



Review

Designing agroecological farming systems with farmers: A review

Camille Lacombe*, Nathalie Couix, Laurent Hazard

AGIR, Université de Toulouse, INRA, INPT, INP-EI PURPAN, 24 chemin de Borde Rouge – Auzeville CS 52627, F-31326 Castanet-Tolosan, Cedex, France



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ABSTRACT

Agroecology is a new paradigm whose aim is to redesign farming systems. The implementation of its principles engages farmers in a radical transformation of their practices, their way of reasoning and their participation in local knowledge production and innovation processes. Acknowledgement of this transformation now frequently leads researchers to invite farmers and other stakeholders to participate in research projects on the design of innovative farming systems. However, the objective of their involvement and the role farmers play in such projects is rarely made explicit and can range from simple knowledge providers to co-designers. Here we review the role of farmers and other stakeholders in such participatory research projects, and its impact on their learning and engagement in the local transformation of farming systems. Using a framework based on design theories, we analyzed thirty-nine papers on the design of innovative farming systems in which farmers and other stakeholders were involved. We identified five main co-design approaches to the design of agroecological farming systems: “De-novo design”, “Case-study design”, “Niche innovation design”, “Co-innovation”, and “Activity centered design”. Despite this diversity, if researchers aim to promote the development of agroecology, there is still a need to better link researcher-oriented approaches and support-oriented approaches, to design local set-ups that will help farmers and other stakeholders in the long term process of redesigning farming systems. In terms of design methodologies, this means sharing project leadership with farmers and organizing co-design locally to better bridge the gap between thinking and doing. This means better accounting for the singularities of farmers' situations and of the local activity system to be transformed. This paper should help researchers choose their participatory methodologies better with respect to both to their transformational and scientific goals, when organizing participatory projects to support the development of agroecological farming systems.

1. Introduction

Developing sustainable agriculture requires reducing chemical inputs that are still widely used to reduce climatic and environmental uncertainty and improve production yield. Agroecology tackles this problem by restoring and managing the natural regulation of the agroecosystem that is expected to limit the use of chemicals to support agricultural production (Francis et al., 2003). In the “Efficiency/Substitution/Re-design” framework developed by (Hill and Macrae, 1996), agroecology falls into the category ‘Re-design’ since it implies the transformation of farming systems to (i) better match farm scale production methods and local ecological, economic and social potentialities and (ii) to restore and maintain a functional agroecosystem (Darnhofer et al., 2012). Supporting farmers in the development of agroecology requires supporting the transformation of their farming practices to maximize local potentialities (Francis et al., 2003). This can be achieved by a change in the mode of reasoning about farming systems from an artificialized system in which production is supported by

adequate inputs, to a logic of steering the socio-ecological processes of the local agroecosystem to support production (Hazard et al., 2017). It also implies a transformation in the way farmers are involved in innovation and knowledge production processes, to co-produce and locally experiment appropriate techniques, practices and types of organization that suit their specific situation (Gliessman, 2009; Guzmán et al., 2013; Stassart et al., 2012). To move toward agroecological farming systems, farmers observe and exchange practices with their peers, conduct experiments in their own situation (Cristofari et al., 2018) and exploit diverse sources of knowledge to enable them to act in their own situation (Toffolini et al., 2017). While agricultural modernization has attempted to reduce farmers to simply implementing “recipes”, the transition to more agroecological farming systems means restoring their roles as pilots of farming systems that innovate and co-produce relevant knowledge to enable them to change in their own situation directly (Prost et al., 2018).

Researchers who work on designing more agroecological farming systems are aware of this change and are developing participatory

* Corresponding author.

E-mail address: ca.lacombe@gmail.com (C. Lacombe).

approaches to include farmers and other stakeholders in their work. If they aim to support the development of agroecology, they need to know whether these participatory approaches enable a real change in farmers' role in the innovation process and if their intervention helps farmers test and implement new ways of reasoning and new practices. This in turn, requires characterizing the expected role of participants as providers of knowledge, targets for learning or co-innovators.

To characterize the role of farmers in participatory research, in 1995, Pretty produced a typology that ranged from manipulation by the researchers, consultation, interaction, up to self-mobilization by the farmers. The challenge of participatory research is the co-production of knowledge to inform a farmer's problematic situation. Taking a design perspective makes the relationship between knowledge production and action to transform that situation more explicit. In fact, Hatchuel defined "Design" as the "simultaneous generation of knowledge and objects" with the aim of achieving "an unknown desire" (Hatchuel et al., 2013). This process can be organized according to different ways of articulating knowledge production and transformational goals, for example: the extraction of knowledge objectified in a model that will serve to define public policies, design driven by researchers that invites farmers to engage in a learning process, or co-design in which farmers and researchers work together to find solutions to a specific problematic situation (Asaro, 1999).

These different strategies do not imply the same level of learning for the participants and transformation of their practices part way through the process. This paper aims at making these aspects more explicit to allow researchers to choose their own strategy to enable farmers to participate in the design of agroecological farming systems as a function of the scientific and transformative goals at stake.

In this paper, we refer to design theories to analyze the place given to farmers and other stakeholders involved in farming system management in the design of agroecological farming systems. We first build an analytical framework based on the literature on design theories concerning co-design. The aim of the framework is to highlight the dimensions of a co-design process that needs to be analyzed to qualify the link between transformative goals of co-design and its real effects on the co-designers' work situations. We use this framework to analyze 39 participatory research projects on the design of agroecological farming systems. We characterize different approaches based on how the farmers and other stakeholders are involved in the design process and what effect their involvement has on their own situation of change and learning. Finally, we identify the conditions for a design approach likely to best support agroecological farming system development, and transformation of the place given to farmers in their design.

2. Materials and methods

2.1. Analytical framework

Analyzing design theories, we identified four relevant dimensions to analyze the link between a co-design situation and its transformational effects (Table 1): who participates and who is considered to be a designer in the design process, what is the object of the design, the spatio-temporal dimensions of the design process, and lastly, how the design is implemented, mainly in terms of knowledge management during the design process (referred as "who", "what", "where and when", "how" in Table 1).

"Who designs and who participates in co-design?" is an important question when the target of the design process is to transform practices and to enhance learning among participant. In fact, it is both a question of "who has something interesting to say?" and "whose transformation and learning is targeted?". This question dates back to the origins of co-design in the 1970s. From a utilitarian point of view, co-design is seen as a way to develop technologies faster and better suited to consumer needs. In this case, the purpose is not to trigger learning and to empower the targeted users. The participants to be involved in the process

Table 1
Analytical framework.

1. "Who" → Who participates? Who designs?
1.1. Who is considered to be the designer?
1.2. Who participates?
1.3. Who formulates the demand?
1.4. Is the demand discussed?
2- "What" → What is the object of design?
2.1. The design object: a technology/a place to facilitate exchange/a new workplace/a new design practice
2.2. Unpredicted output of design/what transformation is targeted in the real world?
2.3. Is the object of design discussed?
3- "Where and When" → Space and time dimension
3.1. Where does co-design take place? (in one or several places?)
3.2. Is the co-design considered as an ending process/an unending process?
3.3. Is the co-design considered as an iterative process, a disjointed process?
4- "How" → Design implementation in terms of knowledge management
4.1. What is considered as useful knowledge for the co-design process?
4.2. What place is given to a prototype/models/predictive tools?
4.3. What place is given to experiential knowledge/practical knowledge/sensitive knowledge?
4.4. Is learning an expected effect of design? (Action oriented design)
4.5. What is the role of consensus?
4.6. Is space allowed for unexpected findings/controversies/debate?

are considered as consumers or "end-users". The designers are those who lead the process, taking the consumers' needs and potential uses into account by involving "lead users" as expert representatives (Von Hippel, 1986). In a less participatory but more objective device, it takes the form of ethnographic approaches to better understand potential uses (Blomberg et al., 1993). Social learning and empowerment are at the heart of the democratic idealism that gave birth to co-design (Gregory, 2003). It aims at producing operational technologies to improve workers' daily work by sharing decisions between workers, designers and managers about which technologies should be designed and for what uses (Kraft and Bansler, 1994; Schuler and Namioka, 1993). It leads to considering that the workers are designers, rather than only participants who express their opinion during the process of designing new technologies or practices they would then merely adopt. According to Engeström (2001) workers permanently re-design objects, instruments and practices in their work. Therefore co-design calls for freedom at work and a rearrangement of the work place to enable the workers to better express their creativity (Mumford, 1987). The development of co-design approaches and methodologies in more complex and open fields (e.g. socio-ecological transitions or natural resources management where boundaries of problems and situations to transform are fuzzy, and where there are no clear hierarchical relations between participants) transformed the question of who is co-designer into the question of who should take part in and transform its practices through a collective design process (Couix, 1997; Grove et al., 2015).

The object of design should be of great concern because co-design processes are usually focused on designing a tangible artifact. Transformational change and learning are not usually an issue in such design even if the artifact causes huge changes in the user's life. They are more likely to be an issue in co-design when the aim is to design a new practice or a new way of working together. The function of the design object could be clearly identified at the beginning of the design process or be unknown and be defined during the course of the design process. That was the case of the development of an environmentally friendly and economical car by the R&D service of a European car manufacturer (Elmquist and Segrestin, 2009). In other cases, the object could be the design process itself, for example the design of an enabling platform to sustain social innovation (Seravalli, 2011). The different natures of the object led to different forms of cooperation with different actors involved in co-design processes. Product design aims to create a tangible artifact to fulfil a function that is clearly identified at the beginning of the design process. The aim of having the users participate is thus to ensure a better match between the artifact and the intended

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