



# Questioning the work of farmers, advisors, teachers and researchers in agro-ecological transition. A review

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## Abstract

The French Ministry of Agriculture has called for agro-ecological transitions that reconcile farming and the environment. In this review, we examine the transformations of farmers and AKIS (Agriculture Knowledge Innovation System) actors' work during agro-ecological transitions, and argue that the content, organization, and aim of farmers' work are influenced by agricultural training, agricultural development, and discussions between peers, research, and regulations. Our main findings concern those transformations. The first finding was that there is an increasing expression of local particularities (situated ecological processes, micro-climates, etc.) and farmers' singularities (e.g., relationship with nature). These particularities challenge AKIS players' forms of organization and intervention, which used to be built on generic knowledge. Our second finding was that AKIS players have to consider their action as one potential contribution to the development of farmers' experience: Their interventions become part of the flow of the farmer's activities. The question for AKIS players is then: How can farmers' own discovery of their natural and technical environment from new perspectives be facilitated? Thirdly, we found that transformations of work are systemic: The "doing", the knowledge applied, and the values and norms to which subjects refer change. Facilitating transition can no longer be considered as a problem of knowledge availability. Fourthly, production of agronomic knowledge and ways in which it is disseminated are being challenged. Not only does knowledge have to be certified by scientific norms and methods, it has also to be valued by actors if it is to have an impact. The prescriptive relationship of science and AKIS players towards farmers is likewise challenged. This review raises many questions: Do agro-ecological transitions contribute to reorienting the development of farmers' activity? Are agro-ecological transitions conducive to the development of sustainable farm work? What transformations of AKIS players' work are needed to better support agro-ecological transitions?

**Keywords** Agro-ecological transition · Work · Activity · Systemic approach to work · AKIS players

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## 1 Introduction: the paradoxical development of agriculture

The main trend in the development of French and European agriculture has been, and still is the increase of farm sizes and the simplification of agricultural production methods to increase labor productivity (see, for example, pig production, in Roguet et al. 2011). More generally, increased agricultural productivity is mainly achieved through automation. To enable this substitution of labor by capital, the main development levers have been specialization, scale increase, and the purchase of inputs. This development model was inherited from the agricultural modernization that was introduced after the Second World War. It still prevails today, at the expense of more sustainable agricultural development, despite its negative effects on the environment (deterioration of water quality, erosion of biodiversity, deterioration of soil fertility, greenhouse gas emissions, etc.) and on the agricultural workforce (over 30% of the total French workforce in 1955 and less than 5% today) (source: SCEES and INSEE, annual statistics). In France, the number of farms and farmers has continuously declined from 2,307,000 farms in 1955 to 514,700 farms in 2010 (INSEE, annual statistics). More importantly, discomfort is an acute issue in the farming profession: Suicide is the third cause of mortality in the agricultural population after cancer and cardiovascular diseases (Bossard et al. 2013), and is therefore far more prevalent than in the workforce as a whole.

Industrialization of the farming sector as a development model has long been questioned and disputed. Environmental protection organizations have been sounding the alarm for decades. Other actors are now joining forces with them and are leading the battle against industrial agriculture: citizens' movements for the defense of rural life, consumers' associations campaigning for a healthier diet, animal welfare organizations, and so on. Alternatives have also emerged within farmers' associations since the beginning of agricultural industrialization: Organic farming, biodynamic agriculture, and so-called self-sufficient and autonomous agriculture are various alternatives (Hubert et al. 2013). These types of farming rely on alternative farming systems and agri-food systems. Farming systems are based on internal and natural biological and physical regulation, while agri-food systems create new value chains and work organization

Government regulations appeared from the mid-1990s to reduce the negative environmental impact of industrialized farming practices. More recently, through the "Projet Agroécologie pour la France" (Agro-ecological Project for France), the French Ministry of Agriculture called for agro-ecological transitions: This program was launched by the socialist Stéphane Le Foll, Minister in charge of the agricultural sector during the E. Valls and B. Cazeneuve governments. This project aimed to provide impetus for new development of the entire agricultural sector. It accordingly developed new policy instruments to support a shift in the French agricultural development model. Such instruments target various audiences: farmers as well as researchers, teachers, innovation brokers, and so on. They are designed to promote the exploration of new foundations for the development of agriculture, and thus to meet the requirements of more sustainability at local and global levels

On a technical level, agro-ecology brings into play a different approach to farming, in which the principles of ecology are articulated in agricultural systems (Gliessman 2007). It employs a set of practices that leverage natural cycles (ecological processes, biodiversity, etc.) and preserve natural resources. This type of farming seeks to develop productive farming systems in order to meet environmental challenges, to maximize eco-systemic services likely to be provided by agro-systems, and to limit negative impacts on the environment (Altieri and Toledo 2011). Both in France and abroad, agro-ecology is often supported by social movements (see the example of Brazil, in Wezel and Soldat (2009)) promoting autonomy or food sovereignty and the reconstruction of social ties (Altieri and Toledo 2011; Bellon and Ollivier 2011). There are therefore three dimensions to this movement: a technical dimension, presented above, an ethical dimension (respect for the integrity of life forms, social justice), and a political dimension (based on a critical analysis of so-called industrial farming and food models).

When the French government launched the Agro-ecological Project for France in 2012, it was envisaged in technical terms, in which agro-ecology was summed up in the concept of doubly efficient agriculture combining competitiveness and environmental friendliness (Ollivier and Bellon 2015). The focus was on changing farmers' practices, to use and sustain natural cycles and preserve natural resources. This political impetus for an agro-ecological transition was therefore perceived differently by advocates of the foundations of agro-ecology, on the one hand, and representatives of conventional and industrialized farming, on the other. The former denounced its lack of ambition in terms of social and economic transition, while the latter sought to bring the agro-ecological project closer to that of productivist farming controlled by environmental norms, in order to limit the changes involved for most of the profession. The "Agro-ecological Project for France" is nevertheless a political framework that challenges, at least partially, the productivist model. Yet, major uncertainties remain as to the agro-ecological models to develop and the transition pathways to follow. Only a few studies (Chantre et al. 2015; Coquil et al. 2014) have really addressed the way farmers and other players from the Agriculture Knowledge Innovation System (AKIS) (teachers, advisers, researchers) (Klerkx and Jansen 2010; Guillot et al. 2013; Moschitz et al. 2015) meet this challenge and develop new practices, new values, and new understandings

In this paper, we consider that the agro-ecological transition (AET) is transforming the work of both farmers and AKIS players, as well as the relationships between them (Fig. 1). We assume that such transformations need to be addressed simultaneously, for at least two reasons. The first relates to our approach, which is inspired by ergonomics

and the distinction it makes between a task prescribed by management, and what the operator actually does (Leplat 2000). Farmers often both prescribe and perform their work. But, the farmer's activity is nevertheless informed by determinants imposed by companies both upstream (suppliers of machines, seeds, fertilizer products, and treatments) and downstream (cooperatives, processors, and distributors), or by all AKIS players. Farmers furthermore discuss their activity, as well as professional norms and identities, with peers in local or remote networks. They are therefore not entirely alone in defining the content, organization, and aim of their work. The second reason why such transformations need to be addressed simultaneously is related to our hypothesis about the impact of agro-ecological transitions on the way in which local particularities and the singularities of farmers' action are taken into account, for we assume that agro-ecology implies paying attention to the local and the singular. Accordingly, we consider the extent to which such agro-ecological transitions challenge AKIS players' forms of organization and intervention. Up to now, a strictly top-down regime of knowledge production has prevailed, which led to prescriptive relations with farmers and relatively standardized recommendations. How is such a regime challenged by uncertainty about how should farmers act with regard to biological regulation, uncertainty about the relevant techniques to support a farming project, and the diversity of projects concerned?

Based on recent research work carried out in France, we first examine the ways in which these studies address the work transformations at play for different actors contributing to agro-ecological transitions. We then present

**Fig. 1** Transition to agroecology: inviting the sens in the learning process in the INRA ASTER-Mirecourt experimental station. **a** Students discovering hay making appreciate quality and dryness. **b** Farmers discovering practical conditions of winter cereals weeding in an organic farm



existing frameworks of analysis that can be used to further understand the diverse dimensions of work transformations during a transition towards agro-ecology. Finally, we propose a research agenda designed to better identify (i) the transformations of work underway among farmers and AKIS players during agro-ecological transitions; (ii) the ways in which agro-ecological transitions reorient development dynamics in farming work; and (iii) the ways in which change in farmers' and AKIS players' work can best be supported.

## 2 Agro-ecological transitions: a transformation of farmers' and AKIS players' work

Changes in both farmers' and AKIS players' work during agro-ecological transitions are examined primarily from the perspective of the professional changes they experience in their ways of doing things and of relating to their professional identity. This professional transition is not simple: All of these actors have to contend with a lack of relevant knowledge and experience, and with the diversity of claims about how best to achieve such a transition. What are the difficulties that they all face when engaging on this path? What resources do they draw on to support such change? To what extent can these transitions support more sustainable work in agriculture? We present research results to point out key elements that need to be considered with regard to transformations in farmers' and AKIS players' work.

### 2.1 Transformations of farmers' work are embedded in their daily activity

Samurçay and Pastré (1998) draw a distinction between productive activity and constructive activity: Productive activity refers to the goal pursued by the worker, and constructive activity refers to their production of resources (physical and cognitive tools, etc.) to perform the activity. This distinction might classically lead us to consider productive and constructive activity as separate, but Samurçay and Pastré (1998) invite us to consider them as integrated into the work as such. As Jourdan (1997) has shown, productive work contributes to constructive work by way of experiential learning (Moneyron 2003). The work of Chantre (2011), Coquil (2014), Lamine (2011) highlights the way farmers operate to bundle the constructive and productive dimensions of their activity throughout their transition process. This process is a source of various pleasures mentioned by farmers (Barbier et al. 2015). Chantre (2011), Coquil (2014), and Lamine (2011) stress the role of experiential learning in collective forms of

experimentation, often closely linked to the productive dimension. They also show the role played by active participation in diverse networks, places, and arenas to support and assess farmers' involvement in experimenting with new practices. Chrétien (2015) highlights specific arenas during productive work on farms, in which experience is transferred from one generation of farmer to the next.

Farmers' activities contribute to their experience: They build a large variety of resources through their work, which might be useful in the future.

### 2.2 Transformations of farmers' and AKIS players' work require new relations to knowledge

Chantre (2011), Coquil (2014), and Lamine (2011) have analyzed work transformations among farmers transitioning towards agro-ecology. They have highlighted changes in farming practices, specific learning dynamics, a renewal of the purposes of farmers' work, and sometimes a change of the meaning they ascribe to it. As they seek to significantly reduce the use of chemical inputs, farmers are in a process of discovery of their natural and "technicalized" environment from new perspectives. They increase their ability to observe natural processes and to develop knowledge on local particularities (Barbier et al. 2015).

This new relationship between knowledge and action in the classroom challenges the superior position of teachers and trainers towards their learners. Cayre (2013) analyses conditions built by agricultural training school teams (teachers, trainers, managers of educational farms, etc.) to engage their audiences in agro-ecology. For example, he studies the way in which the reduction of chemical inputs on the educational farms of secondary schools in agriculture, and the redesign of the farming system that it entails, is used as a learning situation and medium. He shows that to teach their audiences to think about action that promotes agro-ecology, teachers face two difficulties. The first one is related to the growing uncertainties stemming not so much from incomplete knowledge as from the proliferation of available knowledge. That proliferation might either be scientific and technical knowledge distributed across different research fronts (Girard 2014), and/or empirical knowledge, which the context of uncertainty tends to re-legitimize. This situation weakens the teacher's position as it questions the prevalence of scientific expertise over action inherited from an epistemological position of the natural sciences that was meant to define the "truth" through facts. The second difficulty for teachers is related to the need to make choices which cannot be based only on facts: First, reality is too complex for farmers (or future farmers) to have the cognitive capacities to leverage all the knowledge available, and second, action involves emergencies. Therefore, farmers who are transitioning must make (or

learn to make) choices that relate not so much to knowledge itself as to their own beliefs. As a result, teachers and trainers have to manage learning processes that can no longer elude the frictions between facts and values, and between knowledge and beliefs.

The transformation undergone by trainers also applies to crop production advisers. Guillot et al. (2013) show that advisers develop new work practices and new “pragmatic concepts,” meaning, as defined by Pastré (1999), key notions for orienting the way workers act in a work situation. To support farmers in developing more environment-friendly practices, advisers distinguish between “hot” and “cold” advice. Hot is “question-answer”-type advice, for example to monitor production processes during the season, and is based on the farmers’ questions; cold advice is to steer farmers’ diagnosis towards the long-term and to a larger systemic perspective. This is a relatively new distinction. In the context of input-intensive farming, hot used to be how they functioned most of the time. Today, these crop production advisers recognize the importance of articulating a growing variety of forms of agronomic reasoning in the framework of an agro-ecological transition, while looking for ways to make them accessible to farmers. They change hot advice and seek a new position to rebuild an agronomic reasoning process with farmers, to drive a diagnosis, and to define pathways of action. In this way, they rebuild with them an agronomic knowledge capital that they can use to develop a line of reasoning. In this perspective, they question their current technical knowledge based mainly on local analytical experiments and decision tools developed according to a largely standardized technico-economic optimum. Crop advisers seek more experiential and/or systemic knowledge, and when in transition, they tend to reconsider the meaning they give to their own advisory practice.

As shown by these studies, the production and conditions of dissemination of agronomic knowledge are being strongly challenged. In agro-ecological transitions, farmers and AKIS’ players reconsider their own knowledge and the role they assign to scientific knowledge. All actors experience a change in the way they act and the meaning they give to their own work and professions. Bawden (2005), on the base of the Hawkesbury experience, had already theorized this co-evolution of action and the different dimensions of their profession for teaching the systemic approach in agriculture.

### **2.3 Transformations of teaching, advisory services, and research: the necessary move away from top-down?**

We have highlighted a transformation in farmers’ as well as in AKIS players’ work, in which the top-down relationship

between AKIS players and farmers has been challenged by the call for agro-ecological transitions. That top-down relationship has been in place since the Agricultural Development Act in 1966, renewed in 1990 and 2000 without real change of the general organization of the research, development, and teaching system. Yet, the lack of a clear definition of the political impetus for a transition towards agro-ecology has led to a wide variety of developments in the AKIS profession: For instance, a variety of ways of practising the profession of agricultural adviser coexists in the transition context. In their comparative study of two support frameworks for the adoption of green forms of farming, Brives et al. (2015) show the possibility of advising transitioning farmers either with prescriptive advice or with participatory support. In the framework of prescription, they speak of insurance support: An adviser takes responsibility for the trials set up on the farmer’s farm in order to support their transition. For participatory advice, they speak of research support: Beyond a bottom-up model, Brives et al. (2015) formalize a distributed research and innovation model as a form of reassurance for farmers involved in these frameworks.

Olry (2014) considers the way these prescriptive relationships are also challenged, by analyzing the case of water catchment areas in which farmers are reluctant to change their farming practices. Local authorities try to provoke change and require that farmers adopt more environment-friendly farming practices to protect water from agricultural pollutions. In this context, advisers face some dilemmas. First, the mandate from their own employer (local farmers) may differ from the one given by the local authorities. Second, the means (time, tools) given to them by their organization might not enable them to develop new and relevant relationships with such a non-volunteer audience (Guillot et al. 2013): For example, they might not be able to promote peer-to-peer experience exchange with farmers who have already developed practices to reduce nitrogen or pesticide pollution at the water catchment. Duhamel et al. (2017) show that supporting this move within advisers’ organizations is in itself not an easy task. In the CHANGER project, various advisers and organizations experienced it as difficult or even impossible. One of the main reasons is that there is hardly any room to develop a common understanding of the kind of services that will be needed to support farmers in their transition.

We suggest that there is also a real challenge in enabling collaboration and overcoming organizational boundaries. The task is hard in a highly competitive advisory environment in which public and private research and consulting coexist. An example is the difficult transformations of private consulting in the framework of the agro-ecological transition (see box).

### Box: agro-ecological transition and the transformation of work in private consulting

Taking environmental issues into account in farming activity is opening new markets for private companies upstream and downstream in agriculture, and is leading them to reorient part of their activities. We are consequently seeing investment, or reinvestment for some, in technical consulting for farmers, be it by input supply companies (Goulet and Le Velly 2013; Villemaine and Compagnone 2015) or by rural economy centers (Hellec and Deville 2015). Alongside individual support to farmers, there is also a revival of consulting for groups of farmers seen as innovative, delivered by agents from private companies (Brives et al. 2015; Goulet and Vinck 2012). The relationships developed with research organizations seem to vary widely. Some companies fiercely reject scientific knowledge, considering it to be too general and irrelevant for farmers acting in contexts that are always singular. Others, on the contrary, seek to build links with researchers, both to access cognitive resources and to establish their legitimacy in the eyes of farmers. Either way, the production models supported by these companies do not adopt agro-ecological orientations; they are based more on integrated farming and especially soil conservation farming.

Recent EU regulations have encouraged a separation, within input supply companies, between the sale of products and technical consulting for farmers. Yet, as the orientations proposed by these companies are closely linked to the products they sell, this separation leads to technological deadlock. There is moreover increasingly fierce competition between the different technicians and consultants. This competition limits investment in the search for more sustainable forms of farming production, as the emphasis is on capturing new clients and developing loyalty. Additionally, it favors certain farmer profiles, side-lining small farms which then do not benefit from technical advice (Labarthe and Laurent 2011).

### 3 The transformation of work and the agro-ecological transition: the importance of a systemic approach

In this section, we argue that we need a systemic framework for farm work, to better investigate its transformations during transition towards agro-ecology. Such a framework should enable us (i) to study different dimensions of farm work, (ii) to support farmers in relevant ways in their professional transitions, and (iii) to support the renewal of relations between knowledge and action in such transitions, and the consequences thereof for AKIS players. How can systemic approaches to work, particularly farm work, help us to grasp and support these professional transitions more adequately?

#### 3.1 Systemic approaches to work and to activity

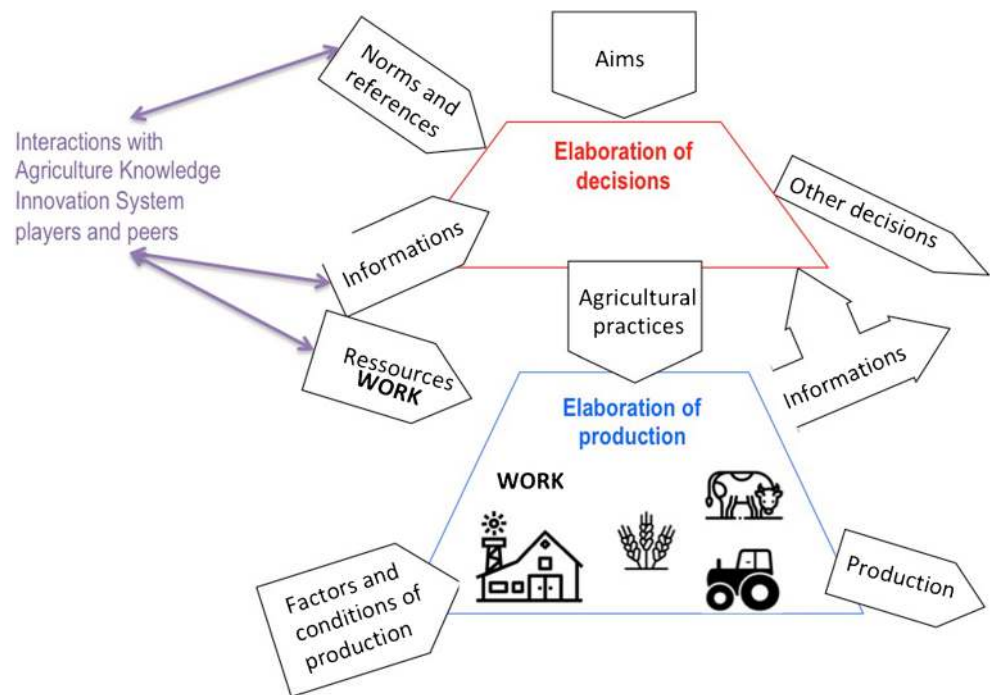
Analyses of farm work have been carried out in the technical and social sciences. They have led to varied approaches referring, implicitly or explicitly, to systemic visions of work.

Agronomy and animal science have developed technology-centered representations of work (Fig. 2) (Dedieu et al.

2008; Landais 1987; Osty and Landais 1993; Sebillotte 1990). These technical sciences focus on the optimal mobilization of farm resource, where the optimum depends on the farmer, and the workforce is one of the resources. Representations of work articulate the availability of labor and of farm implements (for example, tractors, planting and seeding machines, combine harvesters, etc.) with scheduled tasks which are required to achieve productive goals in the farm system (Rellier et al. 2011; Papy et al. 1988; Joannon et al. 2005; Hostiou et al. 2012b). Their approach characterizes the workload required to perform such tasks, as well as its distribution in time between the people and the equipment available in the technical system. For example, the OTELO model (Papy et al. 1988) was designed to support farmers in assessing their way of distributing work and machine resources, and better optimizing it with regard to climate variability in arable farming systems. It considers workforce as one of the resources in this process, like the availability of machines. It simulates the scheduled tasks and their activation by decision rules (as defined by a given farmer) according to various climate scenarios, and assesses the consequences on the feasibility of cropping practices (e.g., the bearing capacity of soil). The QuaeWork method (Hostiou et al. 2014) assesses the amount of work time required by a livestock farming system implemented on a farm. In particular, it assesses the work peaks required by the technical system, task by task, and the organization of work between the different workers on the farm (partners, couple, etc.). These approaches have been used to analyze the room to maneuver that farmers have in the organization of their work when introducing new farming techniques involving new tasks or new task schedules (Joannon et al. 2005). They have also been used to help farmers to consider work organization and quantification during the design of their livestock farming system (Hostiou et al. 2012a; Hostiou et al. 2012b; Hostiou and Fagon 2012).

The social sciences and ergonomics more specifically have also developed systemic approaches to work. These approaches are anthropocentric, focused on the ways farmers balance work, health and personal development in their daily activity, and essentially intrinsic (Rabardel and Béguin 2005), meaning they are built from the perspective of the performer who is engaged in a specific situation. Intrinsic representations focus on the way workers develop their own relationship with their working environment and regulate the balance between their work, their own health, and their personal development. Falzon (2013) formalized the systemic nature of activity and of its long-term development, starting from a representation of the subject at work, as proposed earlier by Leplat (2000). Thus, activity corresponds to the mobilization of the subject, depending partly on the characteristics of the prescribed task, and partly on the elements specific to him or her, for the subject regulates his or her work in the situation. The actual work derived from this coupling has effects on the task itself

**Fig. 2** Farmers' work in the systematic approach of technical sciences: work as a resource in the farming system



(are the objectives reached? etc.) and on the subject (fatigue, satisfaction, etc.), for he or she is not indifferent to the results of the task: His or her satisfaction/frustration regarding the results can lead him or her to make readjustments. Cerf (1996) developed an intrinsic representation of crop-growers' work, and Caens-Martin (1999) developed a representation of vine tailors' work. These representations shed light not only on the personal resources (cognitive, material, etc.) used by farmers to perform their daily work but also on the regulation they carry out in doing so. They might therefore be of didactic interest to inexperienced workers.

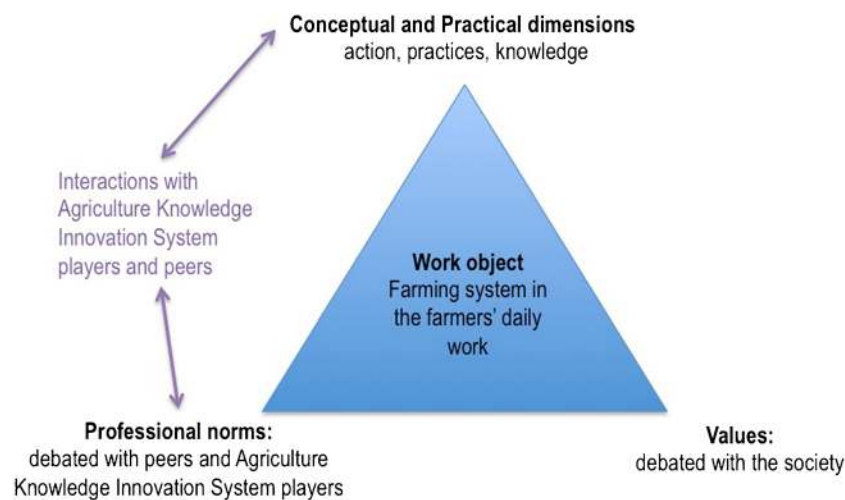
Béguin (2004) has proposed the concept of “professional world” to denote the conceptual, practical, and axiological backgrounds which form a system with the object of the active subject's activity. Coquil et al. (2017) distinguished the professional norms and the values of the axiological background: Professional norms refers the definition of “the good ways to practice” with the peers; values refers to the influence of society debates having impacts on farmer's work. The object of the activity and the active subject are inseparable and form a system (Fig. 3). The term professional world thus refers to a systemic, coherent, and stable organization of a person's activity within his or her environment. Coherence within the system is of a pragmatic nature: As Dewey (1967) pointed out, it relates to disorder, in other words to the quest for practical success. The axiological component is the invisible part of the activity: It is at play in both the singling and the development of the subjects' activity. This proposition of coherence in the subject's work is also proposed by Falzon (2013). Internal coherence refers to the regulation process of the worker seen as a system: He or she tries to decrease the tensions

between what he or she thinks, wants, and does in his or her daily activity.

These representations of work emphasize the analysis of the subject. As activity is quite subjective, what does its study teach us? The insights of these frameworks, proposed by the social sciences, stem from the fact that they analyze the development process of the singular work situations of subjects. As Schwartz (1992) has proposed, the study of the singular subject might be used to build an ontology or to focus on the development process. Building an ontology might lead the researcher to choose what is important and what is not for the working subject. Focusing on the development process of the working subject might allow more generality and enable us to discover the resources that he or she mobilizes to change. What insights do these frameworks of analysis afford on professional work transitions?

### 3.2 How does the system change?

In the field of agronomic science, transition to agroecology is conceptualized as a change of practices, a new allocation of resources including work and the discovery of new factors and conditions of production (Fig. 2). Hostiou et al. (2015), Malanski et al. (2015), and Petit (2015) have focused on the emergence of new tasks (such as new required fields of animal observations), and the reorganization of tasks and schedules during transitions. In cropping systems, crop diversification is usually used to decrease the pressure of weeds, pests, and diseases in the fields, and thus decrease the use of pesticides. But, crop diversification is liable to profoundly change work schedules: New periods of sowing, harvesting, and new



**Fig. 3** Professional world of farmer: farmer's work is represented as a stable and coherent system from his daily work. Conceptual and practical dimensions of his work, professional norms guiding him and values he follows form a coherent system with his work object to make daily work

possible, in good working conditions. Interactions with Agricultural Knowledge Innovation System players might mainly influence conceptual and practical dimensions and professional norms

interventions on crops appear. For example, work peaks that used to exist during the sowing periods of two or three crops covering very large areas decrease with diversification, and the multiplication of crops decreases the areas of each crop on the farm. In these cropping systems, the reduced use of herbicides strongly calls into question the weeding of large crop plots: How does mechanical weeding change farmers' work? In livestock farming systems, Hostiou et al. (2015) speak of a complexification of farmers' work organization during agro-ecological transition. An analysis of the sequences of the work and their organization reveals a multiplication and an overlapping of tasks, reflecting a finer and more complex organization that can lead to a new cognitive load. Yet, few references currently exist concerning the workload in agro-ecological systems compared to conventional ones: Does the workload (assessed here by time spent to perform the work) increase or decrease?

In the field of ergonomics, Coquil et al. (2017) formalizes the development of farmers' activity during their transition towards agro-ecological farming systems. This development might be initiated by four factors (access to unthinkable, practical difficulties, discrepancy between "work" and "ideas", and external obligation) and then follows a non-teleological and non-incremental process, informed by autonomous dynamics and social ones. Development is conceptualized as a tension between farmers' wishes for the future and what is possible in the real life, a tension between the appearance of problems and the capacity to solve them, and a tension between virtual and real. Coquil et al. (2017) qualifies as "autonomous" the dynamics linked to the farmer's search for pragmatic coherence within his or her professional world, where development is processed by the tension between the object of the work and its practical, axiological, and

conceptual backgrounds. These dynamics evolve during the transition, and the farmer manages to reconstruct a new coherence. Coquil qualifies as "social" the dynamics expressed through instrumental geneses (Rabardel and Béguin 2005) and through discussions between peers. Instruments and peer networks are socially constructed: They define professional norms, and good and bad agricultural practices. This systemic change is also defended by Bawden (2005) when he writes "interconnections were made between systemic acts of development in the 'concrete world' and the abstract 'epistemic developments' of actors who participate in them." From an external and skeptical point of view, work might seem complex; from the point of view of people acting and being convinced that theirs is the right way to act, work might be simple. Worldviews evolve during transition.

As highlighted above, techno-centered approaches propose a systemic understanding of the implications of work transformations at an organizational level, to quantify work needs and to assess the associated cognitive load. Anthro-centered approaches propose a systemic understanding of the dilemmas faced by farmers and of the instrumental geneses undertaken in the transition process to build a new coherence in their professional world, along with new ways to regulate their coupling with their work system. We lack an integrated systemic framework inspired by both technical and ergonomic approaches. Such a framework would certainly be useful to better identify the support that farmers need to face work challenges during their professional transition. For example, it could be used (i) to define how to support farmers in building new management entities and action routines, as well as markers and indicators that simplify what at first glance seems highly complex; and (ii) to put into perspective the paradigm and value changes related to the agro-ecological transition by



overcoming dilemmas when faced with change during the process, and supporting the emergence of a new coherence in the activity.

#### 4 Agro-ecological transition and transformations of farm work: towards a research agenda

Through resistance or voluntary change for a greener future, farmers and AKIS players are reconfiguring their work in a variety of ways, and through a diversity of change trajectories, to cope with the project “Agro-ecology for France.” The studies discussed above have provided some elements for our understanding of transformations of work in a context of agro-ecological transition. We propose a research agenda to go a step further and to get a better understanding of the diverse trajectories of systemic activity transformations during agro-ecological transitions.

##### 4.1 Agro-ecological transitions: a systematic development of farmers’ activity?

This review has shown that the transformations of work occurring during agro-ecological transitions relate as much to new ways of doing and thinking as to new ways of valuing the agro-ecosystem and farming activity. Is this always the case? Cayre (2013) points out that agro-ecological transitions induce a shift away from the control over nature by farming. Is this always the case? In their work, Duru et al. (2015) speak of weak and deep agro-ecological transitions, and Hill and MacRae (1995) differentiate gradients of greening of farming practices that Chantre and Cardona (2014) have also highlighted. What are the links between these gradients of greening of farming practices and work development processes? Can we differentiate the development processes at play according to the levels of greening involved?

The politicization of agro-ecology and the political impulse for the transition have brought about a variety of understandings both of the farming practices said to be agro-ecological and of their motives. This fluctuating environment is quite challenging for (i) the understanding of changing processes at stake for farmers and AKIS players; and (ii) the design of capacitating environments to facilitate such changes. How do the diverse motives determine the transformations of farmers’ and AKIS players’ work? Do such motives always result in transforming the actors’ activity in a way which enables them to develop another professional world? Is the simultaneous existence of several agro-ecological models not a source of hindrance of development for actors caught in paradoxical forms of injunction? If so, how is it possible to create capacitating environments both for farmers and for advisers to overcome these hindrances? One can argue that, depending on the

purposes underlying various greening processes, such environments will not necessarily be the same. In which situations does it prove suitable to create capacitating environments that will support change in ways of doing things and in ways of valuing and orienting action? How can this be implemented by AKIS players?

##### 4.2 Agro-ecological transitions and the development of sustainable farm work

The sustainability of farming depends strongly on the orientation given to its development and the way it is assessed. It seems important, however, to consider the sustainability of farm work in the framework of the agro-ecological transition. Beguin et al. (2012) argue that the sustainability of work derives from the preservation of workers’ health and the room to maneuver that their work affords in that respect. Applied to the field of farming, it must be envisaged according to three dimensions: the farmer’s work, farm equipment, and the sustainability of the farming activity. Systems that are designed to limit the use of pesticides, antibiotics, and so on, and to prioritize biological regulation lead to the appearance of new tasks such as ad hoc weeding and intensified observations, for instance to monitor the outbreak of crops diseases. Without specific equipment, these new tasks might be physically arduous and repetitive. The use of specific implements (harrows, hoeing machines, etc.) can partly solve such problems but raises the issue of economic feasibility, due to their costs. Thus, the agro-ecological transition confronts farmers with new trade-offs regarding capital/labor substitution. Such trade-offs are currently analyzed and evaluated in terms of workload and effects on farmer workers’ health, and of resulting agro-ecological and economic sustainability. But, they are not often analyzed in terms of instrument-based theory (Rabardel 1995) which distinguishes the artifact from the instrument: An artifact is an object that has been manufactured, whether materially or symbolically, and that is instrumented by human action. From this point of view, new equipment has to fit in the instrumental system already developed by the worker and/or require new instrumental geneses. Should we not pay more attention to the material and symbolic part involved in each new farm implement and better assess their purpose as assumed by their designers? Should we not analyze the way various farmers assess the benefits and limits of an implement in relation to farm employment (capital/labor substitution) and work (skills required, etc.)? Should we not analyze the use of modern artifacts (computerized, automated, etc.) and the instrumentation process that takes place? Instrumentation processes are related not only to efficiency but also to the subject’s pleasure and sensitivity: Observing animals and reading the sensors monitoring the animals’ physiological variations require different skills and abilities, and are designed for breeders with varying sensitivity

to animals. Should we not identify more effectively the diversity of instrumental processes to support farmers in making their trade-offs during agro-ecological transitions?

### 4.3 Supporting agro-ecological transitions: renewing the work of AKIS players

Our review shows that, as farmers, some AKIS players are engaged in a professional transition involving not only their ways of doing things but also their ways of thinking about their work and the meaning and value that they ascribe to it. It also highlights the significant renewal of knowledge that advisers and teachers mobilize to support respectively farmers or trainees in transitioning towards agro-ecology. As a result, they develop new ways to perform their work and to access relevant knowledge for that purpose. Note here that the main trend in agronomic research is currently focused on inventing valuable agro-ecological systems for the future, which will then be transferred to farmers through advisers. This diffusionist approach relegates innovation—that is, the introduction of invention into productive environments—to a later stage and has shown its limits when the transformation of productive environments is concerned (Temple et al. 2011). The organization of knowledge production is thus challenged, as are scientific positions. In advisory organizations, Delbos et al. (2014) point out that the coordination of back-office services (e.g., experiments and technical-economic references, etc.) and front office ones is often largely ineffective to support farmers in their agro-ecological transitions. This can lead to a mismatch between the knowledge produced and advisory needs.

We have acknowledged that AKIS players intervene in the flow of farmers' everyday activity and contribute to a part of their actual work. It is not yet very clear whether or not they renew their contribution to the definition of the farmer's work. It would be worth investigating this point. Chizallet et al. (2016) challenge the forms of support provided in this flow of activity in order to enable farmers to be more reflexive and projective about work issues, and call for research on the forms and content of support that will enable farmers to acquire and express their capacities. How does this integration of constructive work into farmers' flow of activities challenge and change AKIS players' profession? How does this integration challenge and change the way organizations consider the delivery of advice? There is a need to challenge the frameworks in place to support these AKIS players in their professional transition and to enable them to support the agro-ecological transition, as they inadequately take into account: (i) the change that advisers face in articulating the "two legs of the profession" (Auricoste et al. 2014), namely agronomic reasoning and intervening or facilitating; (ii) the inclusion of different spaces and times of intervention in the farmer's journey; and (iii) the new ties between research, development, and

training in their way of producing relevant knowledge for and with farmers.

## 5 Conclusion

This analysis of research on work transformations during agro-ecological transitions enables us to point out that some farmers and advisers are engaged in a deep transformation of their work. This means that, for these actors who wish to use biological and ecological processes to achieve such transitions, the way to do so must be discovered and understood on a daily basis. In farmers' day-to-day activity, such agro-ecological transitions not only set in motion new ways of doing and organizing work, but also require new skills and new ways of thinking and of living as a farmer. If AKIS players wish to accompany this discovery of the particularities of the environment in an operative way, they also need to integrate the singularities of the actors and in particular their motivations, interests, and ways of representing themselves and acting within the framework of this greening of their activity. As revealed by our review, AKIS players have to develop new skills to intervene: (i) in the constructive activity of the farmer, which takes place in the long run, benefiting from multiple information sources and from the daily experience of his or her productive work; and (ii) in a context of uncertainty due to an abundance of knowledge from various sources (scientific, technical, empirical) legitimized by action. Finally, our review opens the question of the prevalence of science over action: While it is crucial to take singularity into account to successfully carry out a transition process, teachers, advisers, and researchers cannot confine themselves to an expert position. This results in a need to transform their profession and their own organization, as well as the way they collaborate.

But, we have also pointed out that the fuzziness of the political project launched by the French Agricultural Ministry has led to various understandings of an agro-ecological transition. The diversity of agro-ecological models emerging during the transition raises the question of their agro-ecological and economic sustainability. As far as the work of farmers and AKIS players is concerned, we can question (i) the extent to which the motives underlying each model determine the transformations of farmers and AKIS activities; (ii) the extent to which the development of a diversity of agro-ecological models, accentuating the abundance of knowledge available, might hinder the agro-ecological transition; and (iii) the diverse capacitating environments that are required to promote these different agro-ecological transitions. But, we also need to question the sustainability of work designed during the transitions. Does agro-ecological transition guarantee the physical and moral health of workers and allow them to maintain room to maneuver in their daily lives? Agro-ecological transitions bring about new forms of work in the agricultural

sector, with or without “modern” artifacts (automation and sensors). This raises the question of physical arduousness and pleasure in agricultural work. Accompanying work transformations during agro-ecological transitions relates to an ability to be closer to the actors by intervening in the progressive construction of their new activity. How does this integration of constructive work into farmers’ flow of activities challenge and change AKIS players’ work?

We claim that such questions will be better addressed if we are able to draw on the systemic approaches to work and its transformations developed by the agronomic and social sciences: combining transformations of farmers and transformations of farming systems’ organizations. We have reviewed various agronomic studies which seek to identify the implications of transformations at an organizational level, either to quantify work needs or to assess the associated cognitive load. Coupling agronomic and ergonomic approaches can help to (i) identify the resources that farmers need to face these challenges during their professional transition; (ii) define new management entities and build action routines, markers, and indicators that simplify what at first sight seems highly complex; and (iii) put into perspective the paradigm and value changes related to the agro-ecological transition.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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