		24	Introduction of legumes as cash crops, pasture or cover crop *(CCM)	0/1/2	2	2	2	2	1	2	2	2	1	1	2	1	2	1	2	1	2	2	1
		25	Soil fertility maintenance (mulching, manuring) *(CCM)	0/1/2	2	2	2	2	1	2	2	1	1	1	2	N/A	2	1	1	1	1	2	1
		26	Presence of green infrastructures (permanent pastures, hedgerows) *(CCM)	0/1/2	NS	NS	NS	1	NS	1	NS	NS	1	NS	2	NS	NS	NS	NS	NS	NS	NS	NS
		27	Variation in the amount of nitrogen used *(CCM)	-1/0/1	0	1	0	1	1	0	-1	0	0	-1	0	0	1	0	0	0	0	0	0
		28	Variation in the inputs for herbicides (except glyphosate)	-1/0/1	1	0	1	1	1	0	1	0	0	0	1	-1	1	1	0	1	0	0	1
		29	Variation in the inputs of glyphosate	-1/0/1	0	-1	-1	-1	-1	-1	1	-1	-1	-1	1	-1	-1	0	-1	-1	-1	0	-1
		30	Variation in the inputs for insecticides, fongicides and anti-slug treatments	-1/0/1	0	0	0	0	1	1	1	1	0	1	1	1	0	1	0	1	1	NS	0

Legend:

autonomy
environmental
social
… related

Technical changes in study
Impacted
Not impacted
…by the technical change in study

Point determination modality :

Variation in time (-1/0/1)	-1 Less favorable*	0 No variation	-	1 More favorable*	N/A or NS Not applicable Not specified
Variation from farm to farm (0/1/2)	0 Not favorable*	-	1 Quite favorable*	2 Favorable*	

Figure 3. Sustainability evaluation of the farmers' pathways of practices change in the 19 farms surveyed.

Conclusion

This study points out the relevance of complementary approaches in agronomy and sociology; it also emphasizes the usefulness of both normative and comprehensive approaches. Focusing on the trajectories of the agricultural practices implemented in the field by farmers is very suitable to combine those disciplines and, by the way, to reveal farmers' perceptions, strategies and difficulties. Focusing on a limited number of key-practices related to agroecological intensification facilitates the inquiries while reducing the duration of the face to face interviews with farmers. The normative approach allow to go beyond the declarations of the farmers checking to which extent their intentions and objectives are reached; also it allows to explore the possible effects or consequences of the changes of practices over other variables not necessarily taken into account in farmers' initial motivations.

This methodology will be used in 2018 to create a tool for farmers' group animation. The idea is to analyze with the farmers how their agricultural practices have evolved through time using the ESR approach in order (1) to acquire awareness of the diversity of the trajectories inside the group (2) to make clear the reasons and stakes that have motivated these changes and the way farmers evaluate their achievement (3) to highlight the contribution of these changes to a process of ecologisation (4) to point out difficulties and lock-ins and to examine how the farmers' group, with his own resources, is able to overpass them and, by doing so, to strengthen an agroecological transition.

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