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An agroecological transition in design: farmers caught up in a systemic transformation of their work systems

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Abstract: *This paper aims to provide some support for the widespread claim that agroecological transition entails a wide variety of changes for the farmer. To that end, it focuses on farmers' work systems, as evidenced through several subsystems: biological and technical, socio-economic, family, and related to the farmers' characteristics. Two case studies are used to illustrate how farmers' concerns, which are drivers of change, are constructed at the interface of these subsystems. For each case study, the paper focuses on a single concern described by the farmer during a workshop by means of the Chronicle of Change method (Chizallet et al., 2020). This makes it possible to dissect the subsystems of work to which the farmer refers in relation to a concern, to show how these references differ, depending on whether the farmer refers to them in a state of transition, and when he adopts a systemic approach to his concern. Beyond this paper, this research work is continuing with support for farmers' agroecological transition with regard to tools and methods in a systemic approach. It is thus shedding light on the transition from a work point of view and not only from a technical point of view.*

Keywords: *work system, agroecological transition, farmer's work, ergonomics, systemic approach*

Introduction

In France, several agricultural and political actors are promoting agroecology to meet the major economic, environmental and societal challenges that agriculture is facing. A transition towards agroecology involves profound changes in farmers' work, which are often limited to technical changes. This has led us, researchers in ergonomics and agronomy, to examine the full diversity of changes in farmers' work that their inclusion in an agroecological transition can generate or demand. This is crucial in order to re-think ways to support these farmers and to fit their own work constraints into the context of the agroecological transition. To do so, we consider that farmers engaged in an agroecological transition are in a process of redesigning their work systems. Based on this proposition, we have developed a method: the Chronicle of Change (*e.g.* Chizallet *et al.*, 2018, 2020; Chizallet, 2019), designed to help farmers in the development of their design activity. By allowing farmers to reflect on their trajectories and their project regarding agroecology transition, our research-intervention aims at understanding the design process of their work systems.

The main objective of our research is to try to sort out all the complexity of farmers' work systems under design. What do farmers' work systems encompass? What do they or do they not contain? What are their boundaries? How do they interact with other systems? To do so, the paper focuses on the concept of a "work system". First, looking at a farmer's work system as a designed object is a way of accessing many of the elements that impact or would be impacted by the farmers' work. In a context of sustainable development, Thatcher and Yeow (2016) propose to talk about sustainable system-of-systems to develop an approach to ergonomics that can enhance the understanding of existing relationships between man and nature (Thatcher, 2013). This approach seems interesting in that thinking about a system-of-systems (SoS) allows us to grasp much broader determinants than those considered at the scale of the farmers' work (Wisner, 1985). The difference with this approach is primarily that the different

systems are not to be understood as part of a hierarchy. The point is to understand the work system as a system that is transversal to others. We identify two crucial points when it comes to addressing the farmers' work system in agronomy and ergonomics. First, several studies in agronomy have looked at different systems that are thought of in relation to the farm, but rarely in combination and in relation to the mobilization of these systems by the farmers, and their impact on the farmers' work. Secondly, in the ergonomics of the activity (francophone approach), the term "work system" is frequently used, but few studies have attempted to define it.

In this paper, we illustrate the representation of work systems through two case studies. After presenting these case studies and the way we worked with the two farmers involved, we show the work systems that are built into the two case studies, and analyse their dynamics over time, to discuss their intricacy and the systemic links between them.

Method

Two case studies

As part of a PhD research project, we worked with ten farms. In this paper, we focus on two of the cases that we studied in more detail: the case of Farmers X&L and the case of Farmer N.

Farmers X&L are two cereal producers who have been working as associates since 2013. They are the only workers on the farm. After working in conventional agriculture and no-till, *i.e.* without deep tillage, they began their conversion to Organic Agriculture in October 2014, while continuing with no-till. These choices were mainly motivated by ethical and ecological considerations (to preserve the life of the soil by reducing disturbance), by a quest for meaning (to regain meaning in the farming profession), and by economic concerns (to be able to earn a living). In November 2015, their farm comprised 200 ha and extended over a radius of 5 km, (3-4 municipalities). They cultivated cereals: wheat, corn, barley, oats, faba beans and, later soya.

Farmer N is a cattle breeder who has been on his farm since 2008 and has undertaken a transition to a frugal and self-sufficient grassland system. The 80 ha farm has consisted of three separate pieces of land, with 50 cows and a breeder-fattener system. Of the total surface area, 63% is under grass. Farmer N took over the farm from his uncle, who was in conventional agriculture with very little grazing of the animals. This transition to a frugal grassland system is being implemented "along the way" and has gone through several stages that the farmer describes as follows: a new awareness after a poor grain harvest in 2010, after which he dismissed his grain technician; the implementation of multi-species grasslands in the fall of 2013, which he saw as the "real start"; and in the fall of 2018, his decision to stop fattening his male calves and to stop corn silage, to plant more grass. This transition was primarily motivated by major economic difficulties. This farmer, who works alone, says that he no longer found meaning in his work, that he found it particularly difficult to imagine the future, and that he was in deep distress at work, mainly due to his economic difficulties. That was why he *"sounded the alarm"* by contacting "Solidarité Paysans"[1]. Farmers X&L and Farmer N are involved in a group of farmers in the same process of evolution of his practices, which allows him to have a follow-up with a CIVAM[2] facilitator. It is through this facilitator that we met Farmer N (this facilitator is integrated into the guidance of the interviews that we implement with this farmer).

[1] Solidarité paysans: this is a group of non-profit associations fighting against exclusion in rural areas and supporting farmers in difficult situations.
[2] CIVAM : Centre d'initiatives pour valoriser l'agriculture et le milieu rural (Center for initiatives to promote agriculture and the rural environment).

Definition of farmers' work sub-systems

The aim here is to define our understanding of a work system in order to analyze that of the farmers we met. Without claiming to be exhaustive, we have found that in the literature it is possible to identify subsystems of farmers' work that are likely to impact or be impacted by the work itself (Carayon and Smith, 2000), and which the farmers could mobilize in the design of their work system. Taking into account the importance of the place and role of the farmers in the regulation of their work system (*e.g.* the activity regulation model, Falzon, 2013, adapted from Leplat, 2000 ; the activity systems, Engeström, 2001), we propose four subsystems of farmers' work, represented in Figure 1: biological and technical (*e.g.* Maxime *et al.*, 1995; Osty *et al.*, 1998); socioeconomic (*e.g.* Flichman and Jacquet, 2000; Gafsi, 2006; Laurent *et al.*, 2003; Rémy, 2001; Pretty AND Hine, 2001); family (*e.g.* Osty, 1978; Cerf and Sagory, 2004); and in relation to farmers' characteristics – what we have called the target farmer in Figure 1 – (*e.g.* Darré andHubert, 1993; Duru et al, 1988; Falzon, 2013; Laurent *et al.*, 2003; Leplat, 2000; Petit, 1981).

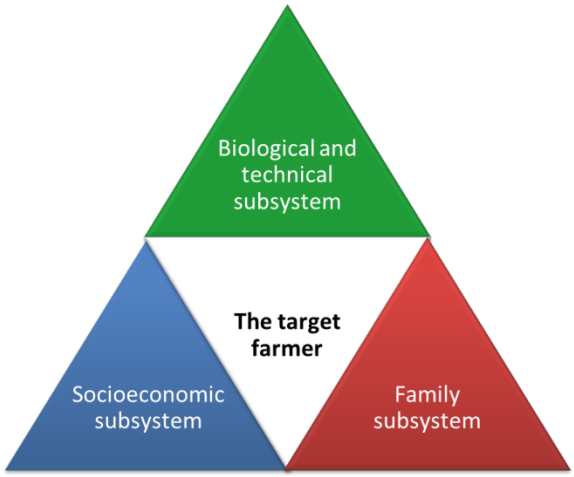

Figure 1: Representation of four work subsystems.

More precisely, the biological and technical subsystem relates to the components of the natural environment exploited by a farmer and the methods, tools and materials available to him/her to exploit his/her natural resources. The socioeconomic subsystem comprises the farmer's social relations (outside the family), whether market or non-market, and the characteristics of his/her financial system. The family subsystem concerns the household and the more distant family that may impact the farmer's work. Finally, the last subsystem is particular since it concerns one specific farmer's own characteristics: the worker's internal conditions such as his/her knowledge, skills, health, state, history, experiences, age, motivation, decision-making ability, etc. It is on the basis of the identification of these four subsystems of the farmers' work that we analyse the design object of farmers engaged in an agroecological transition (AET).

Implementation of the Chronicle of Change to understand the transformative change of a farmer's work system and its design

The Chronicle of Change (CC) was designed within the framework of the PhD research project. It is a form of support that uses a historical timeline. The historical timeline stretches from work system "A" to work system "B", thus implying the possibility of having continuity in the work system that could become a different work system: "C", "D", etc. The timeline is kept on the farm. Several "post-it" notes representing objectives, difficulties and resources are discussed, written and placed on the timeline by

the farmers with and without the help of the facilitator. The implementation of the CC method is based on the same process in both cases: a workshop “Tracing change to today” and some follow-up meetings. The meetings that we drew on for this paper are described in Table 1. An exploratory interview is prior to the workshop “Tracing change to today” in order to build a first representation of the farmers' work for the ergonomist.

		Date / Duration	
Type of meeting	**Goals**	**Farmers X&L**	**Farmer N**
Workshop "Tracing Change to Today"	Creating the Chronicle of Change from the beginning of the change to the day of the meeting	16/12/15 2h30	19/07/17 2h50
Follow-up 1	Updating the Chronicle of Change from the last meeting to the day of the new meeting	9/08/16 30min	26/04/18 3h

Table 1. Chronicle of Change meetings with Farmers X&L and Farmer N.

These meetings were conducted differently in the two cases. First, the ergonomist implemented the Chronicle of Change in the two farms and was accompanied by a CIVAM facilitator for Farmer N. Secondly, the strategy for the Follow-up 1 was also different. For Farmer N, the facilitators went back over each of the post-it notes written during the workshop to find out what happened on the day of the follow-up. This work was not carried out for Follow-up 1 of the X&L farmers but was the subject of a later meeting devoted solely to a rereading of all the post-it notes, which is not the subject of this paper. A goal of the PhD research project not addressed here explains that the methodology was different between the two farms: the use of the Chronicle of Change will continue without the ergonomist at the end of the project. Thus, the methodology has to be adapted to the working conditions of the facilitators who have to accompany the farmers in a defined period of time. We recorded the meetings where X&L and N used the CC with the ergonomist and facilitator to identify the elements of the farm work system and to understand its design.

Representation of Chronicle of Change results: focused design processes

We propose to explore the work system through the discussions on the farmers' concerns and how they dealt with them over time. These concerns constitute units of analysis to describe work system. They are identified with famers and each of the concerns is detailed by the farmer so that a succession of situations related to each concern can be identified, thus constituting a narrative. Each narrative provides a basis to reveal some of the elements of a farmer's work system and to establish which elements of the system are related to one of the farmer’s concerns. A narrative can be broken down as shown in Table 2: initial situation, current situation, events, and projected situations.
This identification makes it possible to construct sequential representations of the farmer's design process, which we propose to call focused design processes (Figure 2), in other words, each focused on one of the farmer's concerns.
We have chronologically retraced the situations related to this with the help of the recordings of the conversations between the farmer and the facilitator(s) during the development of the CC. In addition to this identification and representation of each situation, a thematic analysis was carried out according to the proposed categorization of work subsystems (see the definition of each subsystem described

above). These subsystems were then added to the representation of focused design processes (Figure 2) by a coloured triangle, as shown in Figure 1.
Several focused design processes could be traced in both cases studied. The results section illustrates a focused design process by case study.

Situation type	Definition	Allows you to answer the following question
Initial situation 	The initial situation gives an overall view of the starting situation of the farmer who participated in the construction of his/her concern.	What are we starting from?
Events	The events make it possible to report chronologically on the situations experienced by the farmer between his/her initial situation and his/her current situation.	How do we get there?
Current situation 	The current situation consists in taking a pause and reporting on the current overall situation in which the farmer finds him-/herself, in relation to his/her concerns.	How far do we go ?
Projected situations	The projected situations correspond to the situations that are envisaged or targeted by the farmer.	Where are we going?

Table 2. Description of different situation types.

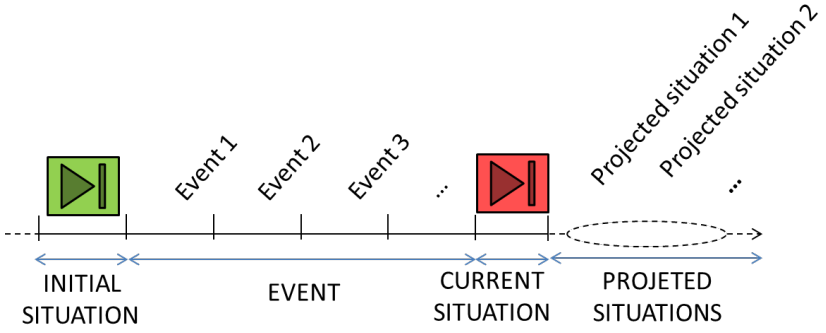

Figure 2. Representation of focused design processes.

Results

Two focused design processes are analysed in this section, respectively on soybean inoculation, for Farmers X&L, and on the economic situation of Farmer N.

Farmers' concerns discussed in the interlinking of several subsystems of work

For each focused design process, all components of each subsystem are identified and represented in figures 3 and 4.
Figure 3 and 4 illustrate the components discussed by the farmer(s) in relation to a particular concern. These components are classified according to the work subsystems to which they refer, regardless of the order in which the farmer(s) address these components. Farmer N mentions all work subsystems. In contrast, Famers X&L do not mention any family subsystem. This is due to a family context and a family history that weighs differently on the farmers' work. For example, Farmer N lives on his farm with his wife

and children and it is a farm that belonged to the previous generation. Moreover, he sometimes works with his brother, who is a farmer and neighbour. Farmers X&L's farm is the result of a new partnership between two farmers who do not live on the farm and do not work with family members.

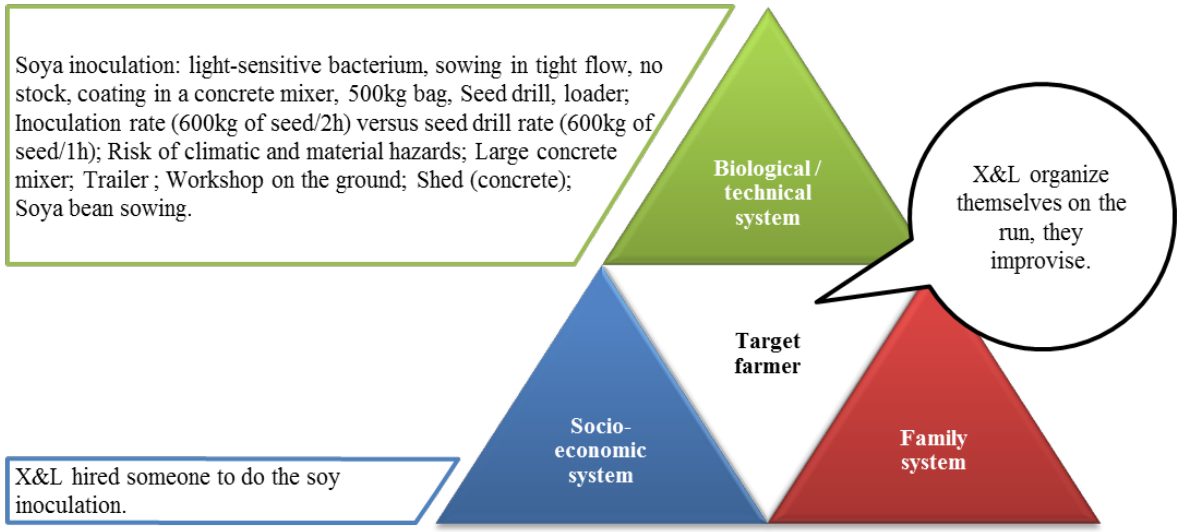

Figure 3. Description of subsystems relative to the soybeans inoculation by Farmers X&L[3].

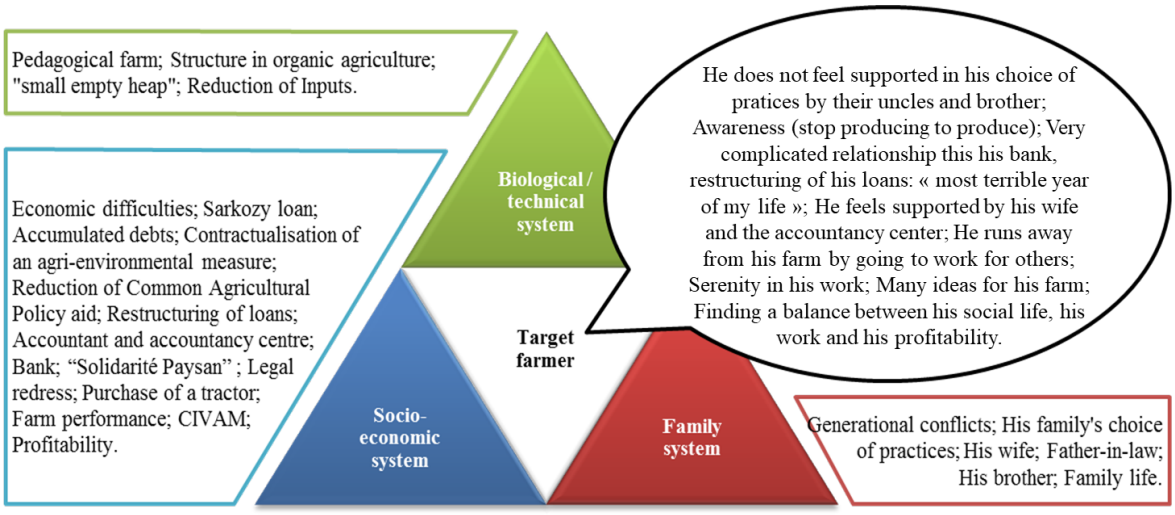

Figure 4. Description of subsystems relative to the economic situation of the Famer N.

If we look at the other subsystems, we can see that the biological and technical components are more numerous in the case of X&L, which is explained by the nature of the concern discussed: the inoculation of soybeans. Conversely, Farmer N is more interested in components with socio-economic characteristics, again explained by the nature of the concern discussed: the economic difficulties of his farm.

[3] X&L want to work living soil. To do so, the resource mobilized is biodiversity, by integrating new crops such as soybeans. The farmers are struggle with the inoculation of soybean which consists of coating soybeans with a bacterium that can convert gaseous nitrogen from the air into mineral nitrogen.

The two figures also make it possible to identify four characteristics of the socio-economic subsystem that organize its analysis. (i) This subsystem may be strictly social. For example, Farmer N relies on the CIVAM facilitator with whom he participates in farm visits, training and projects. The CIVAM is a collective within which technical issues can be explored in greater depth and more personal interaction can be fostered with farmers. (ii) This subsystem can respond to farmers' economic difficulties arising from social and/or economic pressures. For example, Farmer N applied for agro-environmental support and receives a subsidy from the Common Agricultural Policy. (iii) The socio-economic subsystem can be characterized by socio-economic relationships: for example, X&L have hired a person to carry out soybean inoculation with them. (iv) Finally, it can cover strictly economic considerations such as profitability.

Finally, both figures show that farmers discuss their own characteristics when dealing with concerns. The first is their health and general condition. For example, Farmer N talks about the serenity he sometimes feels in his work. Secondly, both farmers also mention their skills and knowledge: X&L's ability to organise a work station (here to inoculate soya), for example.

To conclude, this analysis makes it possible to identify certain characteristics of the work subsystems previously identified in the literature. In addition, despite the fact that the predominant components addressed by the farmer(s) matches the nature of the concern, we note that the concern is discussed through compounds of a different nature. Thus, the farmers in these two specific cases do not seem to have an approach consisting in breaking down a problem or concern, but rather a more systemic approach to the inclusion of several work subsystems.

Subsystems of work mobilized by farmers at different times in the design process

As a first step, we describe a focused design process: “soybeans inoculation” for Farmers X&L, as shown in Figure 5.

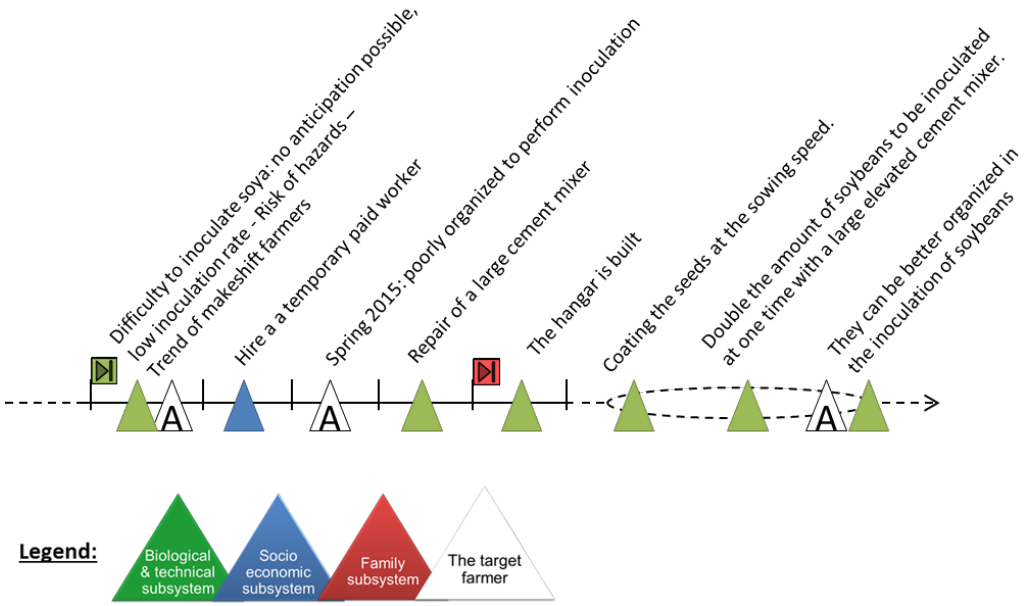

Figure 5. Focused design process on the soybeans inoculation by Farmers X&L.

This focused design process, presented in Figure 5, highlights the fact that for the same concern, farmers do not mention the same work subsystems when it comes to the situations they have experienced and those they are projecting. We propose to take a closer look at how farmers' mobilization of subsystems is evolving. The focused design process is initiated by the difficulties of Farmers X&L to inoculate soybeans. This is a task that requires them to anticipate, while also being highly subject to hazards (weather-related for example) and X&L tend to improvise the installation of this workstation. This initial situation combines the biological and technical subsystem with the farmers' characteristics. The process then consists of three events. The first event involves hiring a third person to inoculate the soybean. The second refers to a bad experience they had in the spring of 2015 during an inoculation for which they were poorly organized. The third relates to X's reparation of a large concrete mixer to better inoculate the soybean seeds. The mixing of the soybean and the inoculum was carried out in a beaker that was too small, which resulted in a low inoculation rate, mentioned in the initial situation. These events therefore refer to the biological and technical subsystem and the characteristics of the farmers, as in the initial situation, and to the socio-economic subsystem. The current situation mobilizes only the biological and technical subsystem since it mentions the shed built by X&L. The process continues with the projection of three situations that consist in coating the soybeans at the same speed as the sowing process, doubling the quantity of soybeans to be inoculated at one time, and being better organized to carry out this task. We therefore find here the two subsystems mentioned in the initial situation.
This example shows us how Farmers X&L refer to their work subsystems when thinking about their future work system. We note that following the hiring of a temporary paid worker, X&L do not seem to plan to take on anyone for soybean inoculation. Figure 5 indicates that the socio-economic subsystem disappeared between the events and the projected situations. This can be explained by the fact that they now have a larger concrete mixer that will allow them to increase the soybean inoculation rate. On the other hand, a "poorly organized spring 2015" event is close to a projected situation: improvement of the organization of soya inoculation. In this case, the references to the biological and technical subsystem and the target farmer are retained. Finally, the reparation of a larger concrete mixer, which refers to the biological and technical subsystem, can be linked to two projected situations: firstly, inoculating soybean with a larger concrete mixer could help increase the speed of seed coating to get closer to the speed of seed sowing on the plots; and this concrete mixer is directly mentioned in the projected situation, which aims to inoculate a larger quantity of soybeans in one go.
To conclude, this figure shows that farmers' concerns are explored differently, that is, according to the different work subsystems to which they refer, in relation to the timeframe of the design process. Furthermore, it underlines the fact that these references to work subsystems are related to one another despite a different spread over time. This is what we propose to investigate further in the case of farmer N.

Implementing a systemic farmer approach to design

We now focus on one of Farmer N's major concerns, which is the economic situation on his farm.
Firstly, this figure allows us to see that all the work subsystems are mobilized by Farmer N to discuss one of his major concerns: the economic situation of his farm. This focused design process was initiated due to economic difficulties and generational conflicts, which the farmer encountered shortly after settling in. N's family is composed of farmers. The initial situation of this process therefore combines the socio-economic and family subsystems. We can then see from this figure that a situation projected by the farmer refers to his socio-economic and family subsystems and to his own characteristics. Here, Farmer N's objective of finding a balance *"between [his] social life, [his] work and [his] profitability"*

seems to have been built on an accumulation of ups and downs, based on the initial situation of the work system. It is indeed because of his economic difficulties that farmer N has resorted to various financial mechanisms such as a loan, the restructuring of all his loans and subsidies. It is also evident that strained relations have developed between him and his bank, causing him to change banks. However, the accumulation of these events exclusively related to the socio-economic subsystem is not sufficient for the construction of N's objective of finding a balance *"between [his] social life, [his] work and [his] profitability"*. It is interaction with agricultural stakeholders and with his wife that trigger the formalization of this objective. To continue with this example, it can furthermore be noted that three other projected situations are exclusively biological and technical. They constitute a subsystem that was not present either in the initial situation, or in the events, or in the current situation. These projected situations are also a response to the economic difficulties encountered by Farmer N. It would then appear that the farmer has resolved his farm's economic difficulties in two stages: first, in the urgency of the situation, he preferred the economic solutions implemented during the ups and downs he experienced. Once these approaches had been implemented, the farmer considered other technical solutions that required more time, which he identified through his projected situations: the reduction of his inputs, a switch to organic agriculture, and the possibility of setting up a teaching farm.

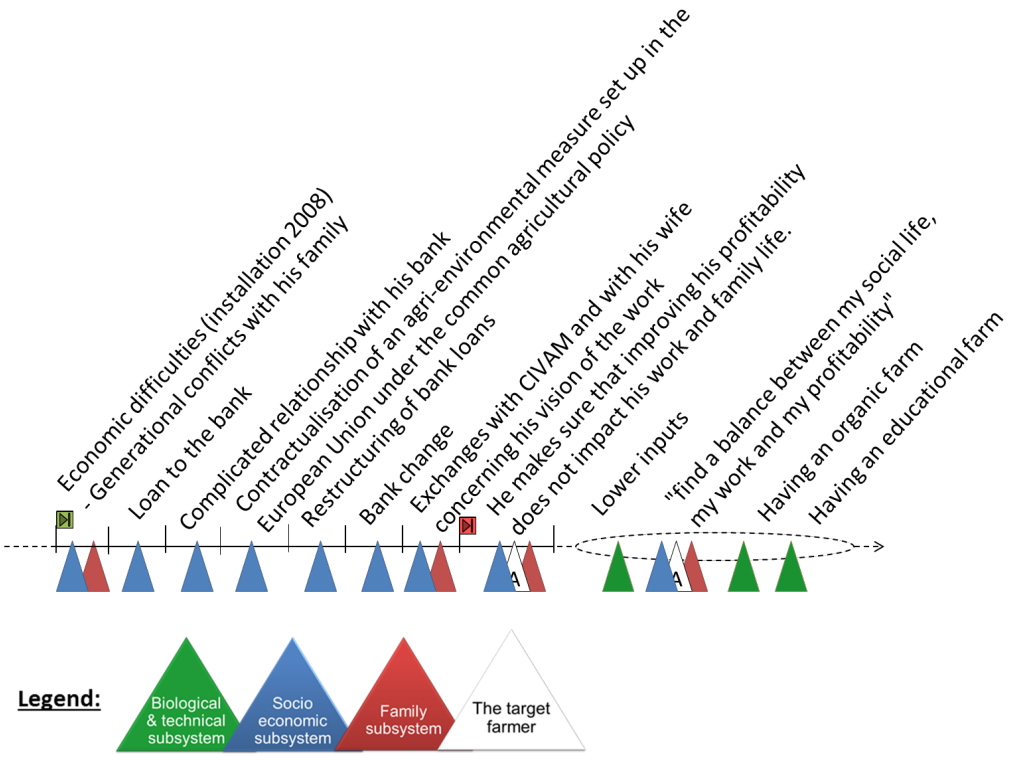

Figure 6. Focused design process on the economic situation of the Famer N's farm.

Secondly, this figure shows us some connected work subsystems in situations experienced and reported by the farmer. Some situations refer to only one subsystem. For example, when the farmer says that he has taken out a loan with his bank, he mentions a situation that mainly concerns the socio-economic subsystem. However, it is more common to see that subsystems overlap with one another. For example,

when the farmer explains that he is ensuring that the improvement of his profitability does not impact his work and family life, this relates both to the socio-economic and family subsystems, and to his values. Beyond this example, this work has been replicated for each of the farmer's concerns, of which we have counted eight. Thus, eight focused design processes could be traced. Initially, the different types of situation make it possible to identify several combinations of the subsystems, ranging from two to four subsystems, as the situations of the focused design processes unfold within the same type of situation. The systemic approach adopted by this farmer in the design of his work system is highlighted here. It is a matter of designing this work system not by dividing it into subsystems but by creating combinations of its subsystems that are then thought out together.

Discussion

Our first result makes it possible to propose a characterization of the farmer's work system. We understand that the notion of “work system” is a way to access many of the elements that impact or would be impacted by the farmers’ work when engaged in change processes, particularly agroecological transitions. While some studies in agronomy have analysed some elements of the farmers’ work system, they have often focused on technical dimensions, or on economics, or yet on the role of the family in the farm management, but they have rarely combined all of these dimensions. We show that the work system can be understood as a transversal system consisting of subsystems, with reference to the work of Andrew Thatcher (*e.g.* Thatcher, 2013). Based on the literature, we characterize the work system as transversal to a biological and technical subsystem, a socio-economic subsystem, a family subsystem, and a farmer-related subsystem. Farmers are at the heart of their work systems. However, the categorization of these subsystems is debatable, and we suggest that they be explored at different scales. For example, the choice of having combined nature and technology within the same subsystem may be questioned: does this not risk restricting our view of change, given the specific context of agroecological transition in which we find ourselves?

Our second result emphasizes the fact that the agroecological transition is to be understood as a systemic transition. We can see that this transition confronts farmers with many work situations and their transformation, which affect all work subsystems. Thus, this result also highlights the systemic approach that farmers need to take when designing their work system. The visibility of this systemic dimension is allowed by the Chronicle of Change. It can be considered as a means, not only for the ergonomist to *"limit the risk of producing fragmented and piecemeal data"* (Vidal-Gomel *et al.*, 2007: 272), but also and above all for the farmer-designer to limit the risk of designing his/her work system from a single focus, for example biological and technical.

Our last result shows that it is the entanglement of singular, and sometimes combined, experiences of work subsystems that allows the farmers to build a systemic vision of their design object and to participate in the construction of projections of work situations in work subsystems. Thus, our results provide support for the widespread claim that agroecological transition encompasses a wide variety of changes for the farmers.

Note that we have not considered the role of support in this research-intervention. Two perspectives to this work could still be considered. First, this research-intervention presented two different types of support, depending on the case: one with the ergonomist alone, the other with the ergonomist and a facilitator specialized in the technical aspect of agricultural work. Here we could consider whether such twofold support might have an influence on the elements of the work system that are reported by the farmer. Second, there are differences as to who is supported: in one case, there are two farmers and

they grow cereal crops; in the other case, the farmer is alone, and he is a cattle farmer. We posit that supporting a farmer or a group of farmers is different since the explanation of the narratives and thus the exploration of their work system also plays a role in the interactions between the two farmers. We also wonder about the difference in the object of the work: cereals and animals, and how these particularities could be better taken into account in the structure of the support itself.

Conclusion

This paper highlights the complexity and scope of the object designed by farmers in their agroecological transitions. In addition, it shows the nature and diversity of the constraints that farmers incorporate in designing their work systems. The characterization of a farmer's work system also underlines the importance of the network of actors revolving around farms and the different forms it may take. Moreover, this result points to the importance of a farmer's personal or family project (Cerf and Sagory, 2004) in the agroecological transition.

We have presented two cases here, with only one focused design process for each case, but the Chronicle of Change has been used in several other situations and reveals several other focused design processes that confirm the results detailed here. One challenge is to maintain its use among agricultural advisors who are farmers' main source of support. Through the PhD research project we see that some CIVAM facilitators are looking for tools and methods to support farmers in their systemic approach, from a work point of view and not only from a technical point of view. Several design workshops and field support mechanisms are underway to support experimentation with the Chronicle of Change with other farmers.

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