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Relational drivers of the agroecological transition: An analysis of farmer trajectories in the Limagne plain, France

Etienne POLGE* [a], **Hugo PAGES** [a]

[a] INRAE – UMR Territoires (Université Clermont Auvergne, AgroParisTech, INRAE, VetAgro Sup), 9 Av. Blaise Pascal, 63170 Aubière, France; *etienne.polge@inrae.fr
*Corresponding author, E-mail address: etienne.polge@inrae.fr

Highlights

- Quantified narratives assess the role of interpersonal relationships and formal arrangement in agroecological transition.
- Disruption events and trial and error process illustrate the adaptive process inherent to agroecological transition
- Agroecological transition and resilience need support from a diversity of food system actors
- Strong farmer groups and territorial supports increase the resilience of organic farming

Abstract

The social network analysis of farmers who have adopted agroecological practices give the possibility to identify which actors are involved in the agroecological transition and are influencing the resilience at territorial level. To understand the dynamics of these interactions, we built and tested an analytical framework inspired by quantified narratives approach adapted to agricultural context. We combined social sequences analysis (identification of common phases within individual trajectories and typology of sequences) and relational chains analysis that is a specific approach within social networks analysis focusing on the mode of access to resources. We applied our analytical framework to study the modes of access to resources mobilized by farmers to adopt agroecological practices in the Limagne plain of the Puy-de-Dôme county in France . We conducted 31 face-to-face interviews with 22 farmers in organic agriculture and 9 farmers in conservation agriculture. The results show that our approach gives the possibility to identify a large range of actors beyond the commonly pre-identified actors and to analyse their specific roles depending on the phase of the transition. The farmers in conservation agriculture mobilize mainly interpersonal relationships prior to the adoption of practices and have little support at the time of the implementation of conservation agriculture practices while the organic farmers rely more on farmers'' groups and on formalized arrangements with support organizations and downstream actors. The framework should be a useful way to identify in all agricultural systems the actors effectively implicated in the agroecological transition, their differentiated roles, and the support needed to improve the transition.

Keywords : Quantified narratives, Relational drivers, Resources, Agroecological transition, Territorial level, Resilient agriculture, Trajectories, Relational chains, Organic farming, Conservation agriculture

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1 Introduction

The identification of the conditions of agroecological transitions is the subject of a growing number of publications. These conditions are multiple and linked to the holistic aspects of the agroecological approach. Basically, the adoption of agroecological practices aims at providing more ecosystem services and higher farming intensity (more inputs such as work, natural or material inputs mobilized by units of land to increase the value added) (Tittonell, 2020) through beneficial biological interactions and synergies among the components of agroecosystems (Gliessman, 1990). Nevertheless, Agroecology is a science, a social movement and a set of practices (Wezel et al., 2020) including ecological, economic and social dimensions with application to the entire food system (Francis et al. 2003). Thus, the adoption of agroecological practices depends on many shifting factors. To be sustainable, the agroecological transition should be based on increasing resilience and adaptability in rural communities. For farmers, conduct a successful transition and face disturbances may require to turn collapse into a reorganization of their farming systems. Farmers need social relationships, engagement with a diversity of actors who operate in a territory, and favourable policy and institutional environments (Newig et al., 2007). The process of the transition is turbulent, and changes in practices imply deep structural changes, including shifts in the relationships between actors (Darnhofer et al., 2016).

Changes in farming practice analysis have a long history in social sciences. The analysis of these changes in practice requires a systemic approach that can identify their determining factors at the level of crop and livestock systems, farming systems, agrarian systems (Cochet, 2015) and, more generally, at the level of food systems, by integrating the multiple actors involved in production, processing and consumption (Lamine, 2015; Meynard et al., 2017). Indeed, changes in practices are heavily determined by the working environment of farmers. It is thus necessary to understand the environment surrounding farmers to understand the determinants of their practices (Lamine et al., 2014). Different systemic approaches integrate different dimensions of the dynamics of the systems and at different scales from the farming system to the food system. However, the analytical understanding of the social relationships that govern activities (here farming practices) is still not sufficiently addressed or only by using reductive decision-making models (Granovetter, 2021), particularly regarding the complex systems that concern agriculture and food (Marsden and Murdoch, 2006).

The multi-level perspective on sustainability transitions (Geels, 2002, 2004) gives a conceptual framework to analyse the complexity of the transitions distinguishing particularly niches level (the locus for radical innovation emerges) and socio-technical regimes level (stabilized configuration disrupted by niches). It has often been mobilized to analyse the complexity of natural resource governance (Pahl-Wostl, 2009; Herrfahrdt-Pähle et al., 2020) or transitions in agriculture (Darnhofer, 2015) and, more specifically, to analyse the way that agricultural innovation systems can work as a niche (Pigford et al., 2018). It gives not only an overview of the complexity of transitions but also insights into the role of agencies and social interaction. Social capital dimensions (bonding, linking and bridging) as proxies of the social network

structure are often mobilized to deeply analyse how social interaction drives transitions (Cofré-Bravo et al., 2019; King et al., 2019; Sharp and Smith, 2003). Innovation depends on the equilibrium between the closeness (bonding) and openness (bridging and linking) of the network ensured by the figure of the broker that connects different groups of people. However, social network analysis as such is rarely mobilized, although it can provide more detailed information on the structure of social networks and on the role of the different actors in the transition.

Nevertheless, a fruitful field of research on the influence of social networks on natural resource management (Barnes et al., 2017) and on biodiversity-based agriculture is flourishing (Labeyrie et al., 2021). These studies, which initially focused on the links that integrate biological components, are increasingly taking into account socioeconomic dimensions. Concerning socioeconomic dimensions, from the work on local professional farmers' groups (Darré, 1996), a tradition of research mobilizing social network analysis to analyse changes in practices and innovation in farmer groups has developed (Chiffoleau, 2005; Compagnone and Hellec, 2015, Scorsino et al., 2019, Pachoud et al. 2009). Technical transformations are considered as products of the socioeconomic interactions that are part of a system of relationships (Darré et al., 1989; Compagnone, 2015). These are based on both support by advisors and the collective dynamics within groups of farmers (Lamine et al., 2009). However, beyond peer groups, the agroecological transition calls for engaging and articulating all the different components of territorial food systems (Lamine and Chiffoleau, 2016). To provide evidence on this postulate, research that mobilize social network analysis broadens the scope of these previous works by examining the changes in practices and innovation driven by other stakeholders of territorial food systems, such as cooperative managers (Chiffoleau and Touzard, 2013), territorial facilitators (Polge and Piraux, 2017; Polge and Torre, 2018), or downstream actors (Polge et al., 2016; Torre et al., 2019). However, these studies are usually limited to some commonly pre-identified actors and do not provide an overview of the diversity of actors who impact the changes in practices. Moreover, there have been difficulties in understanding the dynamics of the social networks involved.

To overcome these limitations and to better understand the relational drivers of changes in practices at the local and territorial levels, we can call on the richness of social network analysis, particularly in the field of socioeconomics and regional science.

Indeed, the following three main approaches within social network analysis are generally identified (Grossetti, 2020): complete networks; personal networks; and relational chains. (i) The complete networks delimited by a border include all the relationships within a given and closed arrangement or organization. Complete networks make it possible to understand the structure of the network (Lazega, 2001, 2003). (ii) Personal networks include the set of relationships that a given individual has (Bidart et al., 2018). (iii) Relational chains include the set of relationships linked to different resources (Grossetti et al., 2011) and are the units of analysis used to understand small-world phenomena (Milgram, 1967). Although these three approaches can be of interest and can complement one another to help us better understand the relational drivers of the agroecological transition, we focus on the relational chains analysed through a quantified narratives approach (Grossetti et al., 2011).

The quantified narratives approach is still not widely used to deal with agricultural and rural development (Galliano et al., 2017), but it has the advantage of providing historical depth and a broad understanding of the actors and resources mobilized in complex processes, such as those linked to an agroecological transition. In particular, this approach makes it possible to consider the transitions as collective actions that involve a diversity of actors in interactions. In addition

to this analysis, the objective of this article is to address the following question: what roles do the different types of interpersonal relationships and formal arrangements (farmer groups, support organizations, etc.) play in the local agroecological transition? Our hypothesis is that the agroecological transition requires the implication of a large range of actors sharing cognitive resources with farmers that go far beyond the traditional support organizations. We expect that these needs depend on the phase of the transition.

Thus, our main contribution is to propose an original resource-oriented and longitudinal social network analysis at the farmer level that allows us to qualify the agroecological transition and to identify and quantify the actors involved depending on the phase of the transition. The application of this framework to our field case study led us to interesting results by comparing the two agricultural models that are based on ecological practices.

We first present the different analytical elements on which our approach is based concerning changes in practices, the role of collective action and the relational driver of transitions. In the Materials and methods section, we present the field case study and the way that we apply our analytic framework to answer our question. In the Results section, we present the results concerning the analysis of trajectories, modes of access and group dynamics. Then, we discuss the application of the analytic framework and the results to propose a broader analytical framework.

2 Analytical framework

Our approach aims to articulate trajectory and relational chain analysis to understand how interaction dynamics drive agroecological transitions.

a. Farmers' individual trajectories and the role of collective action

The study of changes in agricultural practices can be based on an analysis of farmers' individual trajectories. By trajectory, we mean the set of events that have followed one another over a given period of time and that have led to one or more changes in practices (Lamine and Bellon, 2009). When capturing the process of changes in practice, focusing on the trajectory is very helpful. It allows us to analyse the "step-by-step" process and the complexity of the continuous adaptation of technical practice in political, social and economic contexts (Chantre et al., 2015). Thus, many studies have focused on farmers' individual trajectories to understand the processes attached to them. Sutherland et al. (2012) conceptualize farmers' trajectory as starting after the occurrence of a triggering event, followed by successive phases of the "active assessment", "implementation" and "consolidation" of new practices. Chantre and Cardona (2014) analyse technical progress by observing changes in agronomic coherences (input intensive, rationalized, integrated crop management for one crop and for several crops, integrated production and organic farming) along the trajectory and the link with the global strategy of farmers.

Beyond the analysis of individual trajectories, many studies have emphasized the importance of collective action in changes to farming practices. Darré et al. (1989) note the driving force that farmers' groups generate in the creation and diffusion of knowledge within farming communities. Goulet (2013) identifies the ability of farmers to create technical innovations by and for themselves. Other studies explore the processes of knowledge production within farmers' groups about particular practices, such as farm seed production (Derbez, 2018), seed exchanges (Labeyrie et al., 2021, 2016) or no-till practices (Goulet, 2013). Collective action also takes broader forms by encompassing not only all actors in agriculture and agri-food systems but also other sectors of society.

Currently, with the transformation of agriculture, new actors become stakeholders, and traditional actors strive to define their new role (Lémery, 2003) and a new way to organize the agricultural knowledge and innovation system (Klerkx et al., 2010, Compagnone, 2014; Labarthe et al., 2021). The support of advisory services is shaped by the negotiated conception of agricultural development (Compagnone et al., 2008; Cofré-Bravo et al., 2019). Thus, the coordination of territorial agents, including actors such as companies, local institutions (such as regional natural parks) and scholars, also plays a central role in the development of territories that can support the implementation of new farming practices (Wezel et al., 2016; Polge et al., 2016).

In this study, we adopt an integrated analysis approach of the transition process that includes all actors in the agri-food system. This echoes the definition of agroecology chosen above (Francis et al., 2003). Such an approach does not, however, deprive farmers of their central role in the transition. Therefore, our interest is a combined analysis of farmers' individual trajectory with the role of third parties involved in the change processes of their practices.

b. Relational driver of transitions

To produce an analysis of the processes involved in changes in practices, our analytical framework, which is inspired by the quantified narratives approach (Grossetti et al., 2011), combines sequence analysis (Abbott, 1995) with relational chain analysis (Granovetter, 1973).

Sequence analysis aims to identify the phases in life stories and their sequence that become a relevant variable used to characterize and compare trajectories. The identification of common phases and similar sequences allows us to build typologies of trajectories. Inspired by genomic sequence alignment methods, it consists of identifying similarities in the pattern of trajectories.

Formalized as a specific approach within the quantified narratives approach by Grossetti et al. (2011), relational chain analysis consists of analysing the sequences of relationships mobilized to access resources. Even if this approach is not well identified, major publications in the social sciences and, more specifically, in social network analysis, can be identified as relevant to it. Granovetter (1983, 1995) contributes to building this approach with his work on the factors that drive the ability to obtain a job by measuring the proportion of jobs obtained by interpersonal relationships or by formal intermediaries, the length of the relational chain and the strength of the relationship. This work led to documenting the embeddedness of economic activity and the dynamics of information diffusion, innovation and cohesion. In some way, the small-world phenomenon that considers that everyone in the world can be reached through a short chain of social acquaintances is also demonstrated by Milgram (1967) through relational chain analysis.

The quantified narratives approach systematizes the data processing of relational chain analysis. It consists of analysing the situations of access to resources during processes through narratives that identify key events and, at each key event, the t resources and actors mobilized. This approach allows us to qualify and quantify the influence of interpersonal relations versus mediating resources (not only nonhuman mediating resources such as directories or websites but also specific mediating activities such as coordinators, facilitators, and advisers) on the access to resources or the number of intermediaries. A main objective is generally to understand the embeddedness (predominant influence of interpersonal relationships) and decoupling (from the predominant influence of interpersonal relationships to the predominant influence of mediating resources) of activities over time. Quantified narratives have been used to analyse a large diversity of objects, such as science-industry relations (Ferru et al., 2019; Grossetti et al., 2003), business creation (Berrou and Gondard-Delcroix, 2018; Chapus and Nordman, 2021;

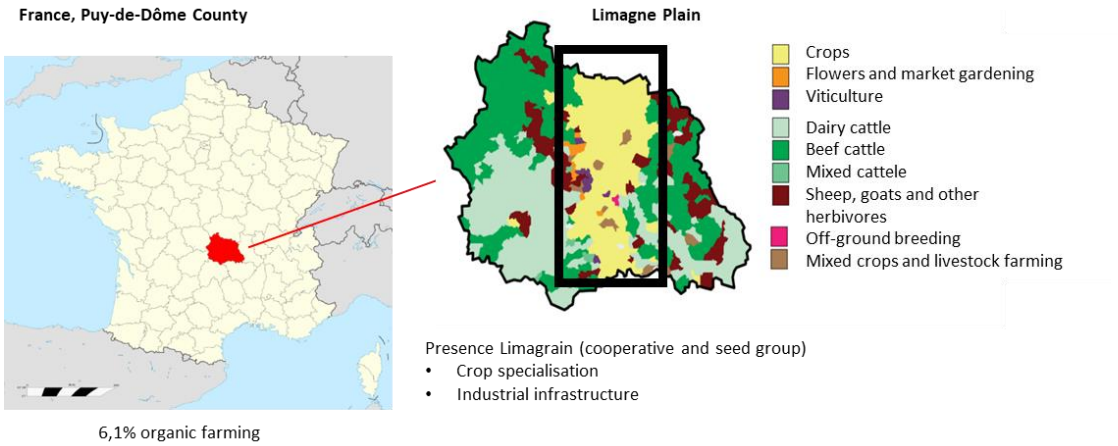
Grossetti et al., 2011), the process of invention (Cloutier, 2014), the dynamics of innovation in rural areas (Galliano et al., 2017) and food practices (Akermann and Coeurquetin, 2021). For business creation, the method aims to identify both the types of actors who help to access the needed resources for company creation (friends, colleagues, banks, etc.) and the nature of the resources used during this solicitation (funding, skills, a workplace, etc.). Narrations can be built from several interviews on the same process (triangulation) or from one narration that provides data on the perception of the interviewee about his or her own trajectory. In this way, Cloutier (2014) addresses the trajectory of individuals by examining the mode of access used during different phases of invention processes (commitment, routing, and formalization).

These approaches that aim to study the role played by multiple actors in the process of accessing resources are very pertinent to analyse the relational drivers of changes in practices at the farm level. Indeed, farms are places of multiple resource flows, and farmers have to deal with many socioeconomic interactions. Moreover, farmers are located at the crossroads of the interests and wills of multiple actors (Lémery, 2003), which impacts their logic of action and their changes in practices. Nevertheless, the specificity of the agricultural context and the holistic and long-term process behind the agroecological transition led us to design a new methodological framework.

3 Materials and methods

We carried out our work in the Limagne plain in Puy-de-Dôme County (NUTS 3 region) in France (Figure 1). This territory is characterized by the presence of the local cooperative and international seed group company Limagrain, which has a structure of integrated supply chains supported by industrial infrastructure. This presence leads to high added value crop specialization and the shaping of territorial dynamics. Puy-de-Dôme County has limited agricultural land engaged in organic farming, which represents 6.1% of the county (source: DRAAF AURA/SRISET, 2019[1]). This case study is interesting because it puts forwards processes that enable ecological agriculture to develop, despite the strong influence of conventional agriculture.

Figure 1: Context of the Limagne Plain



[1] http://www.auvergnerhonealpes.bio/files/81/abenaura/1836/Fiche-AB-Puy-de-Dome-Observatoire-Regional-AB.pdf

We focused on cereal farmers located in the Limagne plain who adopted agroecological practices and who are members of farmers' groups focused on agroecological practices but representingdifferent agricultural models.

To better understand the dynamics of the farmers in the groups and to "recruit" farmers for the study, we first contacted the organizations and advisors that support farmers' groups focused on agroecological practices. We led exploratory interviews and talks with the advisers and leaders of associations, cooperatives and farmers' groups and upstream and downstream actors. Then, we participated in farmers' group meetings to explain our approach, to understand the dynamics of the groups and to directly contact farmers who had adopted agroecological practices and had agreed to be interviewed. Interview requests were also made by phone, thanks to contact lists of farmers involved in the farmers' groups and by snowball sampling.

Given the content of the interviews and the analytical framework, we analysed two subcategories of farmers' trajectories, namely, the farmers who converted or were converting to organic farming and the farmers who were applying conservation agriculture practices. We considered that these subcategories represent two agroecological models that act in several dimensions of resilient agriculture (Jat et al., 2014; Milestad and Darnhofer, 2003). In line with agroecological transitions, organic agriculture conversion usually requires systematic and holistic changes to reduce the use of inputs and withdraw chemical inputs, while conservation agriculture focuses on the specific dimensions of the agroecology concerning the life and structure of the soil. We considered that farmers were part of the conservation agriculture category when they regularly set up or attempted to implement one or more of the following practices: direct seeding; cover cropping; a drastic reduction in the use of ploughing (no less than 80% of the land area); and the regular use of simplified cultivation techniques. For the purpose of simplification, we did not consider as part of the conservation agriculture group the organic farmers who set intercrop covers.

Thirty-one interviews of farmers located in the Limagne plain were conducted (Table 1) through narrative interviews that focused on professional life stories, the resources mobilized to adopt new agroecological practices and the modes of access to these resources. The introductory questions were "Could you tell me about your career from the beginning? Could you identify the main steps that you took to adopt new practices (organic farming or conservation agriculture)? What happened?" To deepen the analysis of what happened and identify the resources and the mode of access to them, the follow-up questions were "Who interceded in this moment? For what purpose? Can you name this person and the organization that they belong to?" During the interview, information of a chronological nature was noted on a timeline to help the interviewee locate the events more easily in time. The farmer had the opportunity to intervene to identify an error in the chronological sequence, which allowed for corrections. We were then able to code the narrative material from a raw quotation.

Table 1: Final sample of the farmers interviewed with basic attributes and the nature of practice change

Model	Number of farms	Type of production	Farm size
Organic Farming (OF)	22 farms (10 converted to OF before 2011, the rest after 2011)	-10 exclusive grain crop production farms - 5 mixed cereals-cattle farms - 7 grain crop farms including another workshop (chicken, medicinal herbs, or mushroom production)	from 49 ha to 128 ha
Conservation agriculture (CA)	9 farms	- 6 exclusive grain crop production farms - 1 mixed cereals-cattle farms - 2 grain crop farms including another workshop (chicken or medicinal herbs)	from 65 ha to 130 ha

Frame 1: Example of coding from a raw quotation:
"I mean, I already had quite a few friends from the farmers' union who were producing organically, so I had a glimpse of what it was like".
"I had a glimpse of what it was like" shows that the farmer had a fairly distant perception of organic farming; thus, the farmer is in an observant position. *"What it was like"* suggests that the farmer could have access to technical overviews of organic farming. It is therefore a phase where the farmer has access to one of the necessary resources for change, such as technical references. We then associate this phase with the "Recognition" sequence (that we associated with the acquisition of previews, references, and explanations).
"Farmers' union" is a formal organization that mobilizes mediation resources, such as technical references, to ease interactions and the access to resources.

To code our narrative materiel (see Frame 1) and to process our data, we mobilized social sequence and quantified narratives approaches that we adapted to our questions.

Following the social sequence approach, we identified the phases of the process that lead to the adoption of new agroecological practices. The first part of the data processing was iterative. We attributed a first name and a first description to each identified phase. Subsequently, the colour and description of the phases in a graphic document that gathered all individual trajectories were helpful to identify similar phases. The typology of phases was inductively stabilized following the data processing. Then, we built a typology of sequences through a qualitative analysis, given the relatively small sample.

Following the quantified narratives approach, we identified the key resources and the mode of access to these resources then we qualify and quantify them in each phase of the trajectory. Usually, this approach is used to analyse the embeddedness dynamics that differentiate two large types of modes of access, specifically, interpersonal relationships when the access to resources is determined by a direct interaction with a person and formal arrangements when access is determined by formal procedures through mediating resources. In our study, in addition to these two main categories, given the specificity of agriculture and the decision-making process, we added the "individual initiative" category when the access to resources came from observation and the experiment (Figure 2). To identify the role of specific relationships or institutions in the process, we applied a second level of the typology that distinguished the different types of actors involved in interpersonal relationships and formal arrangements. These data can be processed for each phase qualitatively through the visualization of a resource-oriented network or quantitatively by summing the number of

resources or modes of access mobilized during the trajectories of a determined group of farmers (Figure 3).

Figure 2: Basic typology of access to resources

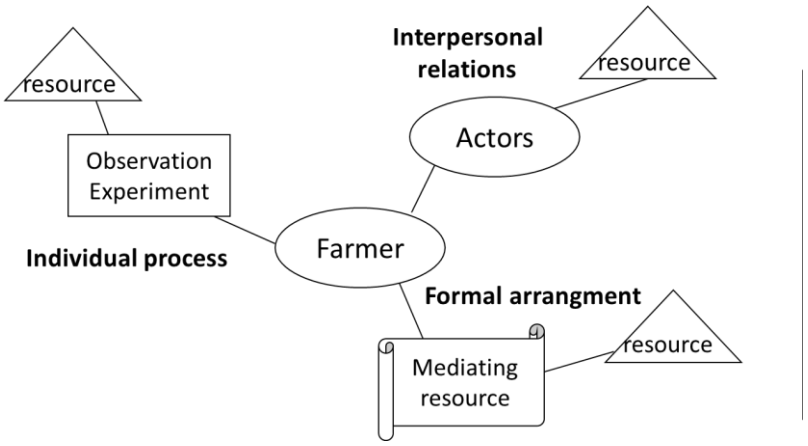
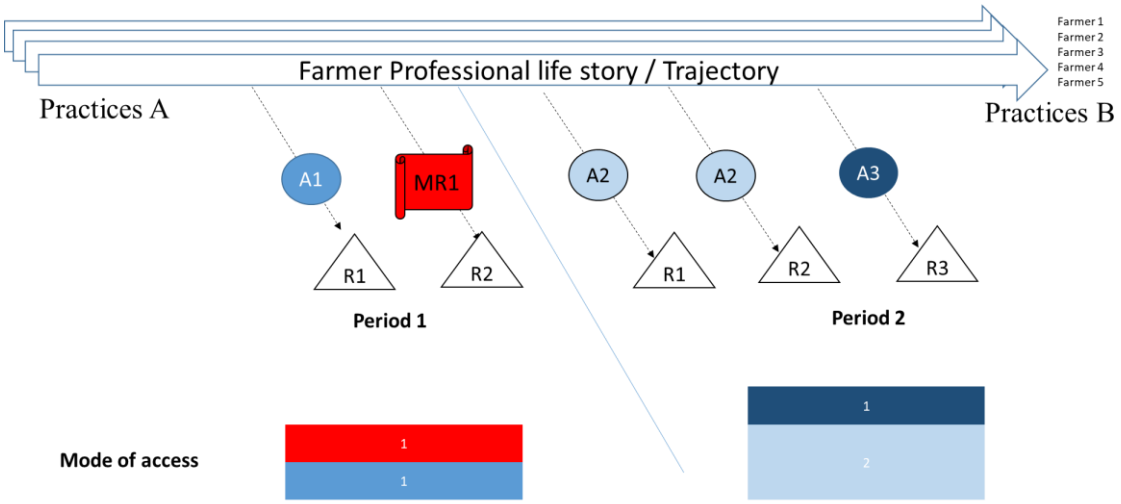


Figure 3: Identification of the mode of access (A=actor, MR= mediating resource, and R= resource). Narrative interviews on farmers' trajectories towards agroecological transition with follow-up questions on resources and the mode of access to these resources during specific events provide the possibility of counting the mode of access by period/phase. In the example, resources were accessed one time by the A1 type and one time by MR1 during period 1 and two times by the A2 type and one time by the A3 type.



4 Results and discussion

We first present our results on the identification of the phases within the trajectories and on the characterization of the sequence types; then, we present our results on the modes of access to resources that we quantify by phase.

a. Phases within the trajectories

We identified five distinct phases, namely, disruption, recognition, preparation, implementation and consolidation. Table 2 below presents the description of each sequence and its associated resources. We identified the following 4 key resources: technical references that correspond to technical data or that describe the way to apply agroecological practices or field experiments;

administrative support that corresponds to the way that practices are registered; technical skills that correspond to the capacity to effectively implement the practices; and market opportunities that correspond to the marketing of the products.

Table 2: Identified phases within the trajectories of practice change and their associated resources

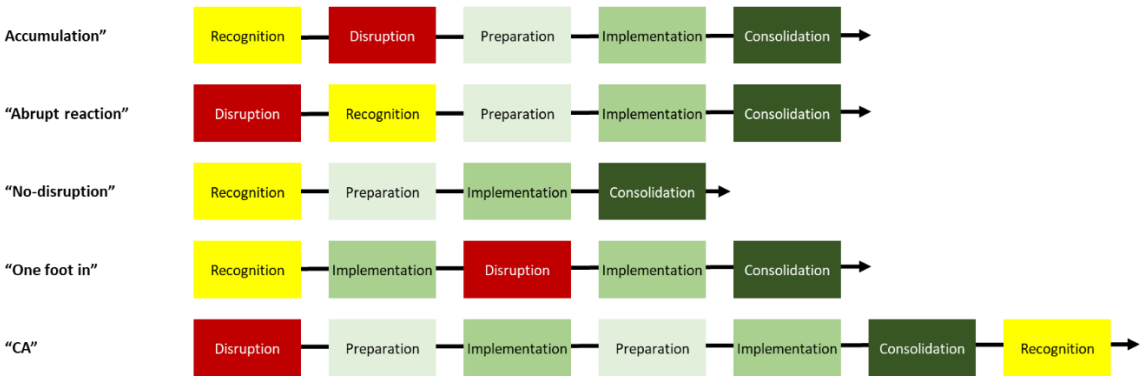
Name of the phase	Description	Resource(s) associated with the sequence
Disruption	The farmer is breaking with his or her way of farming. An event (intoxication, soil erosion, economic difficulties, etc.) or an evolution of the context (change in regulations, yield caps, etc.) pushes him or her to move towards change.	• No objective resources associated
Recognition	The farmer takes his or her first steps in understanding the farming system (OF, CA) that was envisaged. It is a phase of discovery and general information gathering.	• Technical references, • Administrative support
Preparation	The farmer has decided to make the change. This is a change-planning phase, and the farmer is trying to gather the resources that he or she lacks to set up the change.	• Technical skills • Market opportunities
Implementation	The farmer is in a phase of the operational implementation of the change. He or she is trying to establish his or her new techniques in the farming system.	• Technical skills
Consolidation	The farmer has settled on a number of techniques. He or she now wants to perfect them or try to set up others through (individual or collective) experimentation.	• Technical reference, • Technical skills

b. Sequence typology

Even if farmers' trajectories show many differences, common sequences can be found. The type of sequence depends strongly on the farming system and on the social network in which farmers are embedded.

It appears from the interviews that the individual trajectories of farmers follow a diversity of sequences. Within a trajectory, some phases may be multiple and may be located in different areas. We identified five different types of sequences that we call "accumulation", "abrupt reaction", "no-disruption", "one-foot-in" and "conservation agriculture (CA)" (Figure 1). The first four types of sequences are associated with conversion to organic farming.

Figure 1: Types of sequences



In the "accumulation" sequence, the farmer experiences the recognition phase before the disruption phase. Generally, a part of his or her network has already implemented the practices. The farmer knows another farmer from the neighbouring area or from the farming union who has converted to organic farming. Sometimes they know another farmer who rolls crops into

straw after harvest to perform direct seed drilling and shares equipment with them. Finally, the farmer may also have been exposed to the technical standards associated with his or her change in practices during past professional experiences (e.g., as a former agricultural mechanic or a former worker or agricultural service provider). In this type of sequence, the root determinant is usually the result of the gradual accumulation of knowledge that leads to the adoption of agroecological practices.

In the "abrupt reaction" sequence, the farmer is not normally exposed to any outside network that would help him or her discover the type of practices that he or she will implement later. This situation is generally that of farmers who have reacted to a strong event (such as chemical poisoning or a disease associated with its use or soil erosion). This disruption can also be the result of a gradual accumulation, which is sometimes followed by an event that finally pushes the farmer to react. During this trajectory, the farmer takes his or her first steps towards the change of technique after the triggering events.

In the "no-disruption" trajectory, the farmer did not experience a disruption. This is the case for a farmer who has converted to organic farming to seize the opportunity to ensure higher value-added production. This is also the case for farmers who have taken over a farm that was already producing organically without necessarily having experienced a "disruption".

In the "one-foot-in" trajectories, the farmer experienced the change in practice in two stages. The farmer had previously changed practices that would facilitate a second change. This is particularly the case for farmers in mixed crop-cattle farming systems that had already evolved towards a reduction in fertilization and optimized management of rotations for cereal production. This is also the case for a farmer who has converted a part of his or her organic farm during diversification processes to the production of aromatic and medicinal plants (PAMPs). Subsequently, a triggering event (chemical poisoning) can finally convince them to convert entirely to organic farming.

The "CA" trajectory is associated with farmers who have implemented conservation agriculture techniques. Some of them experience a real disruption when they observe a strong erosion of their soils. Others experience a disruption of a different nature: the fortuitous discovery of the agronomic principles of conservation agriculture. This disruption has the particularity of being experienced by the farmer during the recognition phase. It is the discovery of conservation agriculture techniques and the insight that the farmers gain from them that triggers a change in practices. Second, we note that the change in practices is generally experienced as a sporadic process for these farmers; they experience this through several stages. This is not a radical change, as is usually the case with the transition to organic farming.

c. Modes of access typology

Table 3 shows the different modes of access that we identified through the review of the interviews and the recorded statements. The interpersonal relationship category comprises the modes of access to the resources that do not need specific mediating resources (directories, website, facilitator, etc.) to occur, such as the direct interaction between peers (farmers), with other actors from the agricultural world and with other actors who are not from the agricultural world. The formal arrangement category encompasses the access to resources that need specific mediating resources to occur even if interpersonal relationships also play significant roles, including supply chain actors (downstream and upstream), farmers' groups and local farmer associations, farmer unions, and support organizations (e.g., chambers of agriculture, private technical institutes, training organizations, accountants, etc.). As mentioned above, we

identified a third category that corresponds to individual processes of access to resources through mobilizing field observations and experiments on farms with trial-and-error processes.

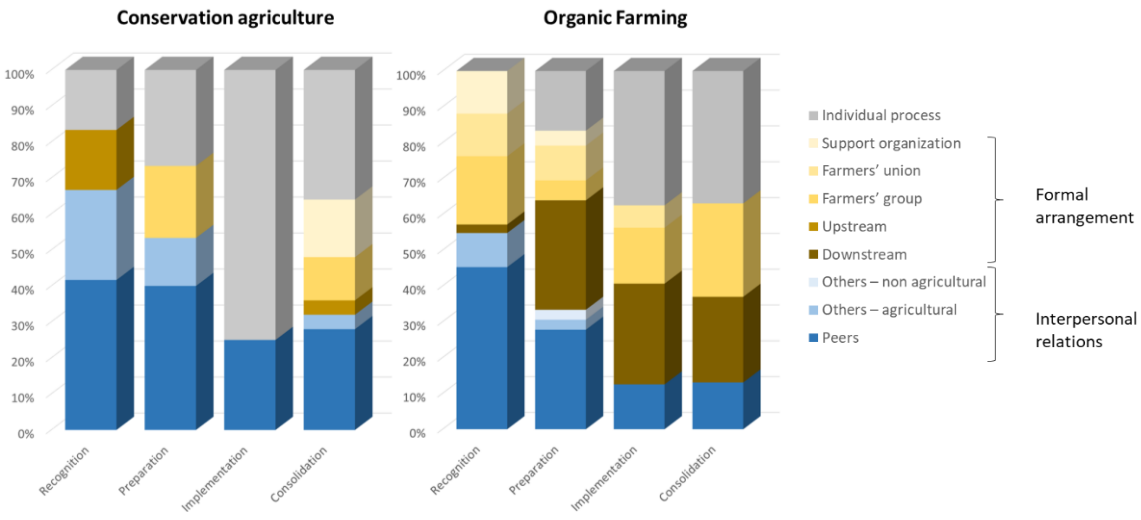
Table 3: Modes of access used by farmers during their trajectory

Interpersonal relationships	Peers
	Others – agricultural
	Others – non agricultural
Formal arrangements	Downstream commercial branch (product buyers)
	Upstream commercial branch (input sellers)
	Farmers' group – Farmers' association
	Farmers' union
	Support organizations
Individual processes	Observations, experiments

d. Mode of access depending on the phase

Switching to organic farming or to conservation agriculture are two very different processes. Currently, the transition to organic farming is based on precise specifications and is experienced by farmers as a profound change in their operations. Moreover, organic farming is linked to a well-identified economic market that is known and valued by the general public. Conservation agriculture is more limited to agricultural production. It brings together multiple practices without being linked to an official set of specifications that could be familiar to consumers. As they respond to different technical and economic issues and interests corresponding to distinct agricultural models, we compare the two support networks associated with these practices. This leads us to quantify the modes of access (all resources combined) according to the phases of the farmers' trajectories and to the agricultural models (Figure 8).

Figure 2: Modes of access to resources mobilized during each phase experienced by farmers who switch to conservation agriculture (left panel) or organic farming (right panel)



For both types of agriculture, interpersonal relationships are mobilized more during the phases prior to the implementation of agroecological practices. A first comparison highlights the low importance of formal mechanisms mobilized to access the resources necessary for the adoption of agroecological practices in conservation agriculture.

In conservation agriculture, farmers find themselves isolated when implementing new practices and do not rely on downstream actors since this type of agriculture has no distinguishing signs that can be identified by the consumer. We identified a very weak presence of formal arrangements that come mainly from outside of the territory (the gentle presence of support organizations as Chamber of Agriculture). Prior to the implementation of conservation agriculture practices, most farmers mobilize their personal relationships, particularly with other farmers, to assess the relevance of the practices. Some others first mobilize upstream actors before seeking information among farmers' groups. The implementation phase is a critical phase regarding this aspect, with experience being essentially developed through individual processes and with peers without specific technical support. The farmers' groups seem to give some support during the preparation and consolidation phases. We can nevertheless observe a dynamic of isolation during the implementation and decoupling (predominant influence of mediating resources) of the support during the consolidation phase. Without certification, conservation agriculture is not differentiated for downstream areas that do not supply resources.

In organic farming, farmers are not isolated before the implementation of practices. They rely mainly on their personal networks, particularly during the recognition phase. However, depending on the phases, formal arrangements play important roles: downstream actors during the preparation, implementation and consolidation phases; farmers' groups during the recognition, implementation and consolidation phases. The recognition phase seems to be well accompanied, whether through interpersonal relationships or formal arrangement. The interactions with peers and farmers groups appear to have an essential role during the recognition period and the consolidation phase, particularly for formerly converted farmers. Downstream organizations also play a major role during the phases of preparation, implementation and consolidation. We can notice a decoupling dynamic (from the recognition to the consolidation phase), formal arrangement becoming more relevant than interpersonal relationships to access resources. However, farmers' groups appear to be crucial in the consolidation phase. In our case study, the process of conversion to organic farming is linked with a process of decoupling. Formal arrangement becomes predominant to access resources once the decision of conversion is made, even if this leads to the development of interpersonal relationships within the organic farming community.

e. Dynamics of farmers' groups

The narration of the professional life story and the follow-up question about the farmers' group allow us to qualitatively deepen the understanding of the dynamics of the socioeconomic network linked to the farmers in the farmers' groups.

Local farmers' groups in conservation agriculture are not very explicit. The majority of farmers led the implementation of conservation agriculture techniques by themselves despite some bilateral solidarity between farmers. The diffusion of conservation agriculture practices in Limagne, which remains slow, has been dependent on the importation of technical references and principles of conservation agriculture from other French territories but also and especially from other territories abroad (Argentina, Brazil, and Australia in particular). The closest network that seems to have most widely supported the diffusion of conservation agriculture in Limagne is the British association BASE (Biodiversity, Agriculture, Soils and Environment), which gathers (or at least gathered in the past) the precursors and iconic personalities of conservation agriculture (Frederic Thomas, Konrad Schreiber, Christian Abadie, etc.). However, a working group on conservation agriculture practices emerged within the large local cooperative

(Limagrain) and led to some adaptation of the technical route imposed by the integrated and lucrative supply chain (authorizing the practices of no-ploughing on the culture of maize seeds in particular) without affording credible support from the cooperative.

The farmers in the organic farming group are strongly connected. First, it began as an implicit group of those who belonged to the regional organic farming federation who produced cereal and lived in the same small agricultural region. Then, following a training workshop, farmers recognized common interests and constituted an explicit group within the federation with specific meetings mobilizing specific mediating resources and forming a community of practice. Through recognition of the group and its labelling as a GIEE (Group of Economic and Environmental Interest) and Ecophyto 30000 (engaged to significantly reduce use of pesticide the group), the group was able to finance one full-time facilitator within the federation to formalize the organization and form a link with partners. In addition to the central role of the federation, downstream actors, such as traders specializing in organic farming, are considered partners who participate in some meetings of the group and act as strong facilitators of the conversion to organic farming. Through common meetings with other cereal producer groups, organic farming groups have adopted an inclusive dynamic, inviting other farmers to adopt agroecological practices and to be part of the group. Finally, the farmers' group allows access to certain resources (all types of resources identified) necessary to change in practices, including through the introduction of the farmer into the wider community of organic farming producers that we can call interrelated communities of practice.

5 Discussion

The work had as an objective to analyse the role played by different types of interpersonal relationships and formal arrangements on the local agroecological transition. Following other findings of the literature (Cofré-Bravo et al., 2019; Wezel et al., 2020), we argued that the agroecological transition requires the implication of a large range of actors sharing cognitive resources with farmers that go far beyond the traditional support organizations. Our results indicate that the level of this implication changes during the process and depends on the agricultural model (organic farming and conservation agriculture).

The results of social sequence analysis show a diversity of trajectories that are differentiated mainly by the role played by disruption events and trial and error processes that lead to several phases of implementation, illustrating adaptive processes linked to the agroecological transition. The results of the analysis of mode of access underline the role of diversified actors in the food system during the transition. Comparing the network composition of the two agricultural models, farmers in organic farming appear to be much more supported by formal arrangements than conservation agriculture. Going more in detail to this composition, we emphasize some features for each model.

- Farmers in organic farming benefit particularly from the proactive posture of downstream private and cooperative companies that have to face increasing demand for organic products. Farmer groups animated by the local organic farming federation play an important role that could be more significant to the phase of preparation when farmers need technical skills and market opportunities. Once the process of conversion starts, support is closer, and resources become easier to access. The types, diversity and objectives (linked to organic farming) of the actors mobilized provide the conditions to increase resilience (Darnhofer et al., 2016; Slijper et al., 2022)

- Farmers in conservation agriculture are more isolated. Downstream actors are absent, and support organizations, particularly local ones, do not give support to conservation agriculture techniques. The strong role of observation and individual processes in acquiring technical skills during implementation with a low implication of formal arrangement leads to little diffusion of local innovation even if interaction with peers can ease access to resources and the consolidation of the farming system. The support organization appears to give little attention to conservation agriculture. Thus, conservation agriculture, without economic valorisation, receives very little support from local organizations when this seems to be a step of ecologization for conventional agriculture. These results are in line with those of Vankeerberghen and Stassart (2016) on the insularization process.

In our case study, regarding the agricultural system in which farmers are embedded and the diversity of the actors mobilized, organic farming appears to be more resilient and prepared to face disturbances and to adapt itself than conservation agriculture. Organic farmers benefit from strong farmers' groups and territorial support. In comparison, conservation agriculture suffers from limited implications for conventional local organizations and could have difficulties to persist even if some soil conservation practices could highly increase the resilience of agricultural systems. Conservation agricultural follows an insularization process without building alternative local organizations.

Agroecological transition could be reinforced considering the interaction between the two agricultural models. These interactions are very diverse going from going the complementaritie to the confrontation (Gasselin et al., 2020; Torre et al., 2019). Taking into account the power relations, the combination of both groups could be considered as an agricultural innovation ecosystem (Pigford et al., 2018). One group could benefit from the support of the organizations linked to organic farming easing structural changes, and the other group could benefit from the experiments of farmers on specific practices (soil conservation) with capacities to bring conventional organizations to support agroecological transition. Nevertheless, although these two models converge in some aspects, several technical, organizational and cognitive features limit the interactions (Vankeerberghen and Stassart, 2014).

The content of the paper takes its place in a series of recent works on social network analysis, based on the collection of qualitative and quantitative relational data from quantified narratives of the professional life of actors. In this respect, it presents three main improvements. The first improvement regards the methodology: we articulate sequence analysis and relational chain analysis by using quantified narratives. This approach gives us the possibility to widely identify the relational drivers of the agroecological transition considered important by the interviewees. More classical complete network analysis usually limits the examination to a given population that is fixed before the collection of data. The second improvement is related to the field of application. To our knowledge, this is the first time that this approach has been applied at the farmer level. Our approach appears to be adaptable to research on agroecological transition and resilience studies because it allows us to analyse the resources and the socioeconomic interactions needed to adapt and change farming practices. The third improvement sit on the fact to consider two farming models (organic farming and conservation) that lead to a comparison of the network composition and to consider their strengths and weaknesses for resilience. Finally, this approach usefully completes the agricultural systemic approach and provides the possibility to practically integrate the relational dimension into the systemic analytic framework that is considered crucial in the farmers' logic of action.

The main limitation of our analytic framework is the limited vision of the structure of socioeconomic networks at the farmer level and at the farmers' group level and the lack of a spatial dimension of the interaction. Other limitations are the partial analysis of resources that do not include material and financial resources or cognitive resources such as value changes. Finally, we analyse how belonging to specific agricultural models affects the trajectory that farmers follow, but we did not go deeper into the effects of the farming system on their trajectories. Our perspective is to pursue research, refine the cross-analysis of the farming system (data collected), trajectories, resources, and mode of access variables and articulate this approach with a complete socioeconomic network analysis of farmer groups and proximity analysis, including the spatial dimension of interaction. This analytic framework can be applied to several farmer groups separately (to highlight their common features and their specificities) or to a population that includes all the farmer groups that can provide information on the coexistence of the agricultural models. More generally, highlighting socio-economic interactions that drive or lock ecological transitions, it gives elements to guide initiatives towards more resilience.

6 Conclusion

A large range of interactions that mobilize different types of interpersonal relationships and formal arrangements play a major role in local agroecological transitions. Several results of the paper can be highlighted. Through a quantified narratives approach, we were able to identify this large range of interactions beyond the commonly pre-identified actors and analyse these specific roles depending on the phase of the transition. Disruption events and the trial-and-error characterization of some sequences illustrate the adaptive process inherent in the agroecological transition. The need for resources depends on the phase of the trajectory, and the different actors of the food system must adapt their support to these phases. Agroecological transition, without being holistic but being limited to the adoption of specific practices and involving only some operators of the food system as production actors, remains fragile. The consolidation of the agroecological transition requires relationships of proximity and trust that can be shaped through informal networks associated with formal networks such as farmer groups and territorialized organizations or arrangements that integrate the different actors of the food system.

7 References

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The authors of this paper declare that they have no conflicts of interest.

9 Ethics statement

As part of the LIFT H2020 project, the procedures for the collection, storage, protection, retention and destruction of personal data that comply with the EU GDPR were respected (for more information, see https://www.lift-h2020.eu).

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