Farming Systems Research: An approach to inquiry[1]

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Abstract *Initially, Farming Systems Research took the farm as a starting point for an analysis of a broad range of issues linked to agricultural production. Soon afterwards, it was recognised that to understand farming, the scale of analysis needed to be broadened, to capture the interactions between farms and their natural, social and economic context. Topics of research now range from on-farm issues such as interactions between crop production and animal husbandry, to farmer pluriactivity, civic food networks, and how cultural landscapes are shaped by farming activities. Underlying this breadth of topics, three characteristics are identified as being constituent of Farming Systems Research: systems thinking, interdisciplinarity and a participatory approach to research. In this chapter we discuss these three characteristics, and the challenges they pose in their operationalization. Given these challenges, we discuss the reasons why Farming Systems Research is demanding, and we highlight that the core quality of a researcher is reflexivity, in designing, in implementing and in evaluating research.*

Farming Systems Research in Europe

Farming Systems Research is an intellectual way of life, a worldview, a concept of the nature of reality and how to investigate it. How this 'worldview' is translated into conceptualising research and how it is translated into practical inquiry will depend on many factors. These include: the context of the research, the specific research question, the choice of spatial and temporal scale, the disciplinary background of the researcher, institutional constraints of those participating in the inquiry, as well as the previous experiences and knowledge of systems thinking by the participants. As a result, Farming Systems Research comes in many guises and labels (e.g. Dent and McGregor 1994; Collinson 2000; Doppler 2000). This explains why Farming Systems Research cannot be neatly categorised and pinned down (Fig. 1).

Fig. 1 Researchers from many different disciplinary backgrounds contribute to the development of Farming Systems Research, focusing on specific aspects and customising it to different contexts. As a result, a diversity of approaches and applications has been developed, a richness that comes at the cost of a simple, all-encompassing definition.

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[1] Draft of a chapter for the book "Farming Systems into the 21st century: The new dynamic" (2012).

At the same time it is a testimony to the vitality of the approach to inquiry, and how it spurs creative research design, tailored to a specific situation, rather than promoting a 'one size fits all' approach. This openness comes at a price: with no standardized set of methods, it demands a high level of reflexivity from researchers, an awareness of a broad range of debates related to the philosophy of science, a clear epistemological and ontological positioning, and an awareness of the trade-offs involved. This chapter will highlight a range of issues that farming systems researchers take into consideration when doing research. Before we detail these, we briefly revisit the evolution of this approach to research in Europe and identify the three core characteristics which have come to define it.

A very brief history

Farming Systems Research emerged to address a new set of questions where the dominant approaches to agricultural research were poorly focused (Beranger and Vissac 1994; Bonnemaire et al. 2000; Brossier and Hubert 2000; Collinson 2000; Colin and Crawford 2000; Brossier et al. 2012). This dominant approach was characterised by disciplinary specialisation in commodity-oriented research, taking place on experimental research stations and in laboratories, and with top down research-extension schemes. This research often emerged from a productivist orientation to agriculture, seeking optimization and striving for continuous productivity gains (measured through, for example, crop yields or return to labour). Capital intensive modernization was seen as the desirable model of development, and the orientation towards commodity markets was to be enabled by technological innovation, scale enlargement, and specialization of farms.

This approach was successful, but only in very specific contexts. These contexts are characterised by a homogeneous production environment, large commercial farm units, stable economic conditions, and biological interactions (e.g. between crops and the soil) which replicated those used in the laboratory or on an experimental farm (Jiggins 1993; Packham 2011). However, this approach to agricultural research and development was inadequate in more complex situations, particularly in heterogeneous environments (e.g. varied soil types, mixed livestock-cropping systems), and where social and cultural factors (e.g. individual preferences, division of labour, pluriactivity) influenced farming practices. In the 1980s it was observed that a number of farmers did not adopt the technologies and production methods promoted by the chambers of agriculture and extension services, partly because the promoted 'solutions' did not address the needs of these farmers (Brossier and Hubert 2000).

There was an increasing recognition that European farms are diverse, many of them family farms and oriented towards multifunctionality, that they did not necessarily follow the production logic underlying mainstream agricultural research and extension, and that they were not managed according to the principles of 'rational decision making' inherent in neoclassical economics. Instead, farm activities, technology choices and production methods were linked to family projects and farming lifestyles, and embedded into territories within their natural landscapes and social networks. Furthermore, the importance of taking into account 'external effects', especially the environmental and social impact (on- and off-farm) of agricultural practices, was increasingly recognized (Bellon et al. 2012).

Researchers thus realized that when developing agricultural technologies, it was important to take the environmental and social context into consideration (Biggs 1995; Collinson and Lightfoot 2000); and to do so would require contributions from several disciplines as well as the involvement of farmers. These were the *initial foundations* of Farming Systems Research. They implied that a systemic approach was necessary so as to capture the 'logic' of the farming system, which allowed us to understand the interactions between component parts. These include material objects (e.g. soils, plants, animals, buildings) as well as subjective perceptions, values and preferences, i.e. how farmers[2] ‘make sense’ of their practices (Fig. 2). The focus on interactions also emphasised that a farm cannot be studied in isolation, but to understand the farming practices, the farm needs to be understood as embedded in a territory, a locale, a region, with its specific agro-ecological setting, economic opportunities and cultural values (Fig. 2).

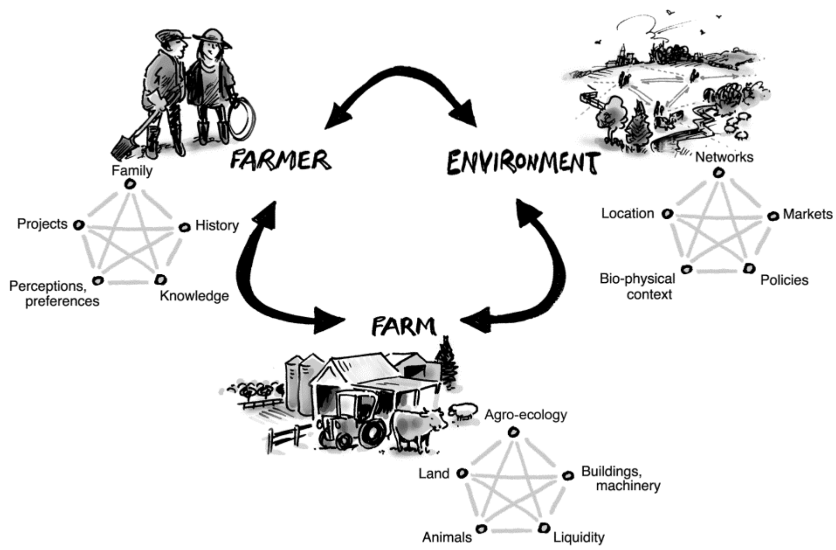

Fig. 2 When analysing a farming system, at least three sets of interacting factors need to be taken into account: the various members of the farm family, with their individual preferences, projects and history; the farm with its resources and assets; and the environment which is constituted by social networks, economic opportunities, political incentives and bio-physical context. This means that the farming system is understood as constructed by the farmer, while being dependent on material resources and structures. As such, a farming system is an emergent property of material conditions and social construction.

Crop and animal scientists thus began to collaborate, and extended the invitation to economists, sociologists, anthropologists, ethnologists, and ecologists. The collaboration was broadened to geographers and landscape planners as it was rapidly recognised that, for many issues, a larger spatial scale would be more appropriate than focusing solely on the farm. The larger spatial scale allowed understanding the interactions between farms, farmers, other rural actors, farming and other sectors within pluriactivity and between the various members of an agro-food network. Farming was thus increasingly seen as being one sub-system of a local community, or of a civic food network. It was seen as interacting with the natural environment and the landscape. All of these sub-systems co-evolve over time through changes in preferences, policies, or technological innovations, thereby generating new collaboration networks or new market opportunities for goods and services.

Currently, few studies in Farming Systems Research do not involve farms as one of the elements of the system under study. However, the farm-scale is not the sole or primary focus. Farming Systems Research is an approach which is used in all issues where farms play a role. In the European context, these are mostly family farms with a multi-functional orientation and often pluriactive family members. As such, Farming Systems Research is usually situated in rural areas, but also reaches into urban areas, e.g. when studying agro-food networks. However, a territorial definition might not do Farming Systems Research justice, as it investigates how spatial, technical and social relations are constructed, represented, materialised and contested by a broad range of societal actors. This emphasis on the constructed nature of relations distinguishes ‘farming systems’ from ‘agricultural

[2] In this text, when we use ‘farmer’ we do not imply an individualistic decision-maker. The term is used as shorthand for the family farm household. We are fully aware that in many cases the various household members will have different perceptions, preferences and priorities, thus resulting in tensions and on-going negotiations about what to do, how to do it, and why.

systems'[3], as the latter are mostly concerned with the biophysical dimensions of food production, thereby neglecting the social constructions involved and the complexity of the farmer's position in the system.

In the 1990s, after the shift towards interdisciplinary research, there was also recognition that scientific knowledge was not sufficient to address a number of issues, so that new approaches to research were developed, which involved farmers and other actors. This gave learning and action-based participatory approaches a central place within Farming Systems Research (see Blackmore et al. 2012; Ison et al. 2012). The aim was to allow knowledge and understanding to emerge from interactions between stakeholders as well as between practitioners and researchers.

Key characteristics of Farming Systems Research

To summarize, Farming Systems Research has three core characteristics:

- It uses *systems thinking*. Situations deemed 'problematic' are understood as emergent phenomena of systems, which cannot be comprehensively addressed by using only a reductionist, analytical approach. It requires thinking about the interconnections between a system's elements, its dynamics, and its relation with the environment. It studies boundaries, linkages, synergies and emergent properties. The aim is to understand and take into account interdependencies and dynamics. It means keeping the 'bigger picture' in mind, even when a study focuses on a specific aspect or sub-system.
- It relies on *interdisciplinarity*. Agronomic sciences (crop production, animal husbandry) are working closely with social sciences (sociology, economics, political sciences) and 'interdisciplinary' sciences (e.g. human geography, landscape planning). This interdisciplinary approach is essential to understand farming in a systemic way. Farming Systems Research is thus distinct from disciplinary research, which can provide complementary insights (e.g. informing the development of new production methods).
- It builds on a *participatory approach.* Integrating societal actors in research is critical to understand 'real world' situations, to include the goals of various actors, and to appreciate their perception of constraints and opportunities. A broad range of societal actors (farmers, extension agents, civil society organisations, associations, etc.) can be involved in research, and may actively shape the research process. The participatory[4] approach also allows integrating local and farmers' knowledge with scientific knowledge, thus fuelling reciprocal learning processes (Fig. 3).

Comprehensively implementing all three characteristics in a single research project is a steep challenge, both conceptually and in practice. Doing so may not be feasible in many settings and often not effective. Scarce resources may make it more efficient to focus on those aspects that are most relevant to the specific situation in which the researcher is engaged.

However, a farming systems researcher should be aware of the choices made in a specific situation, and is expected to make these choices in an informed and reflexive manner. In the coming sections we will discuss various aspects underlying these three core characteristics, highlighting both the theoretical discourse and the practical challenges in implementation. Although a number of issues are fairly well understood at the theoretical level, their implementation is not standardized, fuelling the diversity of Farming Systems Research in practice.

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[4] Some authors may call it a transdisciplinary approach. Transdisciplinary is then understood as striving to transcending the disciplinary divide and the science-society divide (Pohl 2005).

Fig. 3. To navigate situations of change and uncertainty, it is important to be open to learning from a range of different perspectives, even from unexpected sources!

The challenge of systems thinking

What is a system?

Fundamentally, Farming Systems Research implies that farming and related activities are understood as systems. Systems are about drawing attention to the relationship between elements, rather than focusing on specific elements and studying them in isolation. It is about interaction, entanglement, dependencies, exchange, connections, relationships and co-evolution. This is a key distinction from more traditional reductionist approaches to agricultural research, which focuses on analysing separate parts of the system (e.g. animal nutrition, crop yield). These separate parts are conceptualised as an assemblage of fairly isolated mechanistic elements that are determined by linear cause-effect relationships (e.g. appropriate fertilisers lead to higher yields). Similarly, in reductionist approaches farmers are seen as discrete agents (i.e. each farmer takes her decisions independently), while Farming Systems Research seeks to understand how actors interact and influence one another (Röling and Jiggins 1998).

Following the characteristics and types of systems proposed by Ackoff (1999:49ff), farming systems can be characterised as *open* (i.e. it has an environment which affects its state), and as *dynamic* (i.e. there are changes in one or more structural properties of the system, so that the state of the system changes over time). Farming systems are also *purposeful*. This means that a farming system can produce the same outcome in different ways, and can change its goals under constant conditions. In other terms, a farmer exercises choice: s/he selects ends as well as means. A farmer can thus choose between different outcomes and can place different values on different outcomes. It is important to note that not only does the farming system as a whole have a purpose, but its parts may also have purposes of their own. The dynamics and interactions thus lead to emergent properties and behaviours of the system as a whole.

Farming systems research focuses on systems taken as a whole, i.e. it is concerned with total-system performance, not least because 'optimizing' individual parts tends to have undesirable side-effects elsewhere in the system and therefore tends to come at the cost of the performance of the overall system (Collinson 2001). It is in fact a fundamental principle of systems that "if each part of a system, considered separately, is made to operate as efficiently as possible, the system as a whole will *not* operate as effectively as possible" (Ackoff 1999:18, emphasis in original). The performance of a system therefore depends more on how its parts interact than on how they act independently of each other.

Any farming system is embedded in larger systems that provide *context* and meaning for decisions made within the farming system. Understanding the importance of context, Farming Systems

Research necessarily takes a territorial (rather than a sectoral) perspective to study issues related to e.g. farm adaptation, rural development, local agri-food systems, landscape and watershed management, or innovation processes (Cochet 2012). Taking the influence of the context seriously also implies that to sustain systems over time requires managing processes at multiple scales (Gunderson and Holling 2002).

There are thus fundamental differences between the analytical-reductionist approach and systems thinking (Meadows 2008; Ison 2010; Leach et al. 2010; Jones et al. 2011a). As a result, it is not straightforward to add systems thinking as an isolated part of a research project. It needs to be seen as the foundation, the starting point from which to explore and analyse a complex problem in a holistic way. This holistic approach to farming involves exploring the complexity of interactions within the 'hard' system (the biological and technological components that can be modelled, particularly by simulation) and within the 'soft' system (the meaning that actors give to farming systems, now they make sense as biological and technological components).

This focus on understanding the interconnections and multiple causes for a phenomenon, distinguishes farming systems from those approaches that focus on technological fixes, arguing that they will adequately address societal problems (Russell and Ison 2000). Whereas technology certainly has a role to play (Scott 2011), farming systems researchers striving for sustainable systems warn against a naïve faith in market-driven myopic technological fixes that may respond more to the needs and the agenda of influential stakeholders (Woodhill and Röling 1998; Diedrich et al. 2011).

Of 'hard' and 'soft' systems

One of the better known distinctions within systems approaches are between 'hard' and 'soft' systems. *Hard systems* is a term often used to refer to systems approaches based on 'hard' sciences, i.e. based on data from physical, chemical, physiological and ecological processes (Fig. 4). In this view, systems are treated as 'real' structures which exist as such, as if their boundaries and goals are given. In this context, analysis and problem solving focus on the best technical means to reach a goal. Such hard system thinking can be usefully applied to natural systems, and they frequently take the form of mathematical models for e.g. crop growth or crop-soil interactions. They may also take the form of bio-economic optimisation models when they incorporate economic data on farming, e.g. input and output prices (see Feola et al. 2012). Such models tend to be used to inform policy makers, for example about the potential impact of a policy change on land use, or about the likely impact of a price change on production methods, and thus impact on the natural environment (e.g. through nitrate leaching).

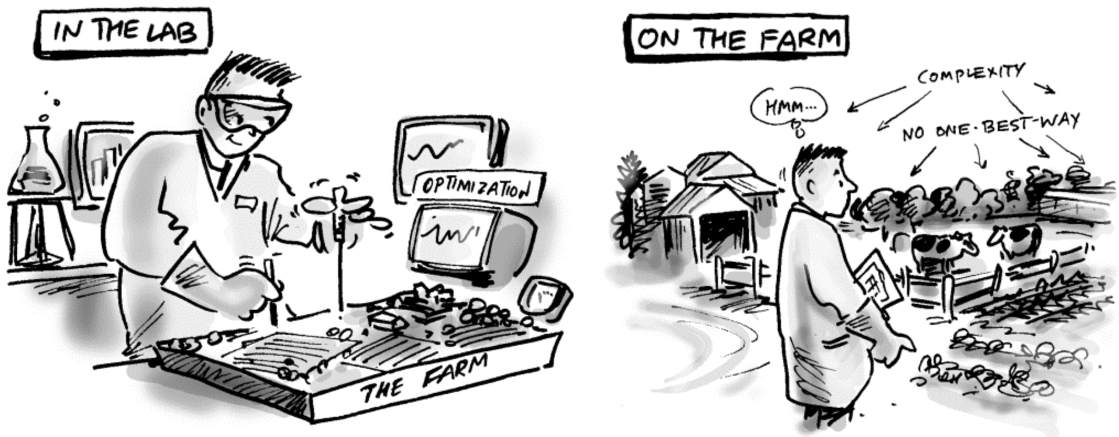


Fig. 4. Within a hard-systems approach, the farm is conceived as a mechanistic system which can be fine-tuned and optimized. This is best done under laboratory conditions, where conditions can be neatly controlled. However, real-life farms are much more diverse than conceptualised, are driven by more complex in the interactions than assumed in the laboratory, and what is 'best' depends for a large part on the perception of farmers.

Such models, especially the economic models, are based on farmers as individualist decision-makers who behave according to the assumption of the rational-choice theory. Farmers are then assumed to have complete information and to choose so as to optimize outcomes; to take decisions based primarily on objective ‘facts’; to select technological options or production methods based on some universal, pre-given categories (e.g. profit maximisation, optimal cost-benefit relationships, or highest yields). Farmers are not believed to be influenced by personal preferences, cultural norms or by the behaviour of their neighbours. Although hard system thinkers make casual remarks about the differences between the modelled system and the actual cropping system observed in ‘real life’, they do not see the discrepancies as a research question (Janssen 2009). This may be problematic, especially if the model results are taken as the starting point for deriving policy recommendation: in effect, the model becomes the standard, whereas the actual practices are (unexplained) ‘deviants’.

These simplifying assumptions of human behaviour as well as the normative stance underlying these models have been heavily critiqued by social scientists (including economists, e.g. Becker 2006). They have pointed out the constructed nature of human perception, and the social nature of many choices. In other words: the choices of farmers are not based on ‘objective’ facts, but influenced by perceptions and values and by the activities of other members of the rural community. Some scientists have worked on understanding farmer rationality and the logic underlying their choices and strategies (see e.g. van der Ploeg 2003; Lémery et al. 2008; Chia and Marchenay 2008; Milestad et al. 2012). These studies make the different farming logics visible, and enable an analysis of their differences, not least by paying attention to the *farmers’ perception*. This work has revealed that in many situations the farmers’ goals were different from those assumed by scientists. For example scientists might assume that the goal is to maximise production or income, whereas the farmer might strive for satisfactory production levels, a limited workload, and financial autonomy (Fig. 5). This leads to a different understanding of farmer’s choices, constraints and goals than the one underlying mathematical models.

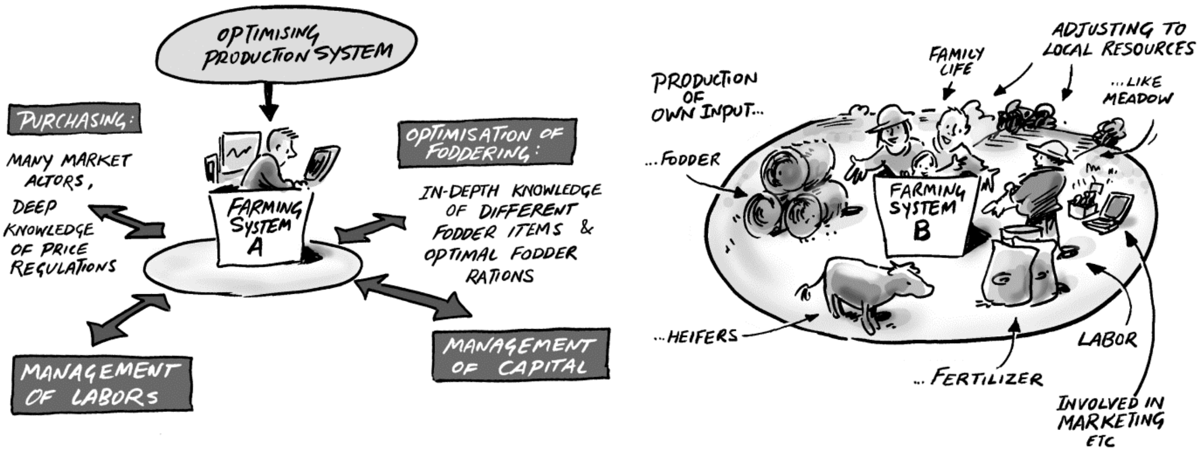


Fig. 5. Using mathematical models for ‘optimizing’ farming systems are usually based on assuming that a farmer is ‘economically rational’ and that all relevant variables can be adequately translated into monetary values. However in ‘real life’ farmers tend to have a mix of goals, which can include issues such as ensuring their continued autonomy in decision making, and basing their production on locally available resources.

In Farming Systems Research, understanding choice as being heavily influenced by social constructions and values has been reinforced by the results of the science and technology studies (e.g. Bijker et al. 1987; Jasanoff 2004), which have pointed out that values play a role in the construction of facts. Of course, this should not be construed as implying that the factual content of arguments does not matter. Ecosystems exist independently of their social construction. However, as Röling (1997) points out, while natural sciences have much to contribute to our understanding of natural systems such as ecosystems, these insights are not effective for informing human activity itself. Whereas the understanding of cause-effect relationships in nature and society may be informed by scientific results, how they affect human behaviour is primarily dependent on processes of appropriation, experience, exchange with others, and learning (LEARN 2000, Leeuwis and Pyburn 2002). Human activity, which is the primary determinant of land use, is the result of human intentionality, sense making, organization, institutions, policies, power, path dependency, and social interaction (Biggs 1995; Collinson 2001). These interactions are dependent on the structures present in a society (Giddens 1984). What farmers do on their land is thus to a large extent the outcome of societal structures as well as processes of learning and interaction among a broad range of actors.

'Soft systems' thinking conceptualises systems as social constructs, where system goals are not given, but contested, and system boundaries need to be negotiated (Checkland and Poulter 2010). In this constructionist view, the agro-ecosystem is a sub-system of a human activity system (Röling and Wagemakers 1998). In soft systems thinking, how humans perceive their environment and their options is put at the centre of attention. The spotlight is therefore on understanding the implication of specific perceptions, and on how these may change, not least as a result of interactions with others. The evolution of a farming system is shaped to a significant degree by human interaction, learning, conflict resolution, agreements and collective action. Given the importance of perception and learning, soft systems thinking accepts that some important causal factors cannot be directly observed, measured or quantified, and that the systems are not amenable to mathematical modelling. With the increasing recognition of the role of subjectivity, collective action, social learning, and the social construction of both problems and solutions, there has been a growing emphasis to include 'soft systems' approaches in farming systems studies.

Currently, Farming Systems Research accommodates both 'hard' and 'soft' systems thinking, with their respective methods and models. This acknowledges the trade-offs between the simplified, but instrumented models at the core of hard systems approaches, and the holistic, but simpler qualitative representations of soft systems. Despite the critiques of quantitative models, e.g. that they are "mathematically sophisticated, but contextually naïve" (Ackoff 1999:317) – the problem is less in the models themselves, than in their unreflected use. All too often, the underlying assumptions are taken for granted, remain unstated and are rarely scrutinized for their validity. This may lead to the application of models outside their domain of validity, deriving recommendations from simplified models for a complex world characterised by uncertainty (Rosenhead and Mingers 2001). However, the same quantitative models, rather than being used for calculating an optimum solution and deriving recommendations for policy makers, may also fruitfully be used to inform the dialogue between stakeholders (Étienne 2011; Fig. 6). Hard and soft approaches might thus be combined to promote understanding and learning in collective processes.

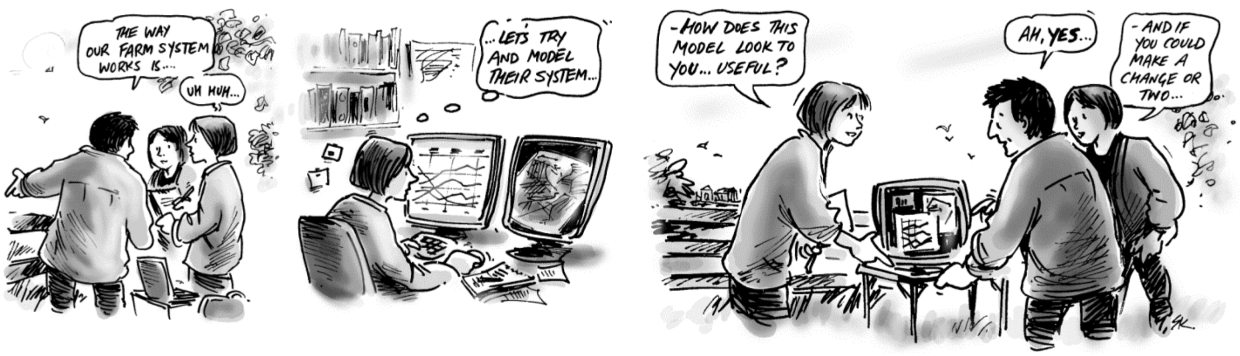


Fig. 6. Simulation models are often adopted as basis for trans-disciplinary research processes. The interaction among scientists and different actors, e.g. farmers, can activate a mutual learning process which results in simulation models that are not only scientifically sound, but also practically useful.

Ontological vs. epistemological status of 'systems'

Another distinction that is important to keep in mind when talking about 'systems, and which is related to the hard/soft distinction, is that some approaches conceptualise 'systems' as things which exist in the world, i.e. separate from the researcher or modeller; whereas other approaches take into account the role of the researcher's perception and choices, thus conceptualising systems as constructed (see Ison 2012). For example, ecologists usually assume that the elements comprising an ecosystem, as well as its boundary, are 'given'. This allows them to classify, describe and research the ecosystem. As the system is understood as existing in the real world, it has *ontological status* (Ison 2010:45ff).

Distinct from this approach is seeing systems as an *epistemological device*, i.e. as a method for knowing, and as a way of engaging with a situation (Ison 2010:46). In this way the researcher actively constructs and makes choices, e.g. regarding the boundaries of the system and the elements he wants to study. These choices may be revised, whenever it seems useful. The system is thus defined for the particular purpose of the study, but not assumed to exist per se. It is only a heuristic device that is effective in describing, classifying and discussing, thereby allowing the enhancement of understanding. This approach is based on a dynamic understanding between the researcher and the situation that is studied. It implies the awareness that any research situation is always co-constructed by the researcher. So although concrete systems and their environment are objective things, they are also subjective insofar as the particular configuration of elements that form the system and its environment is dictated by the interests of the actors (Ackoff 1999:49).

Soft systems thinking *views systems as constructs*, i.e. as brought forth by an observer who has a unique experiential or cognitive history. Conceptualizing systems as constructed not only allows us to 'reconstruct' the system as needed, e.g. following new insights on its dynamics, but it also allows for the fact that different stakeholders are likely to hold different models of the same situation (Fig. 7). In fact, people appreciate the same system, with its elements and its context in different ways, in line with their experiences, world views and purposes. What results, is a number of different models of a system (i.e. constructions of a situation) which are not necessarily shared by all stakeholders. This is radically different from adopting one specific model of a system and deriving recommendations using only this model.

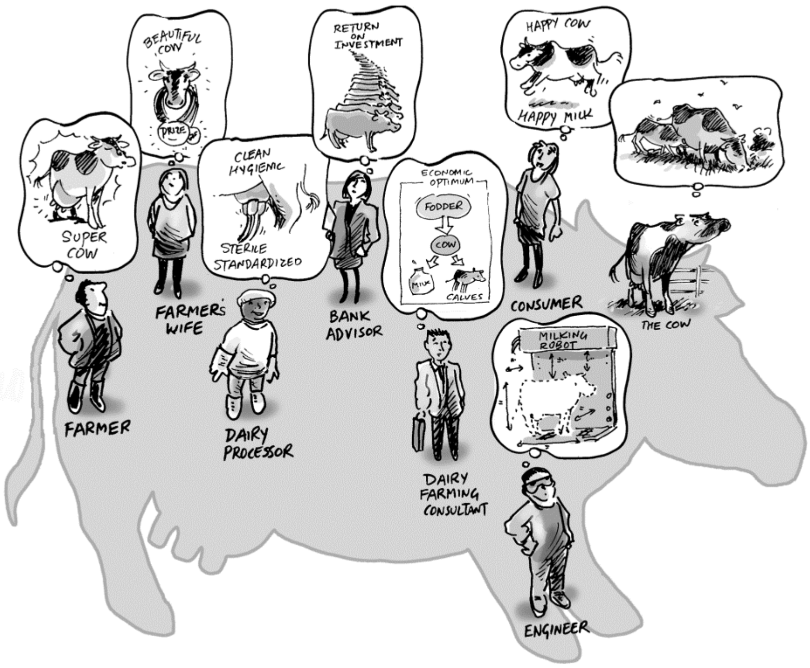


Fig. 7. Understanding that systems are constructed implies an understanding that different stakeholders are likely to hold different constructions of the same system. To illustrate: a cow can be conceptualized very differently by different people. How the cow is perceived is likely to influence the choices and the preferences of the people involved in managing her.

Understanding the dynamics of farming systems

Since systems thinking focuses on interactions and relationships between elements, farming systems researchers typically study interactions. The focus might be at farm-level (e.g. interactions between cropping and animal husbandry, between on- and off-farm work, between technologies and agro-ecosystems); or at territorial level (e.g. interactions between production methods and cultural landscapes, between economic incentives and farm diversity, between farmers and other rural actors). These interactions are not trivial, not least because each of these elements undergoes changes, and these topical changes can have unpredictable effects elsewhere in the system.

For example, with the changes in societal demands towards agriculture, farmers are not only engaged in food production, but increasingly involved in other sectors, be it energy production, the provision of social services (e.g. recreation, care farming, education) or securing ecosystem services (e.g. water quality, biodiversity preservation; see Costanza et al. 1997). This raises various questions, e.g. how the diverse projects on a farm interact, how the diversity of farms in a locality enable collective action, how civic food networks emerge, how the diversity of farms in a territory change over time, or whether that diversity is conducive to strengthening the resilience of farming systems. Farmers may also well hold conflicting goals given their diverse roles: they are farm managers and might want to increase their cash flow, they are the workers and therefore might want to improve working conditions, and they are also part of a community and might want to comply with the local norms and values (Dedieu and Servière 2011). As a result of this internal tension, farmers might not implement a clearly recognizable strategy, or their priorities might shift over time.

When the inherent dynamics of farming systems was recognized, emphasis was put on understanding how stakeholders *manage change*. With the context of farming becoming more turbulent and cycles of change becoming ever shorter (e.g. due to changes in agricultural policy), it became important to understand how farmers perceive and steer through uncertainty and unpredictability (Fig. 8). Of course farmers have always had to cope with weather vagaries or with a sudden disease outbreak. However, the economic and social context of farming seems to become more turbulent, calling for a heightened level of adaptability and flexibility of farming systems (Scoones et al. 2007; Milestad et al. 2012). The strategies are analysed from different viewpoints, e.g. the source of change such as shifts in technical paradigms (e.g. the increasing acceptance of production methods linked with organic farming), or shifts in societal expectations of farming (e.g. increasing sensibility to environmental protection and animal welfare and demand for transparency along the production chain). More recently, change in farming systems is also being analysed from the perspective of socio-technical transitions, acknowledging the pervasive technological mediation of social relations (Russel and Williams 2002). Here, the focus is the co-evolution of farming systems with other societal sub-systems, and how these may constrain or facilitate a transition to sustainability (Smith and Stirling 2008; Elzen et al. 2012).

Fig. 8. With increasing connectivity and complexity, change tends to become more turbulent. And it is unlikely that the challenges ahead can be tackled with a 'business as usual' approach.

Given that most societal changes over the medium to long-term are unpredictable; farmers have to face uncertainty rather than risk[5] (Leach et al. 2010). Indeed not only are future developments uncertain, our knowledge of complex natural systems is also limited. As a result, the uncertainties in achieving desired resource management outcomes remain high. This has increased the interest in *adaptive management* which is based on continuously generating new knowledge about system behaviours, through observation, monitoring and the evaluation of outcomes of implemented management strategies (Plummer 2009; Milestad et al. 2012). Adaptive management builds on experimentation and (collective) learning and thus allows for continuous improvement of the knowledge base, and its usefulness for managing natural resources under uncertain and variable conditions (Plummer 2009). An adaptive approach is particularly important when considering the complexity and dynamics that characterise the real world, where influencing factors are not fixed once and for all, but always susceptible to revision and modification.

Overall, Farming Systems Research thus integrates a broad range of aspects that characterise systems thinking. However, it could doubtlessly benefit from integrating additional insights from various systems sciences. Researchers from a wide variety of disciplines are contributing to the conceptual development of systems sciences, e.g. systems thinking (Meadows 2008); complexity sciences (Mitchell 2009), ecology (Holling 2001), or social systems (Luhmann 1995). These contributions however, are not as interactive and additive as they could be (Bawden 1996; Ackoff 1999:47; Ison 2012; Noe and Alrøe 2012).

The challenge of interdisciplinarity

To understand a farming system requires integrating natural sciences (e.g. plant physiology, animal nutrition, ecology), technical sciences (e.g. engineering, electronics for precision farming, animal housing design), as well as social sciences (e.g. sociology, anthropology, economics, psychology). Despite the widespread recognition of the importance of interdisciplinary work, in practice the extent and intensity of interdisciplinary exchange varies widely.

Distinguishing between multidisciplinary and interdisciplinary

In the earliest and simplest form of collaboration between disciplines, an economic component is included in a production-oriented study. In such collaboration, technical information is exchanged between scientists who each work on their own model. An economist may ask animal production researchers for technical coefficients (e.g. number of piglets per sow and year) that they can use in their model. An animal production researcher may ask an economist to calculate the value of a ton of feed. This approach does indeed see that insights gained for different disciplines are complementary, e.g. that farm management choices should be guided by both technical feasibility and economic profitability. These types of collaborations are widespread, and they often focus on modelling relationships between material dimensions of farming systems. As such they were fuelled by the development of personal computers in the 1990s, which allowed developing ever more sophisticated mathematical models. These models are often used to assess the potential outcome of agricultural policy interventions or of environmental protection measures (see Feola et al. 2012).

However, many of these approaches, not only those focusing on mathematical models, are examples of multi-disciplinary research, rather than being interdisciplinary. In *multidisciplinary research*, the subject under study is approached from different domains, using different disciplinary perspectives (Janssen and Goldsworthy 1996). However, neither the theoretical perspectives nor the findings of the various disciplines are integrated. In fact, the various disciplines tend to work side-by-side. There is little search for a common ground between the disciplines (e.g. economists might ask for coeffi-

[5] In many contexts it is useful to distinguish risk from other forms of incomplete knowledge, such as uncertainty, ambiguity and ignorance (Leach et al. 2010; Stirling et al. 2007).

cients that make little sense to an animal nutritionist). No effort is made at a common reflection on how the farm works as a system, or why the farmer designed it in a specific way (Brossier and Hubert 2000). There is no effort made in order to understand and question underlying disciplinary assumptions (e.g. what defines an ‘efficient’ production method) (cf. MacMynowski 2007). Often, scientists from different disciplines approach the project differently, seeing their discipline as the focal point with which the other disciplines should link (Fig. 9).

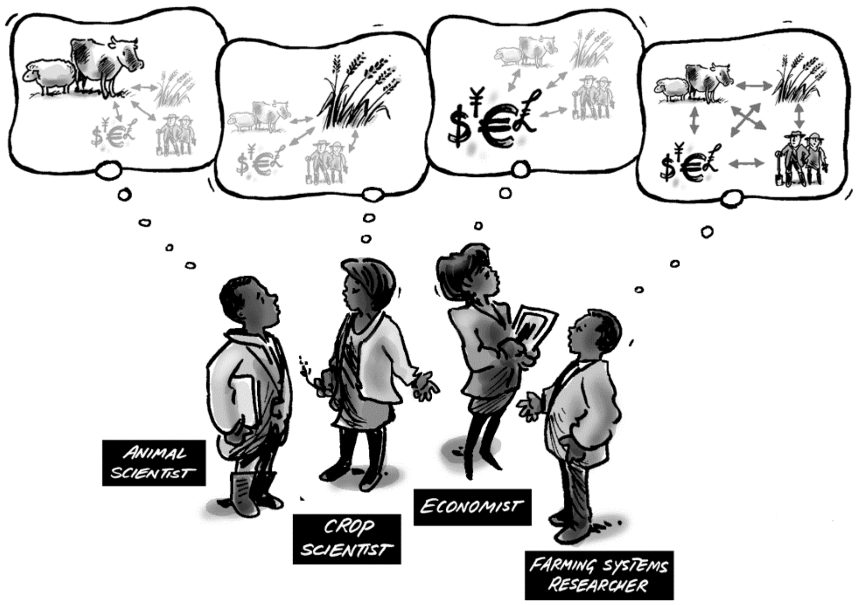


Fig. 9. Interdisciplinary teamwork can still be problematic for some disciplinary trained scientists. They acknowledge that there are links to other disciplines, but tend to privilege their own discipline, expecting others to feed into their methods and approaches. Achieving inter-disciplinarity in which the interactions between the elements of the farming system – rather than any discipline – is the focus of attention, is an on-going challenge to achieve.

However, *interdisciplinary research* requires the mutual integration of organizing concepts, epistemological principles, and methodology (Max-Neef 2005; MacMynowski 2007). This explicit formulation of a uniform terminology and the development of a common integrated conceptual framework is time intensive and theoretically demanding. If multidisciplinary approaches are still dominant, it is less due to the fact that they are preferable from a theoretical point of view, than due to the fact that interdisciplinary research is challenging to implement, because it demands time and effort of (disciplinarily trained) scientists to understand the concepts, assumptions and paradigms of other disciplines.

In Farming Systems Research there have been some efforts to build interdisciplinary concepts. These efforts are often spearheaded by researchers who are attracted to Farming Systems Research because they look for ways to overcome the limitations of their own discipline. For example, some economists engaged in Farming Systems Research were not satisfied with the assumptions regarding the decision making of farmers, or with the assumptions underlying the economic conceptualisation of the ‘firm’. As a result they have developed an alternative conceptual framework: adaptive management (e.g. Petit 1981; Chia and Marchesnay 2008). Similarly, adaptations were needed to conceptualise farmer choices beyond rational choice theory, not only to explain empirically observed behaviour, but also as an underlying framework for collective action. Participation in collective action can actually rarely be reduced to maximising personal utility, as it is often motivated by seeking benefits of the community, such as maintenance of traditions and cultural identity, or enhancing biodiversity through environmental management.

Integrating technological and natural sciences

Agronomy is fundamentally understood as based both on technological and natural sciences as they are linked to crop production and animal husbandry. Where the technological sciences focus on man-made objects, the natural sciences focus on natural objects. Both sciences are integrated in view of the function of these objects for producing food. As such *agricultural systems* focus on the material-technical dimension of farming (Cochet 2012). Agricultural systems are understood as combining natural sciences (plant production, animal nutrition, and genetics) with technical aspects (animal housing, milking and feeding technology, electronics in machinery). The mainstream agricultural development model frames technological developments (e.g. precision farming, milking robots, genetically modified organisms) as key for progress[6].

The integration of technological and natural sciences within agronomy, while not necessarily being unproblematic, has been supported by the fact that they both exclude the social component of farming. Both approaches understand the farmer as a process manager, whose goal it is to ensure efficient production. 'Efficiency' has often been narrowly defined, i.e. it focused on market goods such as milk or meat production. The awareness of production-environment trade-offs (e.g. production of greenhouse gasses, carbon sequestration) is increasing. The effect of a technology or of technology packages however, on the quality of work, the meaning of being a farmer, or on the ability to cope with uncertainty, tends to be neglected (see also Laszlo et al. 2010).

Both technological and natural sciences do include systemic aspects, but mostly focussing on a scale of analysis which is smaller than the farm. They analyse interactions within a plant (e.g. between a plant and soil nutrients), at the plot level (e.g. interactions between crops and weeds), or at the level of an animal (e.g. interactions between genetics and milk composition, between nutrition and health). Based on the insight that an isolated technology is often not efficient, the systems approach also leads to developing technological packages which optimise whole production processes at the farmland and herd level. These packages are the basis for normative-prescriptive recommendations that feed into the transfer-of-technology model of extension, which is based on conceptualising the farmer as a one-sided figure: a techno-economical optimiser (Fig. 10).

Fig. 10. Extension approaches tend to focus on the linear model of transfer-of-technology, which promotes ready-made technology packages. This packages are expected to propel adopting farmers into the future. Family farmers tend to resist such an approach – not least since many of the packages did not meet their needs. This stimulated the development of alternative, participatory and systemic methods.

[6] This is often referred to as the 'productivist' model of agricultural development.

However, this agronomic or agricultural systems approach neglects the role of socio-political and local contexts in the farmer's choices, as well as the farmer's subjectivity, which are central to farming systems (Porcher 2002). We will illustrate this by pinpointing the difference between livestock system and livestock *farming* system. *Livestock system* studies focus on e.g. genetic characteristics, feeding, breeding and at the end on the animal production processes. Such studies usually focus on individual animals (studying e.g. their genetics, nutritional status, health) or more recently on a whole herd, which is mostly conceptualised as the sum of individual animals composing it. This approach tends to overlook the role of the farmer in the performance of a herd. However, the farmer plays a key role in a number of ways, e.g. the relationship between farmer and animals; the various reasons s/he is a farmer; the type of farmer (e.g. craftsman of entrepreneur); the constraints in labour organisation affecting forage management, thus affecting feed composition; or what 'efficiency' and 'success' means to the farmer. This is what distinguishes the *livestock farming system* approach: it addresses the activity as a whole, thus integrating human objectives and constraints with technical knowledge derived from mainstream animal science research. A livestock farming system thus emphasises the importance of the farm level (rather than the animal or herd) as primary level of analysis, and recognises the need for a participatory approach so as to capture the farmer's construction of his farming system (Gibon et al. 1999; Dedieu et al. 2008). This allows integrating insights from e.g. sociologists who have identified a range of distinct logics or 'farming styles' characterised by very different assemblages of technologies and practices (van der Ploeg 2003).

Integrating natural and social sciences

Integrating social sciences with the bio-technical understanding of agronomy has long been recognized as a major challenge, given their different epistemologies. Building bridges between natural and social sciences[7] requires taking into account both the 'objective' material relations and the 'subjective' value relations in the analysis. Where natural sciences tend to focus on the material dimension of farming systems and understand facts as being objective, social sciences focus on the constructed nature of 'facts' and the core role of 'meaning' for human action (Hill 1998; Jansen 2009; Bawden 2010). To understand nature, natural sciences see positivist methods as sufficient, while to understand the social dimension we need an interpretive approach so as to capture norms, values and meaning (Röling and Jiggins 1998; Ackoff 1999). As Jansen (2009) points out, this view separates social systems and natural systems so that the study of the interactions between the social and the natural becomes problematic. To overcome this separation, we need to build bridges between hard systems that address facts, and soft systems that address meaning, reasons and values.

Bridges and integrative concepts

Farming systems research explicitly strives to join the material-technical dimension and the 'human' dimension of farming. The aim is to take into account both the 'things' and their meaning. This requires understanding the structures and the function of systems simultaneously as 'objective' (things, and their interactions, existing in a context) *and* as 'subjective' (i.e. relating to the different socially-contingent framings) (Scoones et al. 2007:35ff).

Bridging this disciplinary divide requires that natural scientists reconsider their normative assumption that human behaviour should be determined by scientifically established cause-effect relationships. At the same time it requires social scientists to learn to integrate 'hard facts', rather than seeing that human behaviour as solely determined by people's construction of reality and by their sense-making. It is a call to overcome the limitation of the implicit normative approach in hard systems, with their focus on facts and clearly identifiable causes, and where humans are expected to act like strictly rational decision makers. It is also a call to overcome the limitations of soft systems,

[7] This applies also to technological sciences, as has been amply shown by studies on Science, Technology and Society (STS), see e.g. Jasanoff 2002; Latour 2004, Law 2008.

and their one-sided focus on communication and reason (Jansen 2009). The two are in fact intertwined, as perceptions and intentions are related to practices, and these practices will have consequences on biological processes and technology use. These biotechnical processes are real and will affect the extent to which farmers' projects can be realized, and they will affect perceptions and practices (Landais and Deffontaines 1988; Darré 1996). This *co-evolution of practices and perceptions*, the feedback loop between intentions and results is however difficult to integrate in research concepts. Proposals for integration have been made, e.g. by Röling (1994) who introduced the concept of 'platforms of inquiry' as a way of addressing issues both in the bio-physical and in the social components of farming systems.

Some contribution to overcome the debate about which causal relations should be focused on, and about the appropriateness of mathematical modelling has come from *complexity science* (Jansen 2009; Mitchell 2009). It points out that most effects have a multiplicity of causes, and that they result from manifold contingent relations. Most real-life situations are complex and uncertain, and are undergoing dynamic change. They have been characterized as 'messes' (Ackoff 1974) or 'wicked problems' (Rittel and Webber 1973). Because of this complexity, of multiple feedback loops, farming conditions change continuously. Changes may occur in bio-physical properties (e.g. soil degradation), ecological processes (aphid populations), economic variables (prices), characteristics of individuals (farmers' enthusiasm for experimenting), and social dynamics (cohesion and trust in a group). It then becomes clear that various causes interact and jointly affect the changes in the farming system, with the natural influencing the social and the social creating changes in the natural (Noe and Alrøe 2012). Causes are thus not only social or physical or biological or technical, but more likely the result of a complex set of diverse natural and social mechanisms, and of the interaction between all these elements of farming systems.

It may be seen as a weakness that Farming Systems Research has never constructed a *unified conceptual framework* (or 'theory') to overcome this disciplinary division. There have been debates on whether such a unified conceptual framework is theoretically feasible, whether it is needed, or whether it would be useful. The debates have not been resolved, especially since the research issues addressed in Farming Systems Research are so diverse. Nonetheless, the lack of a unified conceptual framework has made Farming Systems Research a target of theoretical critique, as this lack of a clear 'yard stick' is misinterpreted by some as implying an 'anything goes' attitude.

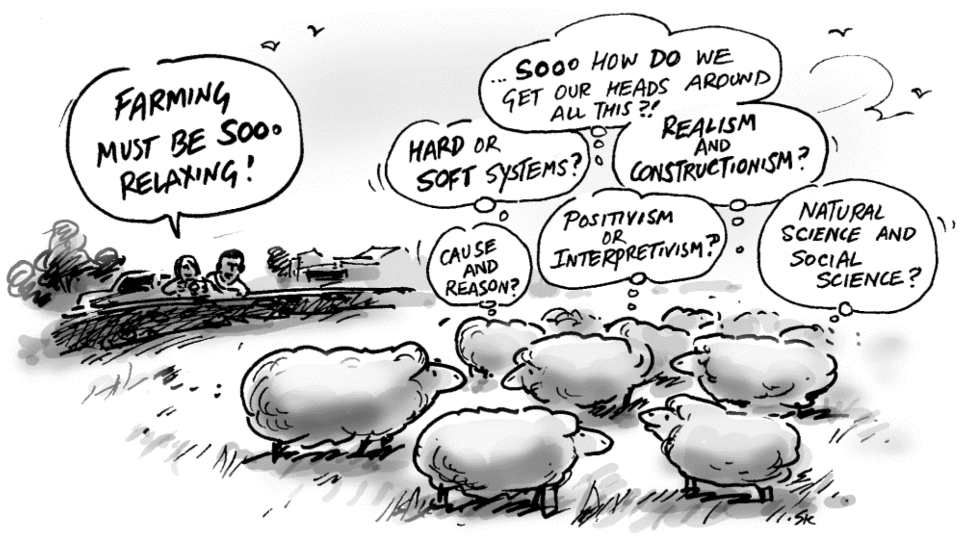


Fig. 11. While making distinctions is often effective, farming systems researchers should avoid dualisms, since these are often unhelpful oppositions, forcing false 'either/or' choices. Rather, distinctions should be viewed as indicating a duality – 'both/and' – which expand our understanding and allow us to appreciate the whole as being constituted of different aspects, to appreciate that various approaches allow us to capture different types of relationships in farming systems.

Undeniably, Farming Systems Research is still involved in the challenge to overcome the unhelpful opposition between hard- and soft systems thinking, between realism and constructionism, between positivism and interpretivism, between technical and natural science, between natural science and social science, between cause and reason, between naturalistic determinism and an ‘oversocialised’ view of farming systems (Röling and Wagemakers 1998) (Fig. 11). Rather than proposing a unified framework which should be used by all, farming systems requires researchers to be reflexive in their practice, i.e. they should be aware of the choices implied in their research design, and ensure that these choices are made consciously, not implicitly or pre-emptively.

The challenge of participation

In the 1990s, with the increasing appreciation of complexity and uncertainty within systems, researchers reemphasized the need for approaches that would allow knowledge and understanding to emerge from processes involving a variety of societal actors and stakeholders (Chambers et al. 1989; Röling and Jiggins 1998; Röling and Wagemakers 1998). These actors needed to be involved in identifying the problematic situation, in understanding the system that produces the situation and in developing measures to address it. By involving different actors, these approaches allow taking into account that they have different implicit and explicit understandings of how ecological processes work and how they are affected by management measures (Jones et al. 2011b). This led to the application of learning and action-based participatory approaches such as action learning, action research, participatory action research, and adaptive management. Many of these approaches are related to Soft Systems Methodology, which takes a set of actors through a process of shared problem appreciation, learning about the problem and taking collective action to improve it (Checkland and Poulter 2010).

Whereas participatory elements are involved in many Farming Systems Research projects, the implication of a participatory approach has been especially developed by those researchers focusing on *extension services*. Their approach clearly shifted from doing research for farmers, to working with farmers. As a result, the structure of education and extension services became a focus of attention: extension is no longer seen as a delivery mechanism of the results of scientific research. Rather, extension is increasingly understood as a societal mechanism for facilitating social learning of appropriate responses to changing circumstance (Cristóvão et al. 2012). Closely related are the studies of innovation in agriculture. These studies have highlighted that innovation is not just about developing a technology. Indeed, to ensure the successful adoption of a technology or practice requires taking into account the whole ‘agricultural innovation systems’, i.e. the culture, power, institutions and policies (see Klerkx et al. 2012), as well as the actors themselves.

Appreciating the importance of integrating various knowledge systems, as well as the dynamic and evolving nature of situations, has led to emphasizing processes that can further ‘social learning’. *Social learning* is the systematic learning process among multiple actors who together define a purpose related to the agreed necessity of concerted action at a variety of scales. This process of social learning includes cultural transformation, institutional development and social change (Woodhill and Röling 1998; Leeuwis and Pyburn 2002). In social learning, farmers and other stakeholders become experts, instead of ‘users’ or ‘adopters’ of scientific recommendations (Röling and Wagemakers 1998). For example, farmers may learn to apply general ecological principles to their own locality and time-specific situations. However, as ecosystems do not stop at the farm boundaries, local communities and wider consortia of stakeholders and resource users also need to engage in learning how to manage landscapes and resources. In this process, communities may develop a common understanding that allows them to make concerted choices regarding the trade-offs among competing interests.

Farming systems researchers are thus called upon to engage with various actors in a continuous process to develop ways of ‘doing better’ through incremental changes to existing systems, accompanied by constant critical reflection and learning (King 2000; King and Jiggins 2002).

Importantly, the changes are not only technical but social and economic. This results in an iterative reflective process, which implies learning more with each cycle (Fig. 12).

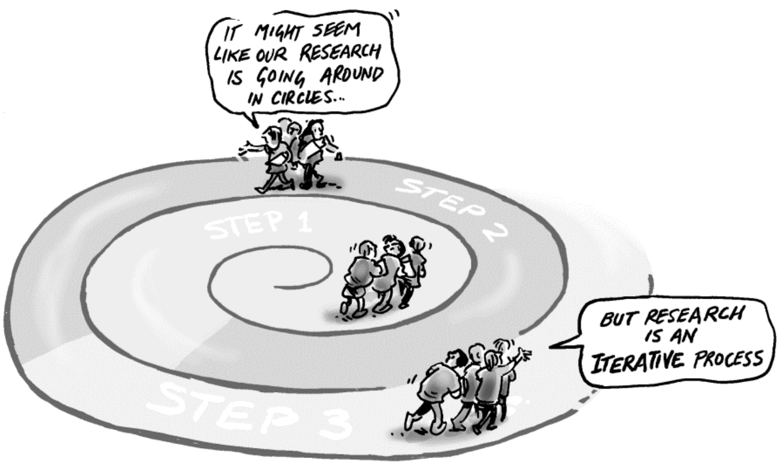


Fig. 12. One of the characteristics of Farming Systems Research is the iterative character, involving researchers and stakeholders. The aim is less to find the 'right solution', but more to engage in an on-going participatory learning process. The research is thus an iterative undertaking, repeating itself throughout the research design, resolving research problems, interpreting results, and determining conclusions.

Although theoretically this participatory process is expected to have significant strengths, its implementation in practice remains challenging (Barreteau et al. 2010). If researchers leave their traditional role as 'experts' and take on a facilitative role in a group learning process, they will need a different set of knowledge and skills, such as knowledge about group dynamics, or methods for structuring critical questioning, facilitation and conflict management (King 2004:11), which they may not have.

Another reason why participation is not as widespread as might be inferred from its theoretical desirability – or why 'lighter' participatory methods are selected (Barreteau et al. 2010; Neef and Neubert 2011) – may be linked to the open-ended nature of participatory processes. Participation does create radical uncertainty regarding the process of knowledge-production: as the stakeholders heavily influence the problem to be studied as well as the process of inquiry, there is no guarantee that something new will be learned about established and pre-constructed scientific questions (Cerf 2011). In other words, ideally a participatory process produces knowledge of use to the stakeholders, and knowledge that researchers are able to position in their own professional world. However, nothing guarantees that participatory research actually does generate scientific knowledge. Whereas this may not be a problem for some, it may well motivate other researchers to retain control over the research process. As a result, even if the need for participation is widely recognized, practices tend not to match the rhetoric, and there is a disconnection between academic theory and research practice.

The work within Farming Systems Research has in this way contributed to making a strong case in favour of participation, especially highlighting their ability to fuel social learning processes. Experiences with the implementation of participatory approaches have however drawn attention to formerly underestimated issues, such as the influence of the institutional context, and of formal science, as well as the role of power relationships in participatory processes (Scoones and Thompson 1994; Cornwall and Jewkes 1995; Woodhill and Röling 1998; King 2004:10; Barreteau et al. 2010).

Mainstreaming Farming Systems Research?

Farming Systems Research was introduced and further developed by researchers to deal with the perceived inadequacies of previous approaches. Despite the broad range of insights and approaches to inquiry developed under the umbrella of Farming Systems Research, it is clear that earlier approaches (e.g. disciplinary approaches, focus on transfer of technology within the agricultural extension system) still dominate. To understand what prevents the mainstreaming of Farming Systems Research (i.e. of taking a systems view, of promoting an interdisciplinary approach, and of implementing participatory processes) it is helpful to take into account the wider institutional context in which research is done, i.e. the needs and pressure that researchers face in their research institution, the demands of academia.

In other words, systems thinking should extend not only to the object of study (farms, rural territories, civic food networks), but also to the research setting itself. This research setting is likely to limit what is perceived as feasible by researchers. Even if they may recognise the shortcomings of traditional approaches, their engagement in Farming Systems Research may be limited unless it allows them to comply with the academic merit system and thus further their career possibilities. In this section we will explore some reasons that may contribute to this 'path dependency' in research practices. Many of the reasons that can contribute to explaining why the principles linked to Farming Systems Research are not used widely – despite being promising in tackling the challenges faced by rural territories and food systems that are due to complex interrelationships and dynamic changes – may be linked with the specific structure of agricultural research, agricultural education and academic incentives (Bawden 2005).

What issues are researched is not only dependent on what is identified as problematic in the real world. Indeed, many issues may be seen as problematic, but given limited resources, these issues will need to be prioritised. This process of prioritisation – as well as the selection of methods deemed appropriate for study, is necessarily a social process, and as such subject to political and ideological influences (see Finlayson et al. 2005). What is actually explored and how it is explored cannot be separated from social interests, and we need to acknowledge that research agendas are often orientated towards the interests of influential stakeholders (Levidow 1998; Vanloqueren and Baret 2009, Diedrich et al. 2011).

This general context for research as well as the established academic merit system also influences the *curricula at universities*. As a result PhD scholars are mostly taught following a disciplinary and reductionist approach, focusing on specific elements of the farming system, rather that attempting to understand the linkages between elements[8]. Linear thinking and simple cause-effect chains are still the dominant mode of thinking, while dynamics and complexity are concepts that do not yet play a key role. Systemic thinking is not taught at most agricultural universities, so that many students are not aware of alternative ways to conceptualise farms (Lieblein et al. 2000; Packham and Sriskandarajah 2005; Gibbon 2012). The fact that the number of Chairs in rural sociology have been reduced, often in favour of agricultural economics, also limits the space for interdisciplinary dialogue and the ability of students to build conceptual bridges between natural and social sciences.

Within this context, it is not surprising that most *research projects* are structured along single discipline-focused sub-project activities that lead to disciplinary teams and outcomes. These conventional structures are often seen as best suited to fulfil the 'silo' mentality attributed to reviewers and funding bodies (see King 2004:140; MacMynowski 2007; Hunt 2009); despite pressures to give societal impact of research more weight (Frodeman and Briggle 2012). Similar structural barriers are at play when attempting to integrate qualitative and quantitative data. Indeed, even where qualitative data is perceived as valid, it is often difficult for the natural scientists or economists to use qualitative data (e.g. as input into existing computer models), or for sociologists to use quantitative data (e.g. to compare different social contexts).

[8] With the possible exception of France, where the 'approche globale' (global approach, see Bonneviale et al. 1989; Hubert and Brossier 2000) is part of the standard curriculum, helping students to understand the interdependencies between biological, technical and social aspects of a farm, as well as the interdependencies between farms and their agro-ecological, economic and social context. INRA research institute is also now promoting interdisciplinary and system approaches. Of course this is not a guarantee that the 'global' or systemic approaches will not be applied in a normative way, focused on the 'efficiency gap', reduced to a simple 'how to', without reflexivity.

In a context where research needs to demonstrate its efficiency, i.e. its ability to produce outputs, there is an increasing emphasis on quantifiable indicators such as the number of publications. This leads to pressure within academia to *publish* in top journals, the vast majority of which have a clear disciplinary orientation (Fig. 13). Within disciplines, there is also a trend towards focusing on ever-smaller component parts (e.g. genetics, nanotechnology), rather than seeing the whole, much less the whole in context (Ackoff 1999:9). This trend highlights a path-dependency in research, where research on a specific topic will lead to new questions raised and thus further research need. Yet, there is rarely a step back to ask whether more information on this very specific topic will actually contribute to solving a problem relevant to the real-world. However, in the real-world the relative importance of one very specific factor is likely to be limited, as the interplay between a range of factors are decisive for the outcome. It raises the age-old issue of doing things right vs. doing the right things.

Fig. 13. The requirements of Farming Systems Research are not necessarily compatible with the dominant academic culture which focuses on publication in peer-reviewed journal. However this does not mean that both approaches cannot be combined!

This academic structure and its reward system require systems-oriented research to clearly argue its added value, since it is not self-evident to mainstream/disciplinary scientists and reviewers. It also requires clarifying the quality criteria that should be used to assess interdisciplinary and participatory research. Farming systems researchers are therefore called upon to develop methods and criteria to assess 'success', e.g. enhanced learning and decision making ability by stakeholders, or whether they have a heightened awareness of the constructed nature of reality. These require criteria to assess the quality of the process, rather than the traditional criteria which focus on a quantifiable outcome. These processes may be difficult to assess, especially given the fact that their maturation takes time, while research projects tend to have a limited lifespan (typically 2-3 years). But clarity on the intended impact of research, and how it can be assessed, may well increase support from funding agencies, which themselves are under pressure to justify their 'effectiveness'. Indeed, while government and funding bodies are interested in research impact, this impact currently tends to be narrowly defined, with a focus on specific and quantifiable technical or material outcome. This is indicative of the underlying instrumental reasoning and reductionist epistemology, building on linear cause-effect relationships.

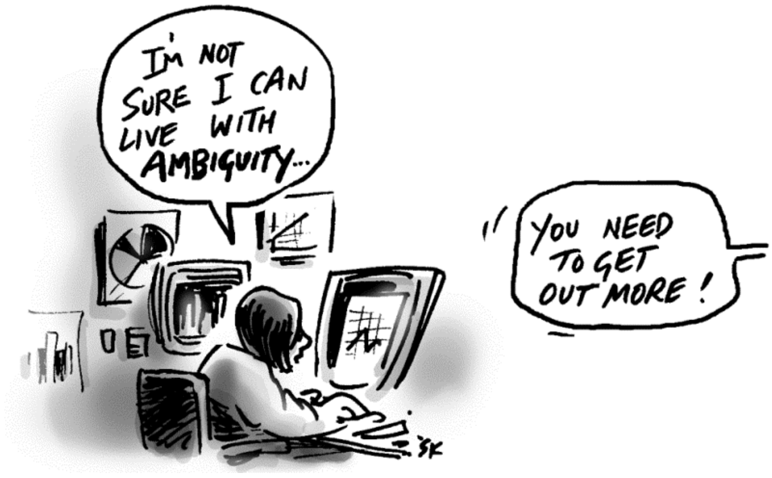
Farming systems researchers also need to be understood as having to act within an institutional system, and the structure of this system – with its specific logic and ensuing incentive structure – will promote certain behaviours and research approaches while discouraging the use of others. While the characteristics of Farming Systems Research may not always be compatible with the epistemology that underlies much of the agricultural research in Europe, the value of the insights it generates is increasingly recognized by a number of societal actors. These actors have limited interest in a top-down transfer-of-technology approach and are appreciative of participatory approaches where researchers' role is to aid the reflexivity of actors, thus facilitating their empowerment. Appreciation for the systemic approach is also growing within the scientific community[9]. Still, farming systems researchers are more likely to be found in social science groups, in environmental research groups or in system sciences groups than in 'classical' animal husbandry or crop production groups.

Outlook: A call for reflexivity

Farming systems is an approach to research, a way of perceiving the world. It does not define itself based on a unified conceptual framework, nor on a fixed set of methods, which can be applied recipe-like. Being a farming systems researcher thus requires a solid grasp of assumptions underlying various theories and methods, as well as their respective strengths and limitations. And above all, researchers need a substantial amount of reflexivity (Bawden 2005).

Reflexivity aims at drawing attention to the complex relationship between processes of knowledge production and the various contexts of such processes, as well as the involvement of the knowledge producer (Alvesson and Sköldberg 2009:8). It asks researchers to clarify the taken-for-granted assumptions and blind spots which may stem from their disciplinary background, research community or personal preferences. Farming systems researchers are called upon to be aware of the challenges of working with systems; the need to understand blind spots inherent in any theory or method; and need to know how to adapt methods to a specific research question and research setting. Being reflexive requires awareness of how we shape our research and how our interpretation of data will always be influenced by our pre-understanding, disciplinary norms, academic culture, politics, ideology, power, language, selective perception and social conventions. To paraphrase Ison (2010:5), it asks researchers to become aware of "what they do, when they do what they do". The goal is thus to make choice consciously, to take into account the inevitable weaknesses and critiques.

Thus, we encourage farming systems researchers to explore ambiguity regarding interpretive possibilities (Fig. 14) and let their construction of what is explored become more visible, thereby avoiding the trap of regarding research results as robust and unequivocal reflections of a reality 'out there'. In this we follow Alvesson and Sköldberg (2009:8) in noting that "it is not methods but ontology and epistemology" which are the determinants of good science.



[9] For example, within the European Federation for Animal Science (EAAP) a permanent working group on Livestock Farming Systems has been established, thus recognizing its contribution to the scientific debate. Also, the number of scholarly journals that accept interdisciplinary papers is clearly on the rise.

Fig. 14. Reflexivity invites researchers to explore ambiguity rather than seek premature closure, or find an erroneous comfort in the clarity which quantitative data and 'hard facts' seem to imply. Rather, researchers should acknowledge the interpretive breadth and the negotiated reality in the 'real world', as well as the fact that how they approach a research setting, how they frame the research question, how they draw the boundaries in space and time will necessarily affect the outcome of their research.

Reflexivity also needs to be applied to the choice of method, so as to take into account how it will highlight some aspects while leaving others outside the scope of the analysis. It needs to be applied to the choice of boundaries (in space and in time, in selecting actors and relationships), as these are necessarily partly arbitrary. Researchers need to make many choices, often for pragmatic reasons. They also need to be aware that they have thereby pre-emptively excluded some aspects, which may or may not be of crucial importance in the farming system under study. In other words, because a researcher has framed the system in a particular way, does not necessarily mean that those elements and interactions which have been excluded are those that play a subordinate role in the farming system.

This is a lesson that the evolution of Farming Systems Research has clearly shown, as it has successively enlarged its object of study in space and in time, based on the realisation that further factors play a key role in explaining observed phenomena. If farming systems started with the biotechnical relations within a farm, it was successively expanded to include economic considerations, the farmer's logic, the environmental impact of farming, community values and activities, sectoral integration through farmer pluriactivity, and the consumer's role in shaping civic food networks.

Reflexivity is about highlighting what might have been left out in previous studies, about the impact of premature framing, reproduction of received wisdom, re-enforcement of established ways of seeing farming systems on our understanding of farming. Reflexive practices provide alternative descriptions, interpretations, and voices, showing the difference it would make if these are taken into consideration (Alvesson and Sköldberg 2009:313). It challenges orthodox understandings by pointing out limitations of and uncertainties behind what may seem to be established knowledge. It challenges the efforts to stabilize a particular understanding of farming, as well as expose the unreflective reproduction of dominant concepts and vocabularies[10]. It means bringing in alternative perspectives, representations, interpretations, framings. Building on the weaknesses that have been pointed out, Farming Systems Research aims at challenging conventional thinking, at problematizing aspects and developing a novel interpretation of how systemic linkages lead to deeper understanding.

Given the increasing realisation that many of the challenges that Europe faces today are interconnected, and given that the limitations of disciplinary and sectoral approaches to addressing these systemic challenges are increasingly recognised, there is no doubt that Farming Systems Research has much to offer. Indeed, to understand interdependencies requires a *systemic approach*. Further developing methods to capture these interdependencies is crucial in order to identify both constrains and levers for change. In the 20 years since its introduction to Europe, it has developed a strong identity. It now offers unique insights on how to understand farming, and proposes a range of participatory methods to work with farmers and other actors to shape a sustainable future. Interdependencies need to be understood as having simultaneously a material and a value dimension; they cannot be reduced to only one of these dimensions. Farming Systems Research has done much to highlight this connection. It is well placed to go further, and to develop its ability to capture both the complexity, diversity and the dynamics of contemporary farming.

[10] While new terms can help clarify distinctions, we would like to caution against the unwarranted coining of new terms, especially for further development of existing concepts or for overlapping concepts. The proliferation of terms tends to lead to confusion, especially with younger researchers who may find it difficult to dissect the overlaps between seemingly (un)related concepts.

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