Agricultural Systems 164 (2018) 122–132

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

Designing agricultural systems from invention to implementation: the contribution of agronomy. Lessons from a case study

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ARTICLE INFO

Keywords:
Participatory design
Innovation
Agriculture
Water catchment area
Design process
Longitudinal study

ABSTRACT

This article reports on the long-term involvement of research agronomists in a design process of agricultural systems in a water catchment area. While agriculture is facing increasing challenges to meet current societal expectations, several studies in agronomy have focused on the design processes that allow farmers to change their agricultural systems. Most of these processes have been dedicated to designing target agricultural systems but, more recently, several studies have acknowledged that agro-ecological practices replace farmers as the actual designers of their own production systems. In this context, how can agronomists support such design processes? How does a better understanding of these processes challenge the inputs that research agronomists can propose, to support them? We contribute to answering these questions by reviewing a case study of a design process supported and analyzed by research agronomists over several years. This case illustrates that the design of agricultural systems is a process that exceeds invention: the implementation of the initial design solutions produces information that should be used to review those same solutions, in order to reach the design goal. The case study shows that the design process depends on a tension between the exploration of an ambitious desirable future and its actual implementation. To foster dialogue between "desirable" and "actual", we show how the researchers involved in this case provided a range of inputs that supported typical design activities (grounding, fostering design reasoning, reinterpreting this reasoning, and design strategy throughout the process), thus opening new avenues of research in agronomy.

1. Introduction

The literature on agricultural innovation processes has significantly increased with the contemporary challenges that agriculture is facing to meet current societal expectations. A significant number of research studies, mainly by social scientists, have focused on the renewal of agricultural systems (for a review of these studies, see for instance Klerkx et al., 2012). Having shown that innovation is the result of "multiple interactions between components of farming systems, supply chains and economic systems, policy environments, and societal systems" (Klerkx et al., 2012), they have called for a systems innovation approach (Klerkx et al., 2010; Lybbert and Sumner, 2012; Coudel et al., 2012; Lamprinopoulou et al., 2014). But what has agronomy's contribution to the research on agricultural innovation been? While some research agronomists have started to take on board this challenging systemic approach (e.g. Meynard et al., 2017), most are contributing to innovation studies by developing design approaches, as a growing literature on the subject attests (e.g. Le Gal et al., 2011; Meynard et al., 2012; Malezieux, 2012; Cerf et al., 2012; Martin et al., 2013; Dogliotti et al., 2014; Prost et al., 2017). In many studies, the research agronomists have been the designers of target agricultural systems, using what Le Gal et al. (2011) have called "design-oriented methods": they propose new agricultural systems by using simulation models (Bergez et al., 2010) or prototyping methods (Vereijken, 1997; Lançon et al., 2007; Colnenne-David and Doré, 2015), with extensive use of assessment tools and indicators. But recent studies have acknowledged that, given the complexity and uncertainties which are key features of design in agriculture, farmers should be reconsidered as designers of their own production systems, and no longer as users of turnkey solutions (Schiere et al., 2012; Martin et al., 2013; Prost et al., 2017). The role of research agronomists in the design processes is consequently being called into question: their role is seen more as a support for farmers' design activity than as a substitute for it. This is in line with what Le Gal et al. (2011) have called "design support-orientated methods", which focus on supporting farmers' design capabilities and fostering "a progressive transition towards innovative systems" (Meynard et al., 2012 p. 12), rather

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https://doi.org/10.1016/j.agsy.2018.04.009
Received 3 August 2017; Received in revised form 24 April 2018; Accepted 26 April 2018

than on defining the agricultural system to foster.

But how can research agronomists support farmers in their design activity? This is a real challenge as farmers' design activity has not been described as such. Furthermore, this type of activity is tightly entangled with the activities of other actors (collectors, transformers, institutions, citizens, etc.) who can legitimately claim to be part of the design of agricultural systems (Prost et al., 2017). We think that, to support farmers' design activity, research agronomists have to reconsider the definition of design. Following Simon (1969 p. 114), who saw design as the process "concerned with devising entities to attain goals", we can define it as an active and goal-oriented process of invention and implementation of something which does not pre-exist as such in the natural realm. In our opinion, research agronomists have focused most efforts on the "invention" side of design processes when they have worked on target agricultural systems. We claim that supporting farmers' design activity requires them to extend this focus to the "implementation" part of the design process, in order to take on board the continuous feedback loops and thus to adjust what is intended to what actually happens. This shift is an opportunity for the research agronomists to critically examine the inputs (knowledge, methods and tools in a broad sense) that they should bring or build if they intend to support farmers in their own design processes. In this paper we contribute to answering these questions by analyzing a case study in which a collective design process was followed and supported by research agronomists over several years. These researchers were involved on a long-term basis in a process where a collective of farmers had to redesign their agricultural systems to restore the quality of water in a catchment area. This level of participation in change processes over the long run is rarely described in the literature (Le Bellec et al., 2012; Dogliotti et al., 2014; Kraaijvanger et al., 2016; Falconnier et al., 2017). In reviewing in this article, the collective design process that was followed, documented and analyzed for over seven years, we aim to substantiate our claims that: (i) the design of agricultural systems is a process structured around feedback loops between invention and implementation; and (ii) that research agronomists need to consider and discuss the agronomic tools that seem efficient and beneficial to support such processes. After providing conceptual inputs on ways to analyze design processes and the support they receive, we describe and discuss two levels of results. First (Section 4), we describe the design process in our case study and the way it was supported. We then (Section 5) highlight several points of analysis about the dynamics of the design process on the one hand and the characteristics of agronomic tools that are useful to feed this process on the other hand.

2. Theoretical background

While designing new agricultural systems has clearly been high on research agronomists' agenda, few have really paid attention to the nature of design as such. Most of the research agronomists involved in designing agricultural systems remain outside the debates taking place within the *Design Studies* field. In this field, which focuses primarily on the industrial sector, many researchers have proposed concepts and methods to develop new ideas and to organize design processes (see Papalambros, 2015 for a review). We can draw on this literature to improve our understanding of the design processes in agriculture and to reflect on ways to support them.

The few studies in agriculture that have been inspired by these approaches (Koerkamp and Bos, 2008; Meynard et al., 2012; Berthet et al., 2012; Cerf et al., 2012; Martin et al., 2013; Elzen and Bos, 2016) have shown that design in agriculture has some particularities: strong uncertainties and unknowns (Voss et al., 2007; Girard, 2014; Duru et al., 2015), long timeframes, and open design processes due first to the lack of a structured organization leading it, and second, to the wide range of actors that can legitimately take part in the process (Koerkamp and Bos, 2008; Berthet et al., 2016; Prost et al., 2017). How can design studies provide guidelines to further analyze and support these processes?

In the design studies literature, design has long been described as a process of "project management" i.e. "the accomplishment of a clearly defined goal in a specified period of time, within budget and quality requirements"(Lenfle, 2008). This "goal" is defined as a vision or intention for the future that is critical in maintaining an innovative ambition and building a design reasoning. It is supposed to be reached through a process characterized by a time frame and progressive work using steps such as initiating, planning, executing, controlling, and closing (Project Management Institute, 2000 p. 4). Debates are taking place in the project management research community about how to define the goal and how to make the process more agile, reactive and exploratory (see Lenfle, 2008; or Garel, 2013 for a review). Yet, this management approach encourages research agronomists to pay attention to the way the goals of design processes in agriculture are defined, and the different steps these processes go through.

The "adaptive management" approach provides an alternative perspective to analyze design processes. As it emphasizes the adaptive and uncertain nature of complex change processes, it is increasingly advocated by research agronomists and ecologists to be used in describing action in these change processes (Jiggins and Roling, 2000; Diaz-Solis et al., 2009; Darnhofer et al., 2010, 2012; Klerkx et al., 2010; Groot and Rossing, 2011; Altieri et al., 2015; Duru et al., 2015), particularly that of researchers in Agricultural Research for Development (Thornton et al., 2017), with approaches like DEED (Giller et al., 2008) or PIPA (Alvarez et al., 2010). Adaptive management, stemming from the management of natural resources, was first proposed by Holling (1978) and then Walters (1986). It stresses "learning by doing and undertaking actions and policies as experiments" and generally involves "monitoring and assessing conditions interspersed with components of: scoping or assessing opportunities, designing policy options or experiments, implementing or taking action, and evaluating and adjusting" (ibid). Defined as "flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood" (National Research Council, 2004 pp. 1–2), adaptive management highlights the need for adjusting the change process to the impacts of what has been already done. It thereby blurs the deliberate and orientated nature of the process that was key in the project-based management approach, all the while encouraging research agronomists to analyze iterations in order to cope with the irreducible uncertainties of such processes.

We suggest that an accurate understanding of actual design processes of agricultural systems should combine key elements from both project-based and adaptive management approaches. When drawing on the adaptive approach, we should focus on the iterations of the design processes, whereas when drawing on the project-based approach, we should focus on the definition of a goal – an intention for the future –for the design process, and on the steps the process goes through. Combining the two is then an incentive to constantly analyze the dialogue between what is intended and what actually happens. This will help us to build an understanding of actual design processes in agriculture. The next question is how research agronomists can support such a dialogue. Agronomic research may seem to have already provided numerous tools for this support, as reviewed by Le Gal et al. (2011): models, experiments, prototyping methods, participatory methods, and so on. But most of them target the "invention" side of the design processes, that is to say, the design of the target agricultural practices (Bergez et al., 2010; Groot et al., 2012; Dogliotti et al., 2014; Lefevre et al., 2014). When it comes to supporting farmers' design processes, and especially to supporting the "implementation" part of these processes, the inventory is not as straightforward. The studies that have advocated the use of adaptive and iterative modes of design management in agriculture are mostly conceptual (Le Gal et al., 2011; Meynard et al., 2012) and fall short of proposing methodological tools. Or when they describe how to implement this management approach (Giller et al., 2011), they are most often focused on one iteration