https://doi.org/10.15414/afz.2020.23.mi-fpap.322-328 **Position Paper**
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A new systemic approach to characterize agroecological systems

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The agricultural models put in place to meet food demand in the 1950s are now showing their limits. Strong impacts on the environment or animal welfare issues require a change in the agricultural model. Agroecology is a response to these ecological and societal crises. The theoretical definition of this agricultural model is explained in literature. However, it remains important to clarify what is an agroecological farm in the field: how does the farming system work? Which indicators are used? What are the worldviews of the farmers? For that, systemic approach can be useful. The aim of this article is to advance a fuller understanding of the management of agroecological systems in the field through a new systemic approach. A new definition of the systemic approach is proposed with three pillars (functioning system, decision-making system and thinking system) to allow a more detailed analysis of production systems by using a specific method, crossing biotechnical sciences, humanities and social sciences. Consideration of all three pillars can explain what an agroecological system is in practice, with identification of specific indicators and worldview.

Keywords: systemic approach, agroecology, thinking system, functioning system, decision-making system

1 Introduction

After the Second World War, Europe had to manage a strong demand for food. To feed the population and achieve food self-sufficiency, agriculture had to modernize. This was made possible by specializing systems, standardizing products and controlling biotic and abiotic processes, in particular by means of chemical inputs (Hubert et al., 2013). This agricultural model has largely met expectations for food production, but is also reaching its limits, due to its heavy impact on the environment. The global livestock sector currently uses 30% of the planet's land and 32% of its water and generates 18% of greenhouse gas emissions (Steinfeld et al., 2006, Herrero et al., 2015). These production models also draw criticisms from society concerning animal welfare (Webster et al., 2015, Beaver et al., 2020) and the origin and quality of animal feed (Jacquot et al., 2019). Numerous research studies have shown that animals are sensitive beings endowed with cognitive abilities (De Fontenay, 1998). This challenges the ontological distinction and discontinuity between humans and non-humans that is basic to how we conceive the modern world in the West (Latour, 2006). This distinction, called "naturalism" by Philippe Descola (2005), places humans outside of and in a position of control over the natural world, contrary to some other cultures (South America, Asia). Several currents of thought have emerged from this context. Industrial farming methods are being challenged, and even livestock production itself (Dumont et al., 2016, Lacroix and Gifford, 2019) through movements such as veganism. Citizens are advocating a more territorially based livestock production, combining quality of products, landscapes, and social relations. Today, livestock production is the target of environmental, societal, and ethical concerns that are driving a bifurcation of production systems towards production systems that take all these aspects into account. To address these concerns, agroecology supported by the French Ministry of Agriculture since 2013, has been put forward as an alternative to the conventional model, and seems to be a promising production model for the future. This agricultural model is based on the strong interactions between elements and flows within the ecosystem (Gliessman, 1998) and correspondingly between the elements of the agroecosystem. In this sense it implies a systemic approach. However, the concept of agroecology, where several fields of scientific inquiry meet, first needs to be defined so that it can be properly understood in practical terms and so be better managed. The aim of this article is to advance a fuller understanding of the management of agroecological systems in the field through a new systemic approach. A better understanding of how these systems work, and of their indicators and management practices, will help to implement and run this agricultural model, which meets societal expectations and addresses current concerns. In the first part, the proposed new systemic approach is presented. Then the theoretical frameworks used in the definition of an agroecological system are specified. Finally, using the proposed systemic approach, field experience is used to illustrate what an agroecological system is.

2 Toward a new systemic approach

What is the systemic approach in the literature?

The concept of a systemic approach is related to that of holism, which emerged in a reaction against the concept of reductionism and mechanism. Its basis is that "the whole is more or something other than the sum of its parts" (Landais, 1994). Concretely, no single part of the system (e.g. the management of a herd or a crop) can be detached from the rest of the farming operation: the farm is considered as a whole and seen as a set of elements in dynamic interaction organized in pursuit of a goal (De Rosnay, 1975). The systemic approaches developed in the 1990s therefore consider the farmer who runs the farm, and who makes the decisions and guides the production, which relies on technical support: the decision-making system and the functioning system.

The farmer is a part of the farm and for this reason can be included in the analysis. The farmer's decisions will thus have an impact on production and implementation. The decision-making system integrates the farmer's goals, i.e. the direction he takes for his farm and how goals are pursued, rules set, and decisions made. The aim is to understand the reasons for certain management behaviors or practices. The functioning analysis is divided into sub-parts such as the livestock production system, the forage system, the crop system, and the processing system. Each sub-system is finely analyzed and put in relation with the other sub-systems. This operation generates flows between sub-systems and between the farm and the outside; the farm environment also influences its operation (climatic constraints) (Figure 1). The aim here is to understand the technical functioning of the system and offer technical improvements to help meet the objectives set by the farmer: for example, an improvement in the reproductive management of a dairy herd to increase the profitability of the farm.

In this approach, the focus is not on an exhaustive and in-depth analysis of the mechanisms involved and their interactions, but firstly on the overall functioning of the farm in relation to the farmer's decisions. This first approach will explain the links between the elements of the system (e.g. forage areas and the herd) and the implementation of certain management practices (e.g. implementation of late mowing of grasslands primarily to build up stock and have cows ruminating) with regard to a decision made on the farm.

Towards a new and more complete systemic approach

Based on the systemic approach used in the literature, a new and more complete systemic approach can be proposed, based on three pillars: functioning system, decision-making system and thinking system.

The systemic approach rests on a first important pillar, namely the functioning system, i.e. the technical operation of the farm. Concretely, this pillar embodies management practices (Figure 2). Its analysis lies mostly within the scope of biotechnical sciences (e.g. animal sciences and agronomy). This first pillar is dependent on the farmer and his decisions. The systemic approach has a second pillar, which is "Why does it work like this?". Here we have access to the farmer's decision-making system, his vision at the functional level. This second pillar comes within the scope of the human and social sciences and the biotechnical sciences. These first two pillars thus enable an understanding of the farming system and constitute the systemic approach developed in a general way in the literature (Landais, 1994, Laurent et al., 2003).

However, to fully understand how a system works and why a particular management practice is implemented within that system, it is important to access the farmer's system of thinking: the last pillar. This provides an understanding of what motivates the farmer and the basis for his decision to implement a management practice on his farm. So “why is he doing this?”. Accessing the farmer's system of thought means accessing his motivations, the ethical, political, and ontological dimensions of the farmer. Adding this third pillar to the systemic approach makes it possible to refine our analysis and to explain the reasons that have led to a particular system being adopted through a better understanding of its technical functioning with regard to the choices made. For example, many initiatives to reduce inputs are encouraged by advisory bodies in the field, particularly in grass management. Numerous management practices are thus proposed in the light of how the system works and taking into account the farmer's decision-making system. Yet such management practices are never put in place. Taking into account the farmer's system of thought, his values, and his worldviews would make it possible to propose management practices adapted to his outlook. It is therefore important to rethink the analytical frameworks and to add this pillar to the first two to extend the current systemic approach. This step requires a major contribution from the human and social sciences. The proposed evolution of the analytical framework will be illustrated through three concrete cases.

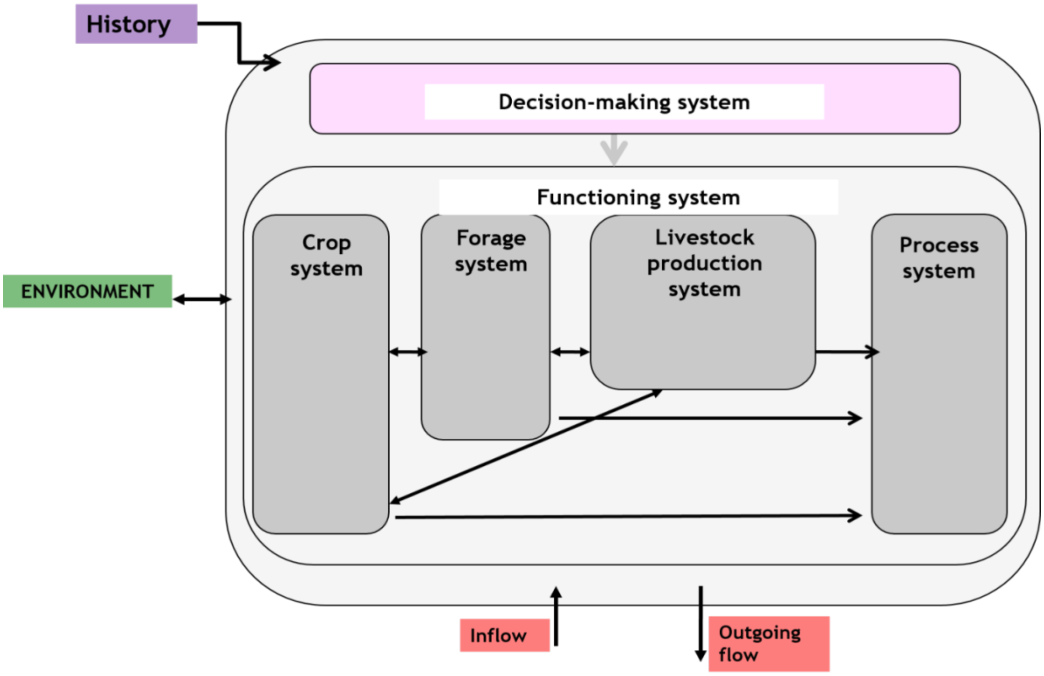

Figure 1 Modeling the elements to be considered in a systemic approach (personal source)

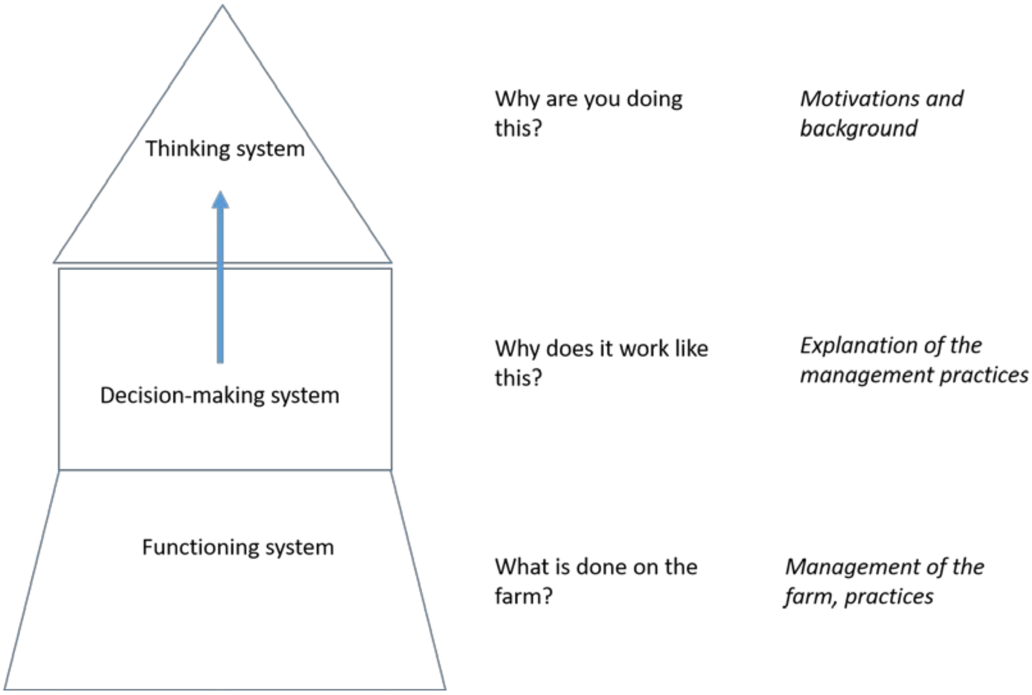

Figure 2 Proposal for a new framework for the analysis of the systemic approach based on three pillars: the technical functioning of the system, the decision-making system and the farmer's thinking system (personal source)

3 Theoretical definition of an agroecological system

Although the term "agroecological system" is increasingly used in the media and in agriculture, its precise definition depends on the country and the branch of science considered. Some view a farm based on the use of grass as agroecological because it uses grass, an ecological resource. Others consider only permaculture systems to be agroecological. It is therefore important to specify the theoretical frameworks used to define an agroecological system and to consider ways to apply the concept of agroecological system to real situations.

First, it is important to define what agroecology is theoretically. Agroecology first appeared in 1929 and was then defined as "ecology applied to agriculture" (Hollard et al., 2012). The term was taken up again in 1965, combining ecology and agronomy. Its pioneers Altieri (1986) and Gliessman (1998) defined it as "an approach to food production that seeks to ensure sustainable yields through the use of ecologically sound management techniques" (Altieri, 1986) and "the application of ecology to the study, design and management of sustainable agrosystems" (Gliessman, 1998). Besides being both a science and a practice, agroecology is becoming a social movement whose aim is not only to limit the negative impacts of certain agricultural practices but also to design alternative proposals to implement transitions. Since its beginnings, the definition of agroecology has broadened and now addresses the entire food system, understood in its multiple dimensions (Francis et al., 2003) and the multiplicity of social, political and economic issues and actors involved in agricultural transformation (Stassart and Jamar, 2008, Doré and Bellon, 2019). Agroecological systems need to be productive, input-efficient, socially equitable and economically viable, all at the same time (Altieri, 1995). With a view to reducing environmental impacts and responding to societal expectations and current concerns, the aim of agroecology is therefore to better integrate ecological processes into agricultural systems by replacing chemical and energy inputs by natural processes and by improving biogeochemical cycling (minerals, energy, water).

Agroecology has been the subject of much debate concerning both the construction of new knowledge and the training of scientists working on agricultural and food systems. Several researchers have proposed management principles and practices in agroecological systems, such as using mineral nitrogen or other chemical fertilizers minimally or not at all, or relying on diversity to increase resilience (Dumont et al., 2013, Wezel and Peeters, 2014, Dumont et al., 2016). However, many models of agricultural development - from organic agriculture to 4.0 agriculture, including sustainable agriculture or permaculture - promote the implementation of one or more management practices identified in the way of agroecology in the literature (e.g. limiting inputs). For this reason, these models claim to be based on agroecology. Thus, while the concept of an agroecological system seems theoretically clear – a system (i.e. a set of elements in dynamic interaction) pursuing a farm management objective following agroecological principles (i.e. a limitation of inputs and use and optimization of cycle management) – it remains to be defined practically (introduction of one practice of agroecology, consideration of all the principles agroecology,...). Some field surveys have highlighted different technical operations, different indicators, and an evolving vision of the world (Cayre et al., 2018). These practical models are thus not only technically different; they are also based on strongly different worldviews (Cayre et al., 2018) and imply the implementation of specific management practices, indicators, and systemic functioning.

4 From initial feedback from the field on the characterization of agroecological systems to a method for collecting field information

Based on the elements proposed to define a new systemic approach, several field surveys were carried out to better characterize agroecological systems in Europe, which is dominated by a naturalistic ontology. This work follows on from the initial work presented by Cayre et al. (2018) but has not been completed yet. However, a first analysis of agroecological systems combined with experience in the Comté PDO in grassland systems allow to propose a comparative systemic analysis of three main types of system, namely (i) a grass-fed dairy cattle system, with a use comparable to the Irish or New Zealand models, but in a less rainy context, (ii) a PDO dairy cattle system for Comté cheese with green or dry grass feeding, and (iii) a PDO organic dairy cattle system for Comté cheese, claiming agroecology with green or dry grass feeding. We present the main characteristics of these three major systems using the new systemic approach presented above in order to identify specific features of agroecological systems relative to the other systems.

Case 1 - Grass-fed dairy cattle system

This type of production system can be found in all grassland areas of France. The technical operation is based on the management of the grass so that it covers the maximum amount of milk production. Calvings are thus oriented or even grouped together in spring so that peak milk production coincides with the maximum level of grass production in quality and quantity. Feeding is based mainly on grazing or grass-based stocks during less productive or winter periods. A young grass, rich in energy and protein content and low in fiber is sought in pasture to favor milk production. To this end, fast-rotating pasture is set up and sustained mineral and organic fertilization is carried out. Stocks are also based on young, low-fiber fodder and are therefore harvested early. The indicators used to control the system are based on milk production and the energy and nitrogen content of the green fodder or stock fodder.

In such a system, the farmer chooses to work on a resource that is inexpensive but requires anticipation and high technical skills. Decisions made at the farm level are mainly aimed at reducing costs while seeking to maximize milk production. Thus, the farmer is seeking to control his natural environment and master all the factors relevant to maximizing milk production, reflecting a naturalist conception of his relationship with the natural world (Cayre et al., 2018).

Case 2 - Dairy cattle system under PDO Comté (Franche-Comté)

This type of production system is located in the PDO cheese area. Its purpose is the production of a pressed cheese: Comté (eastern France). Its technical operation is based on feeding from permanent meadows. Grass grazed or stored in dried form is therefore at the heart of the system. Since production concentrates are limited in quantity (specifications for compliance), the dried fodder or pasture grass must be of a quality (energy and protein content) to enable milk production in line with the objectives of the farmer and the industry. Young, low-fiber fodder is therefore often sought after. Both dry fodder and grass must be young and rich in energy and protein content because calving is not necessarily based on grass management but related to the price of milk. As winter milk often gives higher returns, calving is favored during this period and a high expectation is placed on dried fodder. A milk production quantity is sought that meets the specifications required to set up pasture, which is usually rotated to allow the supply of young fodder at all times. In these systems anchored in a PDO, the notion of biodiversity is present. Farmers will talk about biodiversity and flowers, but above all they will be looking for fodder rich in energy and nitrogenous matter. Biodiversity is therefore merely a consequence of the functioning of the fodder system: if it is favored, then so much the better, but otherwise it is not a priority. The producers know that this is one of the foundations of the PDO. So, they do not hesitate to keep grasslands with low intensity of use for their botanical interest. The indicators used to run the system remain oriented around milk production and grassland management with a production objective, even though processing into cheese is the end goal.

In such a system the farmer must work with the grass, the heart of the PDO. The search for an inexpensive resource is not a priority. Securing the system with a view to maximizing milk production is favored. The farmer also seeks to control his natural environment and master all the relevant factors to maximize milk production, but he has to be more aware of the specific features of permanent meadows in order to comply with the specifications. However, although the concept of biodiversity is acknowledged and promoted, it remains tied to a production objective. Therefore, as in the previous system, the basis of the farmer's choices is primarily naturalistic, but territorial anchoring of production and tight specifications guide his practices toward a better consideration of locally specific features (Cayre et al., 2018).

Case 3 - Agroecological dairy cattle system in PDO Comté (Franche-Comté)

This type of production system is also found in the PDO Comté cheese area alongside more traditional PDO systems. They are most often organic. The technical functioning of the production system is based on the presence of permanent grassland as in the previous example. Grass grazed or stored is therefore at the heart of the system. Here the maximization of milk production is not primarily sought. Working with inexpensive fodder or enhancing the biodiversity of the meadows are also sought by the farmer. Thus, calving is organized around the grazing period to favor a low-cost ration when demand for animal feed is highest. Grazing and mowing management is carried out to take account of and respect the biodiversity of the grasslands. For example, late mowing is deliberate, and grazing management, if carried out as rotational grazing, considers plant growth speed in the rotation. Livestock farmers know the diversity of their plots, work with it and promote it. The indicators used vary and are mainly based on observation of their plots or animals. Production as such is a secondary indicator.

In this system, the farmer works with the grassland, the heart of the PDO, seeking to minimize production costs and enhance the biodiversity present. Also, the farmer is looking more for a balance with his natural environment, working with it instead of against it. The system adapts to the potential offered by grasslands and animals. This difference in how the farmer conceives his relationship with the natural world points to a more analogical register (Cayre et al., 2018).

The analysis of these three examples clearly shows the importance of considering the technical functioning of the system, the farm decision system and the farmer's thought system in order to understand the systems in greater depth and identify the particular features of agroecological systems. Consideration of all three pillars can explain what an agroecological system is in practice. Although the technical functioning may differ, taking into account thought systems shows that other indicators are necessary to understand these farming systems and to highlight their functioning and their link to the natural environment. This initial work can help support changes in management practices in the field. However, to access the elements proposed by this new systemic approach, a specific methodology needs to be devised. This method consists in coupling the approaches of biotechnical sciences with human and social sciences. In addition to the current information relevant to the biotechnical sciences such as herd management and monitoring indicators, it is necessary to access the reasons for these choices through in-depth comprehensive interviews. The analysis of these interviews also brings together methods of the biotechnical sciences with those of the human and social sciences.

5 Conclusion

While the systemic approach has long been based on two main pillars, namely the technical functioning of the system and the decision-making system, the consideration of a third pillar, the farmer's system of thought, explains more fully how the relationship between the farmer and his natural environment helps shape his system of practices and orient his technical system. All these aspects must be considered to understand agroecological systems, pinpoint the specific ways they work, and design evaluation and management metrics for them. Implementing this new systems approach needs to be cross-disciplinary: the biotechnical sciences must work alongside the humanities and social sciences to develop an investigation protocol that includes all three pillars. Such a protocol is currently being tested on agroecological systems with the aim of validating a new methodology and providing references on the functioning of these systems.

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