Farming Systems Research into the 21st Century: 
The New Dynamic
Farming Systems Research into the 21st Century: The New Dynamic
The outline for this book took shape in the course of several discussions during the European Symposia of the International Farming Systems Association (IFSA) held in 2008 and 2010. The discussions centred on the fact that it was not always clear what Farming Systems Research\(^1\) actually is. For many, it was difficult to identify the core principles, given the diversity of empirical explorations and the abundance of ideas debated during the Symposia. The discussions highlighted that one of the major confusions was fuelled by the fact that the term ‘system’ is used in a number of combinations, e.g. agricultural system, agrarian system, livestock system, or crop production system. Is farming system different from these concepts? If yes: how? Why are there a number of papers which describe a research project about farming, displaying many characteristics of a systemic approach, but do not call it Farming Systems Research? Indeed, the term is rarely used as a key word in publications, nor is it necessarily linked to a clearly defined set of methods. This makes it difficult for young researchers to get an overall idea of what sets Farming Systems Research apart, what the underlying commonality is. In the research presented at European IFSA Symposia, the common epistemology is too often implicit, and it seemed useful to state it explicitly. It was thus agreed that a book would be opportune, to clarify the confusion and to retrace the evolution of Farming Systems Research in the European context.

Compiling a book seemed particularly timely for a number of reasons. It had been over 10 years since the last overviews of Farming Systems Research had been published (Hildebrand 1986; Colin and Crawford 2000; Collinson 2000). Timely, because there had never been a book on Farming Systems Research in Europe.

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\(^1\) In this book we mostly keep with the original term, i.e. ‘Farming Systems Research’. However, we make no claim that this is the most appropriate label, and acknowledge that in some contexts e.g. ‘Farming Systems Approach’ is more common, and in others ‘Farming Systems Research and Extension’ is widely used. Despite differences in labels they all refer to taking a systemic view of farming and of the research process; and keeping one label throughout the book was chosen to avoid confusing readers.
except for the proceedings of various symposia (i.e. Dent and McGregor 1994; Doppler and Koutsouris 1999; Doppler and Calavtra 2000; Koutsouris and Omodei Zorini 2000; Cristóvão and Omodei Zorini 2003; Cristóvão 2004; Langeveld and Röling 2006; Dedieu and Zasser-Bedoya 2008; Darnhofer and Grötzer 2010).

Timely, because the European IFSA is about to hold its 10th biennial Symposium, and after 20 years of research, it would be good to assess where we are at. Timely, because after 20 years, the first generation of European farming systems researchers, those who brought Farming Systems Research to Europe and initiated further developments, are about to retire. We want to make sure that their insights, their reflections on the evolution of Farming Systems Research and their ‘lessons learned’ could be passed on to the next generation of researchers. Although history often repeats itself, and some lessons can only be learned by actually going through the learning process, building on insights from past experience might enable us to avoid wandering down blind alleys. Timely also, because we strongly feel that the systemic, interdisciplinary and participatory approaches that form the core of Farming Systems Research have much to offer to rural areas in these turbulent and uncertain times.

The focus of the book is decidedly European, as demonstrated by the topics of research, the context of case studies, and also by the authors, which come from 12 European countries. But we do not work in isolation, and these international links are shown by collaborations with authors from the USA, New Zealand and Australia. With this focus on Europe we wanted to clearly demonstrate that Farming Systems Research has definitely outgrown its roots, which were primarily in developing country contexts. Although its roots are clearly there, as well as in Australia, Farming Systems Research has spread to Europe and developed its own flavour here, being an important approach within research on rural areas. Although it can be argued that this kind of research is most strongly rooted in France (especially the INRA-SAD, the department ‘Sciences for Action and Development’ of the National Institute of Agronomic Research, see Bonnemaire et al. 2000) and the Netherlands (esp. Wageningen University), there are clearly strong proponents of the approach all over Europe, as the geographical spread of the authors shows. But despite its European focus, we are convinced that the content of the book is just as relevant for researchers in other contexts. Even if farming in Europe takes place in a specific context (e.g. the predominance of family farms, the Common Agricultural Policy, the recognition of the multifunctional nature of farming), the lessons drawn in the chapters of this book are applicable to many rural areas worldwide.

While our ambition is to present a comprehensive overview of Farming Systems Research, we acknowledge that it is difficult to do justice to the wealth of knowledge

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2 The full-text of most proceedings can be downloaded from: www.ifsa-europe.org
3 For an overview of the very insightful work done at Hawkesbury Agricultural College (now part of the University of Western Sydney), see the six papers included in the special issue of *Systems Research and Behavioral Science* 22(2): 105–164, which was published in 2005.
and insights that have been developed over the last 20 years. However, our aim is to raise the interest of the reader enough to encourage him or her to further explore farming from a systemic viewpoint, understanding research as a participatory co-learning endeavour, rather than just a producer of knowledge.

Structure of the book

The ambition of the book is threefold: to retrace the emergence and development of Farming Systems Research in Europe, to summarise the state of the art for key areas of research, and to provide an outlook on new explorations, especially those tackling the dynamic nature of farming systems. These are the three parts of the book.

Part I includes five chapters that aim to clarify what Farming Systems in Europe is, and how it came about. Chapter 1 discusses the distinguishing characteristics of Farming Systems Research and the epistemological challenges that a farming systems researcher faces. Chapter 2 retraces the origins of the European IFSA and analyses how the topics of the IFSA symposia have changed as a response to emerging research issues. Chapter 3 highlights the ‘lessons learned’ from some early experiences of Farming Systems Research in Africa, and how they may inform current practices. Chapter 4 highlights the diversity of the community. Finally, Chap. 5 reviews some of the methodological themes linked to Farming Systems Research.

Part II summarises the state of the art on a range of issues: the growing importance of the ethical dimension of farming (Chap. 6), what it means to practice systems research (Chap. 7), which learning theories apply in the context of farming systems (Chaps. 8 and 9), how extension systems are conceptualised (Chap. 10), local agri-food systems (Chap. 11), the inclusion of the landscape in Farming Systems Research (Chap. 12), the use of simulation models (Chap. 13), and how the environmental impact of farming is taken into account (Chap. 14).

Part III focuses on approaches that attempt to deepen the understanding of ‘systems’ within Farming Systems Research. These six chapters highlight how it is widening its perspective from a (static) description of how and why a system functions, towards understanding processes. Indeed, farming systems are neither static entities nor stable structures, but are in an ongoing process of becoming, driven by internal dynamics, as well as being involved in a co-evolutionary dance with their natural, economic and social environment. Chapter 15 looks into complexity and draws parallels to the dynamic behaviours of farming systems; Chap. 16 assesses how farmers keep their farms flexible to respond to change; Chap. 17 provides insights from social systems theory; Chap. 18 gives an overview of how farming systems can be designed; Chap. 19 applies the multi-level perspective within transition studies to farming systems; and finally, Chap. 20 summarises the evolution of systems approaches to agricultural innovation.
An invitation to join the community

With this book we would also like to extend an open invitation to join the community of farming systems researchers. As the chapters of this book show, researchers who are engaged in Farming Systems Research tend to come from a broad variety of disciplinary and institutional backgrounds. The core function of the biennial Symposia of the European Group of the IFSA is to further the discussion and exchanges between the different perspectives. The IFSA is characterised by an openness and genuine interest for understanding the rationale of these various research approaches. The IFSA Symposia are designed to be inclusive, i.e. open to all who are researching issues linked to farming at various scales, from various perspectives, methods or disciplinary backgrounds. The underlying conviction is that there is no one approach that is ‘better’ and no one theory that will ‘explain it all’, but that the diversity in the approaches and the dialogue between researchers – and practitioners – is what enables a comprehensive understanding of the observed phenomena and an effective design of participatory processes. This dialogue will help generate novel insights, thus enabling more relevant and useful research results.

Thank You!

We happily take the opportunity to extend a heartfelt “Thank you!” to all who have made this book possible. That is first of all the authors who, despite their busy schedules and heavy workloads, have taken the time to write a chapter to summarise the state of the art and provide avenues for future research. We also thank Simon Kneebone for his delightful and incisive cartoons. They make the people - who are at the centre of farming systems - visible. They also allow us to convey key messages, while also being open to interpretation, thus highlighting the constructed nature of our understanding. We are so very grateful to Elin Gibbon for taking the time to carefully edit the chapters, untangling many a convoluted sentence and allowing the authors’ messages to flow more easily.

We would like to express our gratitude to those who have worked to bring Farming Systems Research to Europe and initiating the European IFSA: Jacques Brossier, Barry Dent, John Farrington, Bernard Hubert, Janice Jiggins, Murray McGregor, Didier Pillot and the late Michel Sebillotte.

We also would like to thank all those who, over the last 20 years, have taken it upon themselves to organise the European IFSA Symposia, thus offering farming systems researchers the opportunity to meet, to discuss, to critique, and above all—to learn from each other.

We hope this book will serve as an inspiration for all those who seek a ‘different’ approach to research, one that takes the role of human subjectivities and perceptions seriously, one that gives voice to farmers, one that emphasises participation and
co-learning processes, one that focuses on interactions between the elements and how they explain the behaviour of the whole, one that allows to capture interdependencies and their dynamics.

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Part I

Farming Systems Research in Europe
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. 1.1). 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 that dominant approaches to agricultural research were poorly equipped to address (Béranger and Vissac 1994; Bonnemaire et al. 2000; Brossier and Hubert 2000; Collinson 2000; Colin and Crawford 2000; Brossier et al. 2012, this book). 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 and Hemptinne 2012, this book).

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’ ‘make sense’ of their practices (Fig. 1.2). 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. 1.2).

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

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1In 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.
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 systems’, 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, this book). 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.

2Whereas this distinction is generally applicable, there are of course exceptions, e.g. Colin and Crawford (2000) use the label ‘agricultural system’ but give farmers a key role. Similarly, Cochet (2012) uses ‘agrarian system’ but highlights the difference in the francophone and the anglo-saxon use of the terminology.
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\(^3\) approach also allows integrating local and farmers’ knowledge with scientific knowledge, thus fuelling reciprocal learning processes.

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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**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

\(^3\)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).
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. 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, this book). 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).

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 (Jansen 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 Marchesnay 2008; Milestad et al. 2012, this book). 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. This leads to a different understanding of farmer’s choices, constraints and goals than the one underlying mathematical models.

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. 15.5). Hard and soft approaches might thus be combined to promote understanding and learning in collective processes.

**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, this book). 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 s/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. 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.

**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. 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, this book). 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 (Russell 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, this book).

Given that most societal changes over the medium to long-term are unpredictable; farmers have to face uncertainty rather than risk\(^4\) (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, this book). 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, this book; Noe and Alrøe 2012, this book).

\(^4\)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).
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 interdisciplin ary

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, this book).

However, many of these approaches, not only those focusing on mathematical models, are examples of multi-disciplinary research, rather than being interdisciplin ary. 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 coefficients 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). Often, scientists from different disciplines approach the project differently, seeing their discipline as the focal point with which the other disciplines should link (see Fig. 3.4).

However, interdisciplinary research requires the mutual integration of organizing concepts, epistemological principles, and methodology (Max-Neef 2005). 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.\(^5\)

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

\(^5\)This is often referred to as the ‘productivist’ model of agricultural development.
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 (see Fig. 9.1), which is based on conceptualising the farmer as a one-sided figure: a techno-economical optimiser.

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. 2008a, b). 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 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, 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

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6This applies also to technological sciences, as has been amply shown by studies on Science, Technology and Society (STS), see e.g. Jasanoff (2002) and Law (2008).
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, this book). 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
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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.

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. 1.3). Rather than proposing a unified framework which should be used by all, farming systems require 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 (see Cristóvão et al. 2012, this book). 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, this book), 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.

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 than attempting to understand the linkages between elements. 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, this book). 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; 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).

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. Within disciplines, there is also a trend towards focusing on ever-smaller component parts (e.g. genetics, nanotechnology, electronics), 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.

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

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7 With the possible exception of France, where the ‘approche globale’ (global approach, see Bonneviale et al. 1989; Brossier and Hubert 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.
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. 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

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8For 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.
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. 1.4) 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.
Refl exivity 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.

Refl exivity 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. 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

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9While 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.
methods to capture these interdependencies is crucial in order to identify both constraints 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.

References


Chapter 2
The origins of the European IFSA: the first meetings and the agenda renewal

Jacques Brossier, Caterina Contini, Luigi Omodei Zorini,
and Artur Cristóvão

Abstract In the mid-1990s the farming systems movement had reached Europe. The European Group is related to the associations founded in the USA, Latin America, Africa and Asia some years before. These were partly designed to support research and development in the Global South. The European Group followed a novel approach in that it applied the systems concept to the highly diverse situations found in European farming. Hence, we recall the objectives of the first meeting held in Edinburgh in 1993, and then assess how research themes have shifted over the past 20 years, by reviewing the programs of the nine symposia held during this period. Looking back, it is clear that European Farming Systems Research has revealed many of the major preoccupations of European farming and the increasing importance of human and sociological factors, in addition to technical and economic issues. This development is most encouraging and indicates that a dynamic learning community exists among European farming systems researchers and extensionists.

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Origins of the European farming systems association

Beginning in the 1980s, symposia of the Association for Farming Systems Research and Extension (AFSRE)\(^1\) were organised in the USA. The AFSRE, officially created in 1987, was founded with American university research teams working in developing countries with colleagues from those countries (MacArthur \(2000\)). The objective was to conduct research into farming systems mainly focused on farm production, and undertaken under the guidance of the Consultative Group of International Agricultural Research centres (CGIAR) (see Gilbert et al. \(1980\)). This research, usually carried out by agronomists and agro-economists, aimed to improve the model for generating and disseminating technical progress in farming, from experimental units through to the farmers themselves, using extension services. The objective was to make both crop and livestock production more effective. The symposia were supported by USAID, the Florida-based Farming Systems Support Project (FSSP) and American funding bodies, such as Ford and Rockefeller Foundations. They mostly drew researchers from American land grant universities and collaborating researchers from developing countries, but relatively few Europeans.

Even if considerable progress was made regarding greater uniformity in the concepts used in Farming Systems Research (FSR), the methods and concepts were nonetheless formulated in the early 1980s (see Brossier \(1987\); FAO \(1994\); Hart \(2000\)). By the mid-1980s the shortcomings of both theory and concept behind the approach were criticized (e.g. Maxwell \(1986\); Bawden \(1996\)), and the approach itself considered too rigid. The Farming Systems Research movement seemed to be running out of scientific steam, and the causes were pinpointed by several participants at the symposia: the attempt to define a sole model for Farming Systems Research using a standard methodology; the lack of concern for epistemology; social groups other than farmers being insufficiently taken into consideration; an almost exclusive focus on farming in developing countries; the overwhelming presence of North American universities and associated research teams in developing countries, leading to difficulties for French-speaking countries and even for Europeans to make themselves heard.

In 1992, a suggestion was made to approach the upcoming symposium in a different way, and to organize it in Europe. Several European research teams were already working on Farming Systems Research in developed countries. There, research increasingly focused on complex development problems, on environmental issues connected with farming; on applied systems modelling concepts, on action research, and on taking an interdisciplinary approach. It should be noted that the new Common Agricultural Policy supported this course of action by encouraging the Europeans to abandon the intensification model (a capital-based process linked to intensive use of chemical inputs, leading to the deterioration of the natural resources base and the marginalization of family farms).

\(^{1}\)At the 15th international Symposium, which was held in Pretoria (South Africa) in 1998, it was decided to change the name of the AFSRE to International Farming Systems Association (IFSA) (see MacArthur \(2000\)).

\(^{2}\)For a global and international perspective, see Collinson \(2000\).
Several European research teams adhered to this nascent farming systems movement: research teams in France, Ireland, the UK, Germany, Benelux, and Scandinavia (see Bingen and Gibbon 2012, this book). It is interesting to note that a number of American research teams had started to consider the situation of American farming from this perspective (Brossier 1993), even though these teams had surprisingly few connections with research undertaken in developing countries and thus with the AFSRE.

In the meantime, Farming Systems Research had made headway in Europe and particularly in France (Bonnemaire et al. 2000). The important role played by French research teams (INRA, CIRAD) is indisputable. Their research focused on action-research, R&D, spatial approaches (agrarian system concept, see Cochet 2012), role of social groups (growing importance of sociology, see for example Olivier de Sardan 2000), and the emerging preoccupation with environmental problems. The shortcomings of research confined to specific disciplines were underlined (hence the systems approach – whether constructivist or holistic).

The Edinburgh and the Montpellier meetings

In 1992, at the 12th AFSRE Symposium which was held at Michigan State University, Didier Pillot (France, GRET) and John Farrington (UK: ODI and Agrinet) offered to organise the next international symposium in Europe. Their offer met with enthusiasm, all the more since the President of AFSRE, Janice Jiggins, was a European. In 1992 the European Group was formed and a European representative was appointed to the AFSRE board. The AFSRE designated 1993 for regional meetings and decided to hold the following global AFSRE symposium in France in 1994 (MacArthur 2000).

The First European Convention on Farming Systems Research/Extension was thus held in Edinburgh in October 1993. It was the first opportunity to organise discussions between teams working on Farming Systems Research in Europe. It brought together about 60 researchers using the systems approach, from 19 different European countries. As reported by Jiggins (1994), the First European Convention marked the first attempt to bring Europeans who had been applying systems approaches to the problems of Third World agriculture together with those applying systems approaches within Europe. Also, this Convention was held just after the “shift in emphasis of the European Union agricultural policy from production to the restriction of surpluses, and increasing emphasis on environmental and social protection” (Dent and McGregor 1994:xvii). Several issues were raised at the Convention:

- The issue of how close the connection should be with the AFSRE. European researchers did not wish to restrict affiliations to ASFRE (considered by some to be too oriented towards developing countries, and too dominated by the Americans).
- It was discussed whether a European farming systems association should be created in addition to the existing disciplinary associations which were beginning to
offer a platform for researchers using the systems approach (e.g. the European Federation of Animal Science (EAAP), the European Association of Agricultural Economists (EAAE), or the European Society for Agronomy (ESA)). It was decided that a separate association (i.e. the IFSA-European Group) would be preferable, as it would offer a space for the debate between disciplinary specialists.

- A core topic of discussion was whether systems research could be considered as a new discipline; and if yes, what were the links with other disciplines (agronomy, economics, livestock research, sociology, geography, etc.)? Today, there is still no clear answer, because the links with disciplines are important, and also due to the specificity of Farming Systems Research (Fig. 2.1).

The Edinburgh Symposium, although it did not attract all the European researchers using Farming Systems Research, demonstrated its importance and its relevance for studying European farming issues. The Edinburgh meeting was considered a success and the papers were published as a book (Dent and McGregor 1994).

A year after the Edinburgh meeting, in November 1994, the 13th AFSRE symposium was held in Montpellier (France). Although this meeting was international, the Europeans dominated it. It was a great success, with over 700 participants, a great number of presentations, many opportunities for new contacts, lively debates and innovative proposals to develop farming systems in Europe (Sebillotte 1994). On the occasion of the 13th international AFSRE symposium, INRA published a
book presenting the wide array of contributions made by the Agrarian Systems and Development (SAD) research department (Brossier et al. 1993).\footnote{The 26 papers demonstrate the breadth of the research done at INRA-SAD. They were grouped under six headings: (i) agriculture and the environment: a tight knit relationship; (ii) social elaboration of quality, industry subsector, agreement between groups; (iii) in support of a systems approach to animal production, concepts, methods, results; (iv) pastoral systems and land use: a topical issue; (v) agronomic theory, management sciences and decision support; and (vi) tools for regional development.}

The discussions at the Edinburgh and the Montpellier Symposia played an important role in the consolidation of Farming Systems Research thinking, and in the creation of a diverse and broad scientific community (Sebillotte 1994). Both Symposia reinforced the understanding that Farming Systems Research represented a particular set of views for agricultural and rural development research and practices, which contrasted with the conventional views of transfer of knowledge and technology or innovation (Röling 1994).

**Francophone and anglophone approaches to FSR**

In French-speaking countries, origins of Farming Systems Research would be the research developed in the 1960s by tropical geographers – emphasizing the study of local territories and forms of organizing production – and neo-Marxist ethnologists, who underlined the importance of analysing power relations and conflicts, the relationships between exchanges and distribution, and the issues of dependency and social redistribution (Pillot 1993:22).

Such work influenced economists, sociologists and agronomists, and was behind the formulation of the approach known as ‘Recherche-développement de systèmes agraires’ (R&D of agrarian systems), which was applied both in tropical and French contexts. Important contributions were made by authors such as Capillon and Sebillotte (1980), Sebillotte (1974, 1978), Brossier and Petit (1977) and Brossier et al. (1993), among many others, all working for the Institut National de la Recherche Agronomique (INRA), especially in the ‘Systèmes Agraires et Développement’ unit (SAD) now called ‘Sciences pour l’Action et le Développement’ (Sciences for action and development).

In the English-speaking world, origins of Farming Systems Research can be found in international research centres such as IRRI, CIMMYT, ICTA, IITA, or ICARDA. In these centres, which played an important role in the so-called Green Revolution, researchers from different countries started questioning the socio-economic impacts of the proposed technologies, as well as their degree of relevance considering the numerous failures, particularly in more sensitive agro-ecological areas (Pillot 1993:24–25). Norman (1980), for instance, mentioned the growing energy costs associated with Green Revolution technologies, and acknowledged that many traditional farm practices were viable (in economic, social and environmental terms)
and should be preserved. Such questioning opened the way for the formulation of the approach known as ‘Farming Systems Research’, to which authors like Ruthenberg (1971), Harwood (1979) or Norman (1980), among others, made significant contributions.

Pillot (1993:25) underlined that in French-speaking countries the importance of human sciences was critical, and the humanist and Marxist influences were very visible. At the same time, in English-speaking countries the influence of neoclassic economics and agronomic sciences was crucial, as well as operational and pragmatic implementation concerns (see also Fresco 1984). Today, it is clear that farming and rural systems research represents a constellation of systemic and interdisciplinary perspectives.

The evolution of the European view of farming systems

Overview of the European symposia

Since the first meeting in Edinburgh, the IFSA European Group has organized Symposia every two years, gathering around 200 people each time (Fig. 2.2). The proceedings have all been published4:


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4Except for the 1993 and 2006 Symposia, the proceedings are available for download at: www.ifsa-europe.org
2012 in Aarhus (Denmark): Producing and reproducing farming systems. New modes of organisation for sustainable food systems of tomorrow.

With the 1993 Edinburgh conference, the debate on values, procedures, methods and challenges of Farming Systems Research moved to Europe. The search for a space where a European perspective of farming systems could be developed found its motivations in the need to interpret rural development in light of the specificities of European agriculture, marked by small farming enterprises and a strong tie with
the culture and history of the territory. The interest in models other than those of large, capital-intensive cultivations characterised by industrial technologies was thus one of the aspects that shaped the European view from the very beginning. In this context, and parallel to the terms of the Common Agricultural Policy, Farming Systems Research in Europe has focused on the identification and development of an alternative to the exclusively production-oriented paradigm, shifting attention from farm profit to the relationship between agriculture, natural, social, and cultural resources and social welfare.

The Edinburgh meeting witnessed the encounter of different experiences gained in Europe, as well as in developing countries which, however, all share several key aspects. In this regard, Gibbon (1994) identifies the main points of contact between applications implemented in different contexts:

- the holistic vision of the social, economic and political complex that characterises rural systems,
- the interdisciplinary nature and flexibility of the approach,
- the attention towards marginality (be it of the areas, interest groups, and type),
- farmers’ involvement in identifying problems, and
- the collaboration between researchers, extensionists and policy makers to define the possible solutions.

Since the Edinburgh conference, Farming Systems Research and extension has developed, with each conference focusing differently on the various aspects that have characterised the European view of the approach since the very beginning. This path has led to an evolution of the themes dealt with, the methods used and the role assumed by rural stakeholders.

**Major changes**

This section will point out the elements of connection and the major changes that have marked the European view of Farming Systems Research over these past 17 years. The analysis is based on the examination of the papers presented in more than 60 workshops organised in the course of the eight conferences held on a regular basis in Europe from October 1993 to July 2010.

The *conceptual and methodological aspects* represent a constant theme discussed at all conferences. However, the modality and the perspective these aspects are treated with change during the course of the various meetings at the conferences of Granada (Doppler and Calatrava 2000) and Hohenheim (Doppler and Koutsouris 1999), concepts and methods constituted the central themes of both conferences. Both of them sought to build a platform for the development of a structured methodology to provide the various experiences and applications with a basis common basis for these different experiences and applications, to underline how research must have rigour of method and a shared identity.
The principal scope of application discussed at these conferences was that of the environment. In particular, the workshops confronted this theme in relation to sustainability (see for example Bellon et al. 1999; Park et al. 1999), the necessity to integrate both the social and technical perspectives in managing resources (see Almeida et al. 2000; Gafsi and Brossier 2000), the relationship between scientific knowledge and local knowledge (see Hess 1999; Mielgo et al. 2000) and between research, extension, political and institutional contexts (see Koutsouris and Papadopoulos 2000; Dono and Locchi 2000).

In the years that followed, attention shifted from analysing the aspects shared by the various methodological applications to exploring diversity no longer perceived as a risk, but instead as a resource to improve the capability to adapt the approach to the issues that have emerged following the transformations of the agricultural and rural world. The beginning of this path can be dated to the Volos conference of 2000, during the course of which, the approach was conceived as a school of thought to promote innovation, be it in the scope of research, or in the frame of technical assistance. Attention towards diversities in view of developing the capability of adapting the methods to the existing phenomena was maintained at the later conferences, where the evolution of methods followed that of the dynamics concerning European agriculture and the rural world as a whole.

**New topics**

Alongside the methodological aspects, other themes also gained ground, some of which became common denominators of the conferences. In addition to the topic of the environment, other topics discussed with continuity include those related to the learning process in research and extension. In this respect the researcher’s role is analysed, the modalities for creating a social space in which the learning process can be facilitated are explored, and tools are developed to enable the stakeholders’ participation in the learning processes (see Röling and Jiggins 2000; Blackmore 2003; Ison 2002; Langeveld and Proost 2004; Noe and Langvad 2006; Magne and Cerf 2008).

The food systems theme made its way into the picture in 2002 at the Florence conference whose principal theme was the quality of productions and of local specificities. The modalities through which quality can be enhanced were analysed in relation to the tie with the natural, historical and cultural resources of the rural territories, and the possibility of offering a basket of goods and services capable of satisfying the broadest spectrum of the needs of society (Becattini and Omodei Zorini 2003). Many case studies discussed the strategies for enhancing quality, ranging from origin certification (Belletti et al. 2003; Ingrand et al. 2003; Tritf and Casabianca 2003) to biological certification (Milestad et al. 2003; Theodoropoulos et al. 2003), to rural tourism (Carvalho 2003; Owaygen 2003; Figueiredo 2003; Pardini et al. 2003). In this context, attention turned to the relationship between rural areas and urban areas, be it in terms of opportunities for the survival of local
identities in the global market, or in terms of possible issues to confront in order to create a relationship between city and countryside, capable of effectively promoting the sustainability of the local system on the economic, cultural and natural levels.

The reading of the papers presented in the course of various conferences point out that attention progressively expanded towards broader and more complex systems, more difficult to delimit and analyse. While in the studies presented during the early conferences, the point of departure of the analysis was the family farm and the relationships it develops with the surrounding environment, in the later conferences, interest converged on the rural environment, including its natural, socio-institutional and economic characteristics. Successively, attention extended to the urban areas, and with the Vila Real conference held in 2004, the system further expanded with the introduction of the discussion on the new social contract between European agriculture and society as a whole.

In this context, the function performed by the farm itself also transformed, from being a food producer to becoming a supplier of services of an environmental, cultural and social nature. There is consequently also an expansion of the range of activities examined, which range from the production of energy, to direct sale, to the offer of services of a recreational, educational or therapeutic type (Knierim and Siebert 2004; Gunnarsdotter 2004; Theodoropoulou 2004).

Another theme always present at conferences is that of the transition, resilience and adaptive management of farming systems to the changes of the policies and lifestyles of society. Central to this theme are the characteristics which on the farm and territory levels permit the farming community to confront the changes. This topic emerged as a specific theme at the Volos conference and was picked up again at the meetings held in Florence and Vila Real, becoming the fundamental theme of the conference held at Wageningen in 2006. The objective of the latter conference was precisely that of contributing to the development of new systems and arrangements that would facilitate adaptation to changes such as the liberalisation of international trade, globalisation, drop in the prices of commodities, reduction of aid to agriculture, the growing demand for quality productions and the growing sensitivity of consumers towards the environment, animal welfare, and climatic aspects (Darnhofer 2006; Macombe 2006; Hermansen et al. 2006; Reidsma and Ewert 2006).

Parallel to these transformations we note an important evolution with respect to the role of the rural stakeholders who move from being the object of analysis in studies that characterised the early phases of Farming Systems Research to becoming interpreters of the existing dynamics and partners of the development process (Brossier and Chia 1994). In this perspective, learning becomes a very central element. It goes beyond the transfer of knowledge, and implies the active participation of the local actors in the activities of testing and adapting innovations (Hubert 2006). The empowerment of the rural actors also became an increasingly important theme, indeed becoming the central topic of the conference held in Clermont-Ferrand in 2008, which aimed at promoting the strategies of the rural stakeholders by strengthening the capabilities to develop new projects. This path which witnessed the growth in importance of the rural stakeholders continued in the most recent conference, held in Vienna in 2010, where we note yet a further expansion of the
role of the rural stakeholders who become an integral part of the approach, along with researchers, extensionists and policy makers.

In the papers presented in Vienna, a view makes its way into the picture, which is no longer interdisciplinary but instead transdisciplinary, in which the rural stakeholders contribute to realising the process of sustainable development with knowledge, experience and work (Milestad et al. 2010; Leitgeb and Vogl 2010; Hunt et al. 2010). In this theme, emphasis shifts onto communication and ‘equality’ between subjects involved in the research (Alrøe and Noe 2010; Binder et al. 2010; Karner and Chioncel 2010). It is also stressed that this is a challenging path, both in terms of time and in terms of difficulty, and that there is a trade-off between methodologies capable of tackling complex problems relevant to the entire society, and simplified methodologies effective in defining concrete solutions (Aenis 2010; Leeuwis and Milgroom 2010). On the other hand, the reflections that emerged in the course of the Vienna meeting pointed out that dynamic and multidimensional approaches, capable of creating a space of understanding where scientists and stakeholders can cooperate, prove to be indispensable today, considering the changes of the rural and global world, and in the demands society advances for the goods and services that agriculture can supply.

Conclusion

While the IFSA is thriving in Europe, there has been much less activity at the international level in the last decade. The 13th international AFSRE symposium (November 1994 in Montpellier) was followed by two further biennial global symposia: the 14th Symposium in Colombo, Sri Lanka (11–16 November 1996), and the 15th Symposium in Pretoria, South Africa (29 November–4 December 1998; during which the name of the Association was changed from AFSRE to IFSA, see MacArthur 2000). There followed three more international Symposia of the IFSA: the 16th in Santiago, Chile (27–29 November 2000), the 17th in Lake Buena Vista, Florida5 (17–20 November 2002), and the 18th in Rome, Italy6 (31 October–4 November 2005). This last Symposium was organised with the FAO and IFAD under the title of ‘Global Learning Opportunity’.

There have not been any international gatherings under the banner of IFSA since 2005. The role of international development agencies and donor bodies in promoting Farming Systems Research during earlier decades has changed. Farming Systems Research no longer plays an explicit role for addressing global questions related to food security and livelihood of people, along with land use and environmental questions. Possibly, this is due to the incorporation of systems approaches

5See the conference website: http://conference.ifas.ufl.edu/ifsa/
6See the conference website: http://www.fao.org/farmingsystems/ifsa_symposium_en.htm. The proceedings have been published by Dixon et al. (2006).
into the endeavours of many agriculture and food related scientific groups. Perhaps the wider adoption – and indeed mainstreaming – of the ideas and experiences brought into national research and advisory systems during the height of the international farming systems movement, may contribute to explaining the decline in visible activity in this area at the global level. How this observation at the global level relates to the persistence of interest and the continuous re-interpretation of Farming Systems Research within the European network of scholars and practitioners is worthy of exploration.

Indeed the European Group of the International Farming Systems Association today presents itself as a point of encounter of various research experiences in the context of rural development, and the appropriate environment to analyse the various forms of organisation of European agriculture with respect to its capacity to adapt to the conditions of change.

The evolution of the research themes pursued by multi-disciplinary teams within the European Group does of course mirror evolutions taking place in society, and underlines the necessity to take human and sociological factors into consideration along with technical and economic issues. This is encouraging for the future of the European Group.

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Chapter 3

Early Farming Systems Research and Extension experience in Africa and possible relevance for FSR in Europe* **

Jim Bingen and David Gibbon

Abstract Early forms of FSR/E, including farm economic analysis, participatory, on-farm trial methods and gender analysis, began with experiences in Africa, Asia and Latin America. These approaches were initially driven by economists and other social scientists who were exploring more efficient ways of developing ‘off-station and on-farm’ research and development that was more relevant to the lives and livelihoods of poorer, small-scale farmers. However, they also addressed the key issues of: building on historical research experiences, developing more appropriate organisational structures, tackling major inter-institutional relationships, and supporting the training of the next generation of systems researchers. Indications from these experiences were that there might have been many relevant lessons generated for European Farming Systems Research and extension systems, and for the continuing education of the next generation of systems researchers. However, major

*We dedicate this chapter to the memory of Jacques Faye (1946–2010), who always put peasant farmers first.
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changes in world and regional food policies, funding streams, trade and power relations has meant that the application of the basic principles and the learning processes have been very different in the European context.

**Introduction and overview**

This chapter identifies and discusses issues and themes from ‘first generation’ Farming Systems Research (FSR) programs in Anglophone and Francophone Africa. This discussion offers an historically-informed perspective on Farming Systems Research that can help contemporary thinking about, and the application of systems principles to, contemporary agricultural research in the North.

Drawing primarily upon experiences in Senegal and in Zambia, this chapter looks at the historical and policy context of Farming Systems Research programs in these countries. We discuss several key institutional and policy issues related to the relationships between these FSR programs and other agricultural research programs and between FSR and extension (or development).

**Senegal.** In 1982, the Senegal Agricultural Research Institute (ISRA: Institut Sénégalais de Recherches Agricoles) launched a 10–15 years re-organization initiative funded by The World Bank, the U.S. Agency for International Development, and CIRAD (International Centre of Agronomic Research for Development) that included the creation and establishment of a Farming Systems Research department (PSR: Production Systems Research and Rural Technology Transfer) and a Bureau of Macro-Economic Analysis (BAME).¹

¹The Senegal Agricultural Research and Planning Project (Contract No. 685-0223-C-00-1064-00), was financed by the U.S. Agency for International Development, Dakar, Senegal. MSU managed the Master’s degree programs for 21 ISRA scientists at 10 US universities in 10 different fields, including agricultural economics, agricultural engineering, soil science, animal science, rural sociology, biometrics and computer science. Ten MSU researchers, on long-term assignment with ISRA’s Department of Production Systems Research (PSR, Département de Recherches sur les Systèmes de Production et le Transfert de Technologies en Milieu Rural) or with the Macro-Economic Analysis Bureau (BAME, Bureau d’Analyses Macro-Economiques) engaged in research in collaboration with ISRA scientists on the distribution of agricultural inputs, cereals marketing, food security, and farm-level production strategies. Resident MSU faculty also advised junior ISRA scientists on research in the areas of animal traction, livestock systems and farmer groups. Additional MSU faculty members from the Department of Agricultural Economics, Sociology, Animal Science and the College of Veterinary Medicine served as short-term consultants and scientific advisors to several ISRA research programs. The project funded several short-term, in-country training programs in Farming Systems Research, farm-level agronomic research, and field-level livestock research. Special training and assistance has also been provided to expand the use of computers (IBM 5120) in agricultural research, to improve English language skills, and to establish a documentation and publications program for PSR Department and BAME researchers.
Zambia. The Research Branch of the Department of Agriculture in the Ministry of Agriculture and Water Development was responsible for most of the agricultural research carried out in Zambia. The Research Branch was organized along disciplinary lines until the late 1970s, when it was reorganized into a two-tier system. The new system included 16 Commodity Research Specialist Teams (CRSTs) which were established on an interdisciplinary basis to conduct on-station research, and a number of Adaptive Research Planning Teams (ARPTs) were established to conduct Farming Systems Research in each of Zambia’s nine provinces (Kean and Singogo 1988).

**Historical overview – policy context**

**Senegal.** The Experiment Station in Bambey, Senegal, established in 1921 to undertake groundnut research in Senegal, gradually expanded its research program and by 1950 became the Federal French West Africa Research Centre with responsibility for more than ten research stations throughout the Soudano-Sahelian zone of Francophone West Africa. After political independence in 1960, the Government of Senegal requested France, through IRAT, The Tropical Agronomic Research Institute, and several other French research institutes (IRHO, IEMVT, CTFT and ORSTOM) to manage the country’s agricultural research programs. Additional research stations were built in each major agricultural region and by the mid-1960s most of Senegal’s research programs, focusing improved groundnut varieties, better soil fertilization practices, the use of animal traction and improved cultivation techniques, were in place.

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2 Zambia is an interesting parallel case. It was supported over a 12-year period (1981–1993) in order to institutionalize FSR and to move research in new directions. Tanzania, Kenya and Ethiopia were also supported with a similar objective. The main donors were: CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo), ODA (Overseas Development Administration, later DFID (Department for International Development)), FAO (Food and Agriculture Organisation of the United Nations), USAID (United States Agency for International Development), SIDA (Swedish International Development Cooperation Agency), NORAD (Norwegian Agency for Development Cooperation), and DGIS (Netherlands Directorate-General for International Cooperation) (A. Sutherland, pers.com.). Training and capacity building were important components of this support.

3 CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement), CTFT (Centre Technique Forestier Tropical), IEVMT (Institut d’Élevage et de Médecine Vétérinaire des Pays Tropicaux), INRA (Institut National de Recherche Agronomique), IRAT (Institut Français de Recherche Scientifique et Technique pour le Développement en Coopération), IRHO (Institut de Recherche pour les Huiles et Oléagineux), ORSTOM (Office de la Recherche Scientifique et Technique d’Outre-Mer).
Several substations, or PAPEMs (Pre-Extension and Multi-local Experiment Stations), were also built during the 1960s in order to adapt research programs to the specific agricultural conditions within Senegal’s principal agro-ecological regions. The PAPEMs brought on-station varietal trials closer to farmers, including demonstrations and visits for extension personnel and farmers. By the late 1960s, concern that research should be carried out under farmers’ conditions led to the creation of the well-known Unités Experimentales (see Benoit-Cattin 1986).

During its 12 years of existence from 1969 to 1980, the Unités program marked a significant phase in the evolution of agricultural research, in Senegal. It helped to gain acceptability for off-station research and it was widely regarded as an intellectual precursor for Farming Systems Research in West Africa. It provided a means for researchers to push their trials and experiments off the station and to farmers’ fields under different, specific agro-ecological conditions. The program also contributed to the integration of socio-economic research into IRAT’s and ISRA’s research programs, and to defining CIRAD’s agrarian systems research activities. The Unités program was not without its critics. Many ISRA and French researchers felt that the Unités did not represent truly scientific research. Extension personnel charged that the program should have been the responsibility of the agricultural extension agencies, and throughout the life of the program a research-extension link was never made.

The policy context in east, central and southern Africa

In most of these countries, early agricultural research systems were strongly influenced by British colonial and post-colonial policies and by the actions of, and support by, some key international agencies (FAO, SIDA, DGIS, CIMMYT, ICRISAT, ILCA and ICRAF). In the 1970s and 1980s, due to the failure of the Green Revolution in Africa, and of the top-down approach to technology generation, there was strong support for smallholder farming. This evolved with an emphasis on improvement of key food commodities through public sector funded agricultural research and the recognition of the complexity of the innovation process among resource-poor farmers (Biggs 1989b). During the 1980s there were major international research programmes that focused on on-farm research (Ewell 1988). In one such programme, research was carried out into nine National Research Systems (three each in the major continents) into client-oriented, participatory research (Biggs 1989a; Merrill-Sands et al. 1991a, b; Waters-Bayer 1989).

In the Agricultural Research Divisions (or Branches) of the relevant Ministries of the nine countries of the Anglophone speaking region, Farming Systems Research

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4ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), ILCA (International Livestock Centre for Africa, now ILRI – International Livestock Research Institute) and ICRAF (International Centre for Research in Agroforestry).
(or FSA – Farming systems Approach – as FAO preferred to call it) was developed initially, either as a separate unit or a system-wide model and within these two divisions, as a centralized or a decentralized model (see Fig. 3.1, Dixon and Anandajayasekeram 2000). The Zambian model was organised as decentralized, separate units within the national research programme. At the International Research Centres, Farming Systems Research was also established from the late 1970s onwards, including ILCA, ICRAF (1978), and ILRAD (1973). Other CGIAR Centres from outside the region had key outreach personnel based at these Centres or with NARS. CIMMYT personnel were responsible for the very early development of adaptive systems research on farms within NARS and this was also adopted by other donor funded programmes.

**International support for Farming Systems Research**

*Senegal.* In 1975, the Government of Senegal nationalized the agricultural research programs that had been managed separately for almost 15 years by French research institutes and created ISRA. Research activities were reorganized into scientific research departments, including a Department of Sociology and Rural Economy, the PSR Department’s predecessor. At this time, ISRA was also mandated to: create five regional agricultural research centres; train Senegalese agricultural scientists; and expand socio-economic and off-station research programs. The first Five-Year (1979–1984) Indicative Research Plan included most of these changes and sought to improve the responsiveness of Senegalese agricultural research to the country’s development problems. The Agricultural Research Project that was designed to help carry out this plan, began in 1982 as a 6-year multilateral project financed by the World Bank, USAID, France, the UN Interim Fund for Science and Technology and
the Government of Senegal. In addition to funding ISRA’s research programs and financing significant construction, the project initiated a dramatic reorganization of ISRA’s scientific and administrative structure. The speed of this infrastructure development and organizational change pushed ISRA into the throes of an institutional crisis that resurfaced many old and unresolved organizational and scientific issues that had lain dormant for almost 30 years.

With specific reference to Farming Systems Research, the project called for the creation of five farming systems teams (each composed of an agronomist, an animal scientist, an economist, and a rural sociologist) at each regional research centre and Bureau of Macro-Economic Analysis (BAME) that was responsible for addressing a range of policy issues, including those directly related to the Farming Systems Research activities. In addition to managing the regional farming systems teams and the BAME, the Farming Systems, or PSR Department, managed several subject-matter, or support-research, activities in agro-climatology, weed control, farm equipment, post-harvest technology, soil fertility and agricultural hydrology. A multidisciplinary, Dakar-based Central Systems Analysis Group of senior Senegalese, French and American researchers was created to provide scientific guidance and support for each PSR team and for the subject-matter researchers.

Finally, the PSR Department/BAME managed a significant program for degree (largely MSc-level) and short-term training for its scientific research staff, the introduction and use of computers (the first generation of personal computers) for the farming systems and policy research, and in establishing the research-extension relationships with rural development agencies. In other words, the PSR/BAME was more than a unit tied to a foreign aid project; its programs and activities were an integral part of ISRA’s institutional structure.

Zambia. In Zambia, the ARPT teams complemented the Commodity Specialist Research Teams (CSRTs) by identifying a significant percentage (60%), of research problem areas. The key reason for the establishment of ARPTs was that in earlier times the technology generation and transfer process failed to address the needs of small farmers who operated in diverse environments. There were four main reasons for this: ineffective research programme formulation, a single crop or commodity approach, the neglect of social and economic factors and insufficient on-farm trials. Farming Systems Research and Extension was meant to address all these deficiencies. The first steps in the process involved using

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5The Macro-Economic Analysis Bureau gradually established its programs starting in 1982 to oversee agricultural policy research on the economics of agricultural production, cereals marketing, agricultural price policy, consumption, international agricultural markets and food security. These programs, based in Dakar, Djibol, Kaolack and St. Louis, were closely coordinated with the activities of each regional PSR Team and focused on: cereals marketing in the Groundnut Basin, the Casamance and the Senegal River Valley; vegetable marketing for Dakar; the economics of agricultural production (for the Lower Casamance, the Southern Sine-Saloum, the Senegal River Valley) and Senegal’s food security situation.

6In reality the PSR Department was able to begin only three production systems programs (Djibol, Kaolack and St-Louis) over a 3 year period, plus a multidisciplinary, sylvo-pastoral research program at the Dahra Centre for Animal Production Research.
CIMMYT to develop a ‘recommendation domain’ approach to guide the on-farm research programme and the ARPT teams (FSSP 1987). Each of the nine provincial teams included one agronomist, an economist, a sociologist, and (where livestock were important in the system) a livestock scientist. Three nutritionalists were incorporated into the central team to address household food security issues in three regions. Most teams also had a Research-Extension Liaison Officer (RELO) established in the Extension Branch. The teams had a central coordinator within a national support team (Ndiyoi and Phiri 1998).

Similar to the situation in Senegal, capacity building was an important part of the international support for public sector for Farming Systems Research in East and Southern Africa. NGOs and other organizations were also involved in both short- and long-term graduate training programmes, both at regional institutions and in many US, UK, Australian and Dutch agricultural research and education institutions. Much of this training was highly dependent on foreign aid (Anandajayasekeram and Stilwell 1998).

*The design and implementation of FSR*

**Design**

*Senegal.* The first Farming Systems Research team was launched under the Agricultural Research Project in the Lower Casamance Region. Drawing largely on Norman et al. (1979), Collinson (1982) and Norman (1988), as well as lessons learned from the *Unités*, the research program was established in two phases: a pre-diagnostic phase, followed by a phase of diagnostic research, experimentation and technology transfer in collaboration with the regional agricultural development and extension agency, PIDAC (Integrated Development Project for the Casamance). Researchers began the first phase by identifying the research area and reviewing previous research and development studies on the Lower Casamance. Exploratory surveys in 35 of the 330 Lower Casamance villages, chosen with assistance from PIDAC field agents, followed bibliographic work and lasted for approximately 3 months during the first year’s dry season. The entire PSR Team

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7The program began in March 1982, but staffing the PSR Team took place over a 2-year period. An expatriate economist and agronomist were joined by a Senegalese economist and a sociologist in 1983. In 1984 a Senegalese animal scientist and an agricultural engineer were added to the team. French and US funding was used to provide regular scientific advisory support for the team from France and from the US.

8A prepared interview guide was used during these surveys to help direct introductory visits with local government authorities and ‘interviews’ with farmers in their fields. Researchers used group and individual discussions in the village meeting place and in some households to improve their understanding of some problems and to raise issues not addressed in the first field visits. Following each village survey, one Team member prepared the village report to be reviewed and jointly completed by the Team.
J. Bingen and D. Gibbon participated in these surveys, with occasional assistance from ISRA plant breeders, entomologists and from soil fertility and commodity specialists.

Consistent with Norman (1988) the team used the results from this first phase to identify three criteria for defining five agricultural zones or ‘recommendation domains’ within the Lower Casamance: (1) the division of labour; (2) the relative proportion of the area in rain-fed crops as opposed to irrigated crops; and (3) the extent of animal traction use. The team also identified priority research questions for more detailed study and determined the technologies to use for experiments and tests in each zone.  

Zambia. Very similar drivers and models were used for the early development and actions of the ARPTs in Zambia and other countries. Much of the early work drew heavily on the work and experience of Michael Collinson and David Norman. The overwhelming driver for this work was the need to develop greater farming participation in the research process, particularly resource poor farmers, to increase the cost effectiveness and client orientation of the research agenda in Farming Systems Research and Extension.

Implementation

Senegal. The second phase of the research program comprised closely related formal surveys and agronomic trials. Formal surveys, done by village-based interviewers using pre-coded questionnaires, verified, refined and quantified information obtained during the exploratory surveys. The surveys include a household demographic census, field and plot identification, a resource inventory, and a survey of cultivation activities from soil preparation through harvest. For this latter survey, labour time was registered at the end of each activity period by type of cultivation practice, by crop and by type of equipment used. These surveys provided a clearer picture of the resources available within households, the agricultural labour calendar and constraints in each zone, the cropping calendar, the farmers’ agricultural practices, and the amount of production and the distribution of various crops.

In 1984, an economic survey and input-output study was added for a sub-sample of 30 representative households. Four sociological research studies also began in early 1984: (1) the social organization and topology of agricultural households; (2) land tenure; (3) migration, including attention to its impact on agrarian systems; and (4) off-farm activities. A combination of survey instruments including participant observation, a structured questionnaire and a genealogical survey was used in these studies. With the arrival of an animal scientist and an agricultural engineer, diagnostic

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9In each delineated zone, two representative villages were chosen for the formal survey sample (from a family concession) census in these ten villages, a random sample of 125 compounds, including 230 households, was drawn for an agro-socioeconomic survey. This sample was reduced to 80 compounds of 150 households in 1985 to concentrate on target group households and to prepare recommendations by zone and by target group.
surveys on livestock production and animal traction were undertaken. In 1985 experiments with oxen-drawn equipment, in animal health and in the use of manure on cereal crops (grazing, composting, etc.) were also completed.

Agronomic trials were run from 1982 through 1984 to examine the following: (1) cropping intensification through fertilizer and herbicide use and different varieties of maize and rice; (2) diversification with different varieties of sorghum, millet, cowpeas, sweet potatoes and manioc; (3) the recuperation of abandoned land through trials on saline soils; and (4) the use of residual moisture through the production of sweet potatoes following the rice harvest in low-lying areas. In addition, two types of ‘systems’ trials were designed to test and propose new cultivation practices in comparison with actual practices. These trials examined: (1) the technical effectiveness of proposed practices in terms of production, labour time and the use of marginal areas and, (2) the adaptability of new practices in terms of seeding and harvesting dates, weed control, fertilization level and the farmers’ limited resource capabilities.

On-station systems trials, different from standard on-station trials only in their underlying logic and objectives, were prepared to address the question of technical effectiveness. Off-station trials, managed directly by farmers with the aid of a field assistant, were exploratory and had few, if any, repetitions. The fertilizer and varietal trials, for example, used two repetitions, but were conducted on fairly large plots (500–1,000 m$^2$). The trial results were assessed in discussions with peasants and through standard statistical analyses. Depending on the evaluation, some trials were modified for management directly by farmers on larger areas, or for continued testing by the Team.

Throughout the first 3 years, the Lower Casamance Team annually revised the overall survey and trials program. The revisions reflected the broadening of the research perspective as new researchers from different disciplines joined the team, as well as an accommodation to each year’s research results. Discussions with the Central Systems Analysis Group and two external consultant missions led to important modifications in the 1985 research program and to proposed changes for 1986. The zonal boundaries were adjusted and a more representative sample of villages from each zone was identified. Plot-level and household surveys were significantly reduced to permit more detailed data analysis and a more specific study of the constraints on the adoption of new, proposed technology. Additional protocols with other ISRA researchers were also prepared to include research on agricultural policy. Finally, the Team enlarged its analytic perspective from the level of the household to the level of producers’ groups and the village land area (*terroir*) (Jouve 1988; Jouve and Mercoiret 1987) (Fig. 3.2).

The Team’s overall research perspective changed as well. The 1982 surveys and studies showed that farmers had rapidly expanded rain-fed crop production in response to 10 years of increasingly uncertain irrigated agricultural production. The timely development of an on-station field for rain-fed crop trials helped to understand this evolution. Furthermore, and in response to farmers’ interest in small, earthen salt-water intrusion dams, the Team shifted its orientation toward irrigated rice. As a result, the Team’s overall research program started to reflect a more
complete analysis of the problems along the topographical sequence from the rain-fed uplands to the inundated rice fields.

Zambia. The first step in the Farming Systems Research approach was diagnosis. The results from early surveys characterized a number of farming systems and crop sequences into which particular interventions were feasible. Early socio-economic surveys in most farming systems in Zambia identified a ‘hunger period’ during the agricultural calendar year from December to February. This led to trials which responded to the needs of farmers in this situation with the introduction of an early maturing maize variety. In addition, Carioca bean varieties were introduced to address the incidences of protein deficiencies found among children who were under five.

The Farming Systems Research also identified the importance of household food security in wetland areas. This problem had not been previously recognized by researchers. It was found that Dambos (wetland depressions) were very important for many families since they provided many needs: water for domestic use, heavier soils for crop production, grazing for livestock, fish and birds. These early studies by ARP Teams also identified the importance of indigenous knowledge and local adaptation, the importance of the application of participatory, qualitative research methods and the use of engaging methods (plays, field days, seminars) in disseminating findings (Ndiyoi and Phiri 1998).
Relationships among researchers

Senegal. Prior to the creation of the Djibéléor Production Systems Program, commodity researchers at the Djibéléor Research Station worked essentially on various aspects of rice production in the Casamance: varietal improvement, physiology, weed and insect control, fertilization, and cultivation practices – including the use of animal and motor-powered equipment. Researchers principally conducted on-station trials and managed a network of controlled trials under farmers’ conditions. Based on their long experience in the region, commodity and subject-matter researchers at Djibébor played an important role in helping the PSR Team design the exploratory surveys. These commodity researchers did not, however, modify their programs in response to problems identified during the exploratory diagnosis. On the contrary, they viewed the systems researchers as competitor or threats to their well-established programs.

Similarly, the PSR Department as a whole met staunch resistance from ‘non-systems’ researchers. Considerable hostility emerged from the animal production and health department, which harboured the unfounded fear of losing control over its off-station research programs and management of the two livestock research centres at Kolda and Dahra. In fact, the climate of opposition and hostility reached such a level that the PSR Department was summoned before a general meeting of ISRA scientists and administrators to present and justify its research approach, its program of work and the calendar for establishing the Team programs. During this meeting, the Department was attacked for not taking existing research results into consideration, for repeating research that had already been done, and for seeking to reorient all research programs and thereby create a ‘super’ research department. Fundamentally, the criticisms were not directed to the systems approach or methods. The Department instead was serving as a lightning rod for the hostility of many researchers toward the World Bank-funded Agricultural Research Project. The PSR Department’s ability to attract new financial and technical support also made it an envious target susceptible to attack.

From the beginning the viewpoint of the PSR Department concerning the relationship between commodity and systems programs was very clear. Instead of capturing other programs, the Department invited commodity researchers in rice, maize, millet, sorghum, sweet potatoes, cowpeas and manioc to assist in the PSR trials without sacrificing their own off-station commodity work. Non-PSR researchers were invited to accompany the systems team during its fieldwork and to discuss their experiences together. They were also encouraged to factor many of the identified constraints or priorities into their on-station work. In addition to linking the Departmental research programs with those of other departments, the PSR Department organized several training workshops between 1984 and 1986 to bring together researchers from different departments and agents from several regional development agencies.

Zambia. Similar tensions and rivalries emerged in Zambia between CSRTs and ARPTs. According to Kean and Singogo (1988) the relationships changed over time. In the early establishment phase (1981–1985), CSRT scientists felt that the programme favoured the ARP Teams with resources. ARPT scientists found that few technologies which had been generated by the CSRT scientists were ready for on-farm trials.
This situation was not helped by senior managers who sometimes failed to understand and support the role of the ARP Teams. In the second phase (1986–1987), the level of interaction between the teams improved with greater mutual respect. The benefits of this were considerable in both directions, as there were critically constructive comments and action from both teams. In this way, both the work of the CSRT and the ARPTs improved in quality and in the learning of team members (Kean 1988; Kean and Singogo 1988).

Research-extension relationships

Senegal. The need for a close relationship between agricultural research and extension programs had been debated in Senegal for over 25 years. At political independence, the promotion of Research-Development was a pillar of the government’s rural development policy for the 1960s. Agricultural researchers were criticized for non-adaptive, ivory tower research while ‘developers’ (agricultural production and extension personnel) were charged for their largely productionist orientation that overlooked farmer problems and interests (Fig. 3.3).

Most recommendations for closing the research-extension gap focused on improving communications and contacts between research and extension personnel. In response, and under the Agricultural Research Project, each Farming Systems Team was to include a researcher/agricultural extension specialist who would fill a joint ISRA-Extension position within each Regional Development Agency. However, ISRA did not have personnel qualified to fill such a position and preferred to assign researchers exclusively to ISRA research programs.

In place of the research/extension specialist position, ISRA proposed joint protocol agreements as the means to institutionalize the research-extension relationship in Senegal’s major agricultural regions. ISRA and SOMIVAC (The Casamance Development Agency) signed such a protocol in 1983. Under this Agreement an ISRA-SOMIVAC Liaison Unit was created as the contact and communication institution between researchers and extension agents. During the first year of discussions under the Unit’s auspices, SOMIVAC agreed to assist the PSR Team in defining agricultural zones for the Lower Casamance and in preparing a joint plan of work for watershed management in the mangrove swamp areas. The Liaison Unit’s performance fell far short of expectations. Managers and planners from SOMIVAC rather than field and technical extension personnel attended the few meetings that were held; and the Unit’s meetings rarely arrived at concrete conclusions or led to specific, coordinated activities. To improve the effectiveness of the Unit, ISRA and SOMIVAC created seven, small subject-matter technical working groups to design specific and joint research-extension activities focusing on priority topics and problems.10

10Training was also an important component of the ISRA-SOMIVAC relationship and SOMIVAC/PIDAC personnel participated in all the Department Workshops.
Under the protocol agreement, the ISRA-SOMIVAC relationship in the Lower Casamance evolved through joint or coordinated research activities and studies, training, and discussions and review of regional rural development policy. SOMIVAC’s acceptance of the agricultural zones delimited by the Djibéléor PSR Team represented an important step toward closing the research-extension gap in the Casamance. The PIDAC (Casamance Integrated Development Project Authority) extension program was modified to include several themes or recommendations for intensified cropping that were proposed by the PSR Team.

Zambia. In Zambia, the history of relationships between research and extension followed similar lines, to those noted above, in the early years (in the 1960s and early 1970s). Initially, the two activities were organized in very different ways, with Agricultural Research being designed to generate technologies and the Extension Branch structured to ‘deliver’ these perceived superior technologies to farmers through the Training and Visit System (a carefully designed and overly rigid system of control and delivery). There were many reasons for the gulf in thinking between the two. One was the difference in education levels of the staff which hindered communication (researchers had degrees and used technical jargon; extensionists were educated to certificate or diploma level). Secondly, extension workers considered that since much research was conducted at research stations it was not relevant to the situation of small-scale farmers. Thirdly, there were few opportunities for effective exchanges on views and debate about priorities. The ‘ivory tower’ mentality prevailed here as well. The creation of the ARPTs offered an opportunity for real progress to be made. However, the level of effective cooperation between extension

Fig. 3.3 The relationship between researchers and extensionists was not always straightforward, not least because their different educational backgrounds and institutional setting lead to different reward systems, resource availability, planning horizons and power relations.
workers and the ARPTs was highly variable between and within Provinces. The appointment of Research-Extension Liaison Officers (RELOs) was meant to help this situation. Results, however, proved to be quite variable, and there were continuing problems with recruitment, high staff turnover and poorly defined areas of responsibility, but the general effect was positive (Kean and Singogo 1988).

**Management issues**

*Senegal.* The PSR Department’s programs were adequately funded, but ISRA was unable to assure timely budget support. Furthermore, the government’s budget commitment to ISRA did not cover the salary costs for Senegalese personnel. Consequently most of the investment and operating costs for agricultural research were covered by outside financing.

During the time of the World Bank Project, ISRA received financial and technical assistance from over 50 separate projects, more than 15 of which directly supported the PSR Department and BAME. Some research programs had as many as five or six different sources of financing. An extremely complex budgeting system, consistent with Senegal’s public accounting procedures was developed to manage the multiple sources of financial support. This created additional difficulties since the public accounting procedures required separate accounts by program, by source of financing and by unit of disbursement. Added to this, each donor agency required ISRA to follow its own, separate accounting system. ISRA was never able to manage the many complex financial and accounting systems, and consequently, there were significant delays in disbursements and the institute found itself plagued by an on-going budget crisis.

ISRA’s dependence upon donor-financed projects made the continuing search for financial support and the maintenance of good relations with multiple donor agencies and consultants an important, time-consuming part of the job of senior ISRA research administrators and scientists. Consequently, it proved extremely difficult to undertake long-term planning with a measure of internal program coherence among the many research activities and multiple sources of financing.

Recruiting and keeping an adequately trained and experienced scientific and technical staff continued to pose a serious problem. At independence Senegal, like most African governments, accorded low priority to agricultural research or to training national research scientists. When ISRA was established in 1975 there were scarcely ten Senegalese researchers in the Institute (or just about one-tenth the current number of national scientists). While training was stated as an important ISRA priority, no ISRA training plan existed. Moreover, instead of gaining valuable research experience, the few, higher trained Senegalese researchers were assigned to administrative positions, thereby leaving many research programs largely in the hands of expatriate scientists.

In 1980, ISRA initiated a massive recruitment and training campaign, whereby 20 of the PSR Department’s 27 Senegalese researchers were hired between 1982
and 1986. Three of these were sent to France for advanced studies (DEA) and eight were sent to the US for MSc-degrees. Consequently, most of the PSR Department and BAME researchers, while highly motivated, were inexperienced. In addition, the few senior and experienced ISRA researchers had little time to give critical scientific guidance to younger researchers. Even with nine French (CIRAD) and five American (MSU) researchers on the Department and BAME staff, several outside consultant missions were required annually to advise on program direction and activities.

**Zambia.** Donor support for the Research Branch and the ARPTs in particular, was complex, with at one time eight different donors involved, with a total amount that reached between 30% and 50% of the total Research Branch recurrent and capital expenditure. The irregular flow of government funds inevitably created difficulties in accounting procedures and in the erratic disbursement of resources. Through many seasons, the amounts dispersed were generally inadequate during the season, followed by the allocation of large amounts of money in December, within a week of the accounts being closed for the year. There were always big delays in the payment of bills and allowances.

The numbers of scientists employed more than doubled between 1977 and 1986 from 69 to 157. Of these, 32 were employed in the ARPTs in 1986. The Research Branch also employed large numbers of technical and support staff, reaching 250 in 1986. Expatriates were very significant members of all research teams with the share of employees falling from 78% in 1977 to 46% in 1986. The record in recruiting women was poor with the number rising from 7 in 1977 to 17 in 1986, which remained a constant 9% over the period.

The University of Zambia was initially the only source of professional staff, but these were very few, with only 33 graduating in 1986. Initially, most of the academically gifted graduates joined private or parastatal companies, because of greatly superior conditions to those in the civil service. Several senior research branch managers were involved in very active recruiting drives at the University after 1983. There were also good links for pre-graduating students to carry out research projects with the research Branch and ARPTs.

Most scientists considered that short and longer term training opportunities were important incentives to join, but promotion was not too attractive as there were relatively few senior positions in the service. Most donors supporting research teams have allocated funding to send Zambia staff for further training – technical staff for BScs and scientific staff for MScs and PhDs. Short courses were also offered, mainly at the International Agricultural Centres (Kean and Singogo 1988).

**Summary of issues**

**Senegal.** ISRA may have been overly ambitious in creating a separate PSR Department with the same administrative and scientific standing as the other, older research departments. Because this new Department began with the mandate to identify
research problems and evaluate technical solutions at the farm level, it immediately upset the Institute’s organizational and scientific structure. Non-PSR researchers rejected the legitimacy of the Department’s role in programming and evaluation, believing it represented a threat to their autonomy, and some even felt that the Department wanted to control all of ISRA’s agricultural research programs.

The creation of a new PSR Department accentuated ISRA’s budgetary stress. The projects that financed the creation of the PSR Department/BAME channelled additional resources into ISRA, but experience revealed that these resources could overwhelm the Institute in the absence of a rigorous selection and definition of its research priorities. The animosities generated by the creation of the PSR Department, often detracted from dealing with critical administrative and policy issues.

A major lesson to be drawn from the ISRA experience was that the Agricultural Research Project significantly overestimated ISRA’s capacity to undertake the changes required during the short life of the project. The Department’s senior researchers could not adequately advise and guide the many new researchers and technicians whose mission was to launch the three PSR Teams. Expatriate technical assistants were helpful, but they were no substitute for national researchers and technicians during the long, tedious and intense on-the-ground training period required to develop a good research scientist.

It is also clear in retrospect, that training should not have been limited to systems research disciplines, but should have included commodity researchers. The vogue of PSR often overlooked that systems researchers do not create new technology. It is created by scientists carrying out commodity research in the areas of soil fertility, plant breeding, and agricultural equipment, among others. Thus, a central question arising from this experience was not how to introduce a production systems approach or department into a research structure, but how to get the research institution as a whole to evolve toward an approach that is sensitive to farmers’ problems.

The ISRA PSR experience did not generate any innovations in PSR methodology. This experience added little to the available literature on production systems research. The ISRA case, however, does permit reflection on the adequacy of PSR, as commonly conceived, to deal with the complex problems of agricultural development in Senegal and throughout Sub-Saharan Africa.

The PSR program was oriented almost exclusively to farm-level production systems. Given the problems of environmental degradation and the loss of physical resources that have occurred in Sahelian Africa, issues such as erosion, deforestation, and drought, merit critical and analytic inquiry without sacrificing a concern with farm-level problems. Furthermore, these agricultural and environmental issues cannot be thoroughly understood without including an analysis of the structure and influence of the village community, producer and cooperative associations. The rapid withdrawal of Senegalese governmental agencies from agricultural development, credit, input supply and extension programs in favour of ‘local self-reliance’ suggests that PSR programs could give more attention to the role of local organizations in agricultural development.

 Zambia. The Zambian system also suffered from many organizational and problems of implementation following the introduction of Farming Systems Research and Extension.
The system also had some high operational costs due to transport and the payment of daily subsistence allowances (DSAs). Under the later economic climate (Structural Adjustment Programmes imposed by the World Bank) such support was inevitably not sustainable without generous donor support. Staff turnover was very high, particularly of social scientists, and there continued to be a major issue of capacity and capability under conditions of falling budgets and lack of suitably qualified staff. A great deal of effort was focused on the survival of the ARPTs while other stakeholders in rural development were given less education and training in the principles of Farming Systems Research and Extension. In retrospect this appeared to be an error.

Despite these difficult issues, the development of Farming Systems Research within the research system had a significant impact, both on the structure and on the operation of the service. The acknowledgement that farmers have to be part of the whole process of technology generation and development has now been widely accepted within, and throughout, research.

The future evolution of Farming Systems Research and Extension thinking may emerge from the development of professional associations like the Farming Systems Association of Zambia (FASAZ) which has been involved in working with NGOs and newly donor funded projects. As travel costs from central locations remain a major issue, it might be appropriate for research staff to be devolved to districts together with extension staff (Ndiyoi and Phiri 1998).

**Concluding observations**

The history of off-station and on-farm research with the *Unités* helped to create a measure of acceptance for this type of research among crop and animal scientists. The significant investment in long-term training and in long-term French and US senior technical assistance however, made the PSR Department and BAME appear as financially and scientifically privileged units within the Institute. This created significant and enduring bureaucratic jealousies that ultimately undermined the farming systems and macro-economic analysis programs. Added to this, managing the amount and schedule of World Bank investments overwhelmed ISRA’s management capacity.

Similar tensions emerged within Zambia’s Research and Extension system as most of the adaptive research teamwork was well-funded in the early years. This was at a time when the country was undergoing a recession due to the fall in the copper price. In some cases there was rivalry between provincial teams when they were supported by different donors. This changed in the longer term as donors ended their commitments and staff numbers declined.

Regular discussions with the ISRA Central Systems Analysis Group and with invited external advisors were critical to the intellectual development of the farming systems program. Critical reviews of the Zambian programmes came from internal monitoring and external evaluation of projects and programmes
J. Bingen and D. Gibbon

(as demanded by all donors). This had an important cultural change as constructive criticism became accepted as part of the norm rather than something that was carried out only rarely by external evaluators.

Extension agents and those working directly with peasant-farmers were only marginally involved in the Liaison Unit in Senegal, and an effective means to include farmers’ representatives (from producers’ groups, cooperatives or village organizations) in the Liaison Unit was never created. This Liaison Unit thus never made a significant contribution to agricultural development by calling the attention of policy makers to the important accomplishments and effectiveness of programs designed on the basis of farmer-defined problems.

Very similar observations can be made about the lack of effectiveness of communication linkages between the key stakeholders and actors in the Zambia system, despite the creation of specific posts that were intended to make these processes more efficient (RELOs). Ndiyoi and Phiri (1998) also draw attention to the lack of clearly defined performance indicators for staff and the inability to appreciate the rapidly changing farm environment in a dynamic way. This reduced the efficiency and effectiveness of many field teams.

Potential and actual lessons for FSR/E in Europe

In reviewing this substantial body of experience and learning, the question arose as to whether any of this experience might have been usefully transferred or adapted into the European (or any other developed country) context. It was considered by many, in the initial establishment of the European IFSA in the early 1990s, that developed country agricultural research and extension systems were very different, had different histories and were primarily designed to serve modern, commercially driven farming systems and commodity production systems. It seemed likely that there would be little benefit of any transfers from these experiences.

Of the European countries, France was exceptional in that it had developed close links between overseas R&D systems and those in France and had created INRA-SAD within the national system (Brossier and Hubert 2000; Brossier et al. 2012, this book). Many other countries in Europe (notably the UK, Netherlands, Sweden, Norway, Denmark) also had linkages with research and extension through aid programmes to NARS or within special projects, or they made direct support to the International CGIAR system. In most cases there was little connection between these activities and the national agricultural research systems in Europe. However, in the Netherlands there has been a strong link of activities and people who worked on systems research both in countries of the South and in Europe. There are many Dutch researchers who have used farming systems case studies from Africa, Asia, Latin America and the Netherlands to illustrate their understanding of learning processes and to demonstrate findings and principles that have universal relevance to the development of knowledge (see for example Röling and Wagemakers 1998; van der Ploeg 2008).
National agricultural research systems

In the UK there has been little influence of this experience on the structure, organization or management of publically funded agricultural research systems. Through the 1980s, 1990s and more recently there has been a major reduction in funding for public sector agricultural scientific research. The 32 institutions of the old Agricultural Research Council were reduced to eight (and this process continues) and many applied research centres run by the Ministry of Agriculture (known as experimental husbandry farms) were closed. A major restructuring of the scientific research institutions has been taking place for many years. The new policy has been to support ‘blue sky’ i.e. basic research in the public sector, and leave applied research to the private sector. In practice, the private companies have funded increasingly narrowly focused, disciplinary scientific research, including gene mapping and the search for new, genetically modified organisms. Applied research continues with groups of farmers, within the organic movement and in some private organizations. The extension system has been privatized so that farmers now have to pay for advice or work in small learning groups.

These trends have continued in the recent past and this has made a number of senior researchers and academics call for a new vision for research which incorporates some of the elements and values that have been lost (Leaver 2009). Leaver, in presenting evidence to a House of Commons All Party Group on Agricultural Science and Technology claimed that the drastic reduction in public funding for applied research and development has seriously disadvantaged the UK in its ability to conduct relevant research and development for the current agricultural industry. However, even this discussion is still within the conventional productivist paradigm at a time when there are big differences of opinion on the current control of food and farming systems and the research systems that might be needed to support them (see McIntyre et al. 2009).

The key elements within Farming Systems Research – of interdisciplinarity (see Fig. 3.4), farmer or stakeholder participation and systems thinking and practice – do appear, sometimes in new guises or terminology and sometimes in non-agricultural research institutions. For example, in a new, collaborative research initiative between the main UK academic research funding bodies, the Rural Economy and Land Use Programme has been formed: “The Rural Economy and Land Use Programme enables researchers to work together to investigate the social, economic, environmental and technological challenges faced by rural areas. The Programme will encourage social and economic vitality of rural areas and promote the protection and conservation of the rural environment.”11 The Programme is an unprecedented collaboration between the Economic and Social Research Council (ESRC), the Biotechnology and Biological Sciences Research Council (BBSRC) and the Natural Environment Research Council (NERC). This programme has enabled multi-institution collaborations to take place in order to

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11See RELU website: http://www.esrc.ac.uk/about-esrc/what-we-do/our-research/RELU.aspx
try to develop interdisciplinary research, sometimes with a systems perspective and sometimes involving stakeholder participation using participatory methods (Lyon et al. 2005).

Over the course of the last few IFSA meetings, many groups of researchers have expanded the boundaries and evolved the basic elements of Farming Systems Research and Extension to embrace a multifunctional concept of farming and rural livelihoods with expanding and varying boundaries and a multi-stakeholder learning environment.

Europe-wide research collaborations between institutions are now common and have been made possible through EU-Funding. Some have focused on the analysis and development of landscapes and water catchments, and one example is the SLIM project (Social Learning for the Integrated Management and sustainable use of water at catchment scale, see Ison et al. 2004). This was a multi-country research project funded by the European Commission. Its main theme was the investigation of the socio-economic aspects of the sustainable use of water. Within this theme, its main focus of interest lay in understanding the application of social learning as a conceptual framework, an operational principle, a policy instrument and a process of systemic change. This project involved several scientists who had previous experience in systems projects in Africa and elsewhere. It incorporated many of the
principles that have been learned through systems thinking and application and from this collaboration the European LEARN group emerged (see Blackmore et al. 2012, this book).

There have been a number of examples of farmer-participatory research developing within the organic movement (Davies 2006; Jones et al. 2006), and a number of researchers continue to look at interdisciplinary research on sustainable farming systems (Harris et al. 2009). However, there is little continuing support for this research through the UK Department for Environment, Food and Rural Affairs.

Higher education training in Farming Systems Research in Europe

There have been linkages of Higher Education institutions in Europe with other institutions in Africa for many years through graduate students and staff who operated and gained much experience in both spheres and from the support for postgraduate training. From the 1970s onwards there were many researchers who had both experience in Africa and in Northern research systems. These institutions continued to host young researchers from both African and European countries who carried out farming systems, and research on livelihoods and natural resource management which was based on systems and participatory principles. Undergraduate and graduate programmes in some institutions continued to contain a strong systems core and case studies from Africa and other Southern country regions, were used in teaching and training. However, it is probable that any lasting impact of systems principles has been carried only in a few principal institutions (the Open University, Lancaster, East Anglia, Hull, Bristol).

Graduates who emerge from many agricultural institutions today frequently have not had exposure to many of the basic principles of interdisciplinary systems thinking and participatory methods, and few have undertaken an extended period of experiential learning in the same way that the previous generation was encouraged (or obliged) to do so.

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Chapter 4
Textual analysis and scientometric mapping of the dynamic knowledge in and around the IFSA community

Marc Barbier, Marianne Bompart, Véronique Garandel-Batifol, and Andréi Mogoutov

Abstract Using the proceedings of six European IFSA Symposia, we analysed the themes that were central in these Symposia as well as trends from a number of papers and authors. We then assessed the wider domain of agricultural research based on a corpus extracted from the CAB and SCI databases of the Web of Knowledge. The co-word analysis allows the generation of maps which graphically represent how keywords are linked, and allows the identification of thematic clusters. The dynamic of keywords in the period 1991–2007 was also analysed, thus allowing the identification of keywords which were of central importance during different periods. This showed how themes such as sustainability emerged, disappeared and re-emerged under different guises. The various analyses are provided to further the reflexivity of the IFSA community, especially regarding its publication practices and thus its efforts to make results from Farming Systems Research more widely available.

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**Introduction**

Mining a textual corpus and analysing the co-occurrence of terms allows an overview of the knowledge used by a scientific community. The notions of ‘knowledge’ and ‘concept’ are – in this context – constructed, based on the interpretation of associations of various terms, as they are provided by the authors of scientific publications. The terms selected may include authors, keywords, journal, or institutional affiliation. The terms are analysed within a previously constituted corpus, i.e. a set of papers stemming from conference proceedings or a set of papers published in journals.

This type of analysis is currently used as a research approach, and to evaluate research. It provides an overview of concepts and knowledge that characterise a particular community, by identifying relationships between terms. This relationship might be ‘homogeneous’ when the types of terms used are similar (e.g. keyword vs. keyword); or the relationship might be ‘heterogeneous’ if the types of terms used are different (e.g. keyword vs. author).

Such an analysis might be realised without the involvement of the members of the community under study, but it can also be designed and fine-tuned based on constructive and critical exchanges with selected members of the scientific community under study. This second approach has been chosen for the analysis of terms used within the European IFSA community. The purpose of this analysis was to highlight the key terms that characterise the conceptual domain of the European IFSA, so as to feed into current debates. For example, analysing the frequency and relationship of key terms related to Farming Systems Research might contribute to the positioning of the IFSA community within the debate around the greening of agriculture or around the potential of biotechnology to address future food needs (Vanloqueren and Baret 2009; Barbier 2010).

Two methodological approaches have been combined in this analysis. On one hand we have performed a classical textual analysis of the corpus of papers included in the proceedings of six European IFSA Symposia. The abstracts of the papers included in the proceedings were fed into a database. Then, the terms included in the abstracts were analysed using an upstream hierarchical clustering approach (Reinert 1990). Also, a set of two databases was built using abstracts and keywords extracted from the Web of Knowledge (WoK): one being extracted from the Science Citation Index (SCI), the other being extracted from CAB Abstracts (CAB). The texts in this second database were analysed using co-word analysis. The goal of this second analysis was to describe how terms that can be associated with farming systems are used in the scientific literature outside of IFSA.

This chapter starts with a quick overview of some principles of co-word analysis. We then describe our methodological framework and some technical steps that were taken to design the ‘machinery’ we used to process the two text corpuses. We then present the main results, which allow retracing the evolution through six European IFSA Symposia, and highlighting the differences between the proceedings and the results from the WoK. In conclusion, we propose an interpretative view of the dynamic of knowledge in and around the IFSA community.
Textual analysis of scientific corpuses

Co-word analysis is a branch of network analysis. It is largely grounded in the Sciences Studies movement, in close relation to the emergence of Actor-Network-Theory (ANT) (Callon et al. 1983). Co-word analysis has been proposed as a method to represent associations between terms, integrating both qualitative and quantitative aspects. The specific algorithms allow the mapping of homogeneous or heterogeneous association of terms, based on the frequency of their co-occurrence within a corpus of texts. Its close relation to the rise of evaluation and policy of science (Callon et al. 1986; Law et al. 1988), should not hide the fact that co-word analysis is a further development of earlier work on co-citation (Small 1973). This earlier work was largely grounded in a Mertorrian sociology of science, paying attention to authoritative positions of authors in disciplines and to the measurement of normative reward through citations. However, co-word analysis is not reduced to the analysis of references, as is the case of the citation frequency which feeds into the impact factor of journals, since all types of terms can be analysed.

Co-word analysis maps various types of associations between terms that ontologically represent the textual strategizing of authors. Indeed, the association of terms is indicative of how authors assemble entities, how they set-up their own repertoire of meaningful terms and expressions (Latour and Fabbri 1997). Co-word analysis is a non-intrusive method since it respects the contents of texts. It identifies associations between terms, and represents these associations as maps, which can then be interpreted by the analyst.

Given the proliferation of electronic databases which allow for data mining, co-word analysis is being used to trace and to map knowledge, and has thus contributed to the development of scientometrics and the evaluation of research. Through the development of network algorithms new insights can be generated, e.g. by describing socio-semantic evolution within one database (Chavalarias and Cointet 2008; Roth and Cointet 2010). Tracing the evolution of a scientific network through time has allowed overcoming the simple characterization of collaborations or of disciplinary knowledge at one point in time (Powell et al. 2005). Recent studies have explored the emergence of multi- or trans-disciplinary fields of research (Lucio-Arias and Leydesdorff 2007; Mogoutov and Kahane 2007), of translational research (Jones et al. 2011), of emerging paradigmatic fields of research (Granjou and Barbier 2010), or of technological promises (Tari et al. 2010). Mapping networks within one specific area of research can help to understand the social dynamic of research activities (Cambrosio et al. 2004, 2006; Bourret et al. 2006). Taramasco et al. 2010

Co-word analysis, despite its recognized strengths, has received criticism in relation to the significance of the relationships of words and the context in which they are used (see e.g. Leydesdorff and Hellsten 2006). However, in the present analysis, we have avoided an evaluative perspective. The aim is not to draw conclusions based on the maps, but to foster reflexion within the IFSA community. Indeed, the aim is to contribute to a more reflexive dynamic of knowledge production within the domain of Farming Systems Research. Co-word analysis was thus used as a tool to
interact with members representing the IFSA community, thus realizing a kind of participatory sociology of scientific knowledge (Fig. 4.1).

This attitude toward using co-word maps in interaction with a scientific community is similar to shifting the use of a tool from a scientific context to a science policy context (Noyons 2001). The development of Knowledge Engineering of Information Extraction in the field of ontology detection (Uschold and Gruninger 1996; Ding and Foo 2002; Sarawagi 2008) also relies on this type relationships with so-called ‘experts of the domain that is under study’.

**Building the databases**

This study is the result of a collaborative work, which included representatives of the IFSA community in a bottom-up process to establish both the objectives of the analyses, and to make choices at various steps, e.g. the selection of terms and assessing preliminary results.

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*Fig. 4.1* Analysing the textual corpus built on the proceedings of the IFSA symposia enabled us to show which terms were used most frequently and how these terms have evolved over a time span of 12 years. By closely involving members of the IFSA community in the analysis, and by presenting the results at the IFSA Symposium 2008, it enabled members within the IFSA community to reflect: IFSA *quo vadis?*
A first database was built to include all papers that had been published in the proceedings of IFSA Symposia from 1996 to 2006. These had to be retrieved from various sources, and fed into a database (hereafter called the IFSA Database). The content of this IFSA Database was analysed to characterize the dynamic of the IFSA community, as well as core themes within the Symposia.

Two additional databases were then built by retrieving bibliographic notices (i.e. for each paper: its authors, title, abstract, and keywords) one from the CAB database and the other one from the SCI Database. The CAB database was selected because it is dedicated to journals, proceedings and reports that are specific to agricultural science and related disciplines. The SCI database is not specific to agriculture, but comprises the journals with an impact factor as compiled by Thompson ISI. To enable a comparison with the corpus included in the IFSA Database, the queries were limited to papers and reports published between 1991 and 2007 (some references of 2008 were included since the extraction was made in 2008, but this do not affect interpretation and results). Corpuses extracted from the SCI database and the one extracted from the CAB database were analysed separately.

The definition of the query that was used to retrieve the bibliographic notices has been a particularly long and difficult process. It relied on three ways to select terms, which have been pooled: (1) a systematic selection of terms according to a measure of the specificity of keywords; (2) a terminological extraction based on the title, keywords, abstract of the IFSA proceedings; and finally (3) the views of IFSA experts on a preliminary list of terms to select those that are most related to Farming Systems Research.

The overall purpose was to create a pool of data that could be used for co-word and content analysis. Two methodological approaches were thus combined: (1) construction, data mining and information extraction of the IFSA Database; and (2) information retrieval and co-word analysis of the two WoK Databases (CAB and SCI). The purpose was to foster debates about the positioning of the IFSA community, not to benchmark the IFSA community against the work published in journals listed in the Web of Science. Indeed, it was rapidly apparent that the authors of the papers included in the proceedings of the IFSA symposia were distinct from those included in the WoK Databases.

**Technical constitution of the IFSA database**

The first task was to build a database with the papers included in the proceedings of the IFSA Symposia (Table 4.1). We collected the entire text of all papers, standardized them according to a common structure, and tagged them, to allow the non-ambiguous recognition of terms for pre-defined fields. Thus each of the 325 papers was processed so as to fill the 15 bibliometric fields of the Microsoft Excel database (e.g. author, year, affiliation, keywords, thematic session). The affiliations of the authors were processed,
so as to be able to identify the institutions of the members of the community. This preliminary work allowed a lexical indexing with a tool called Beluga (Turenne and Barbier 2004) and the frequency analysis of bibliometric fields.

Going through the proceedings to process each paper and include it into the IFSA Database revealed a strong heterogeneity in the structure and formatting of the papers, both within a symposium and between the symposia. For example, most papers included references, which could have been included in the database and analysed e.g. for the number of times that papers of previous symposia were cited. However, given that the formatting of the references was so diverse, it was decided that re-building a common bibliographic structure would be too time-consuming. This choice was reinforced by the fact that the limited number of papers in the proceedings, and the relatively high number of references made it likely that the insights that could be derived from the analysis would be limited.

A second ‘surprise’ was the low level of standardization of the inner structure of IFSA papers (Fig. 4.2). For example, not all papers had an abstract (e.g. in the proceedings of the symposium held in 2000, 20% of the papers did not have an abstract). Interestingly, few keywords were repeated from a symposium to another. Generally it seems that there were big efforts to standardize the structure of the papers in 1996, 1998 as the proceedings were published in book format. Where the proceedings were not formally published as a book (e.g. in 2004 and 2006) the structure of the paper is more heterogeneous. Of course, these layout issues do not allow any indication about the content of the papers or about their scientific quality.

**Table 4.1** List of the six European IFSA symposia whose proceedings were used to feed the IFSA Database

<table>
<thead>
<tr>
<th>Year</th>
<th>Place</th>
<th>Theme of the European IFSA symposium</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Grenada</td>
<td>Technical and social systems approaches for sustainable rural development</td>
</tr>
<tr>
<td>1998</td>
<td>Hohenheim</td>
<td>Rural and farming systems analyses environmental perspectives</td>
</tr>
<tr>
<td>2000</td>
<td>Volos</td>
<td>European farming and rural systems research and extension into the next millennium. Environmental, agricultural, and socio economic issues</td>
</tr>
<tr>
<td>2002</td>
<td>Florence</td>
<td>Farming and rural systems research and extension local identities and globalisation</td>
</tr>
<tr>
<td>2004</td>
<td>Vila Réal</td>
<td>European farming and society in search of a new social contract. Learning to manage change</td>
</tr>
<tr>
<td>2006</td>
<td>Wageningen</td>
<td>Changing European farming systems for a better future</td>
</tr>
</tbody>
</table>

**Mapping of the scientific context of IFSA**

While the first part of the study focuses on analysing the proceedings of the IFSA Symposia, the second part of the study focuses on analysing how terms related to farming systems are used in international scientific journals and other publications. For this part of the study, two corpuses would be built based on abstracts extracted from the CAB database and the SCI database (Fig. 4.3).
Textual analysis and scientometric mapping

Fig. 4.2 Untangling the over 300 papers published in the IFSA proceedings turned out to be challenging, as they were not strongly standardized in the type of information and in the formatting of e.g. references. Building a database that would allow analysing the structure of terms used by the IFSA community thus demanded considerable patience and attention to detail.

Fig. 4.3 Schematic representation of the steps involved in building the database of bibliographic notices extracted from the Web of knowledge. The terms used for the query were selected in collaboration with IFSA experts. This collaboration, as well as the terms extracted from the analysis of the IFSA Database allowed to widen the terms and yield an extended corpus of bibliographic notices.
This part of the study was done in close collaboration with members of the IFSA community, so as to select the terms that seemed most relevant to this community. This collaboration allowed to “delineate” (see Zitt and Bassecoulard 2005) a set of terms that would be used for the queries within the CAB and SCI databases. The participatory process allowed reducing the asymmetry of knowledge between the analysts and the members of the IFSA community, thus enabling an interpretation of the results within the context of Farming Systems Research. The process was iterative: An initial query within the CAB and SCI databases led to the constitution of two initial corpuses of bibliographic notices (CAB corpus and SCI corpus). These initial corpuses were pre-analysed, and the results discussed with IFSA experts. The list of terms was then enriched with additional terms (e.g., those extracted from the IFSA Database) and a second query made, which yield the extended corpuses. These final corpuses were then analysed using ReseauLu.

For the initial query, we used terms related to systemic approaches dealing with agriculture, livestock and agroforestry (Table 4.2). Discussions with IFSA experts allowed identifying additional 58 terms that could also be included. The analysis of the IFSA Database using Beluga yielded an additional list of 23 terms and expressions. The specificity of each term was then established by comparing its occurrence in either the entire CAB or the SCI corpus. The result of the specificity measurement was then discussed with IFSA experts. As a result the terms used for the second

<table>
<thead>
<tr>
<th>Query</th>
<th>Terms used for the query</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial query 1</td>
<td>TS = (“agroforestry systems” OR “agroforestry system”) OR TS = (“agrosilvicultural systems” OR “agrosilvicultural system”) OR TS = (“Farming Systems Research” OR TS = “farming system research”) OR TS = (“grazing systems” OR “grazing system”) OR TS = (“farming systems” OR “farming system”) OR TS = (“cropping systems” OR “cropping system”) OR TS = (“agricultural systems” OR “agricultural system”)</td>
</tr>
<tr>
<td>Query 2</td>
<td>TS = (“farming systems” OR “farming system”) OR TS = (“cropping systems” OR “cropping system”) OR TS = (“agricultural systems” OR “agricultural system”) OR TS = (“agricultural knowledge”) OR TS = (“farmers participation”) OR TS = (“natural resource management”) OR TS = (“nature conservation”) OR TS = (small scale farm* OR smallholder farm* OR family farm*) OR TS = (“livestock systems” OR “livestock system”) OR TS = (“organic agriculture”) OR TS = (“livestock farming systems”) OR TS = (“rural system” OR “rural systems”) OR TS = (“agrarian system” OR “agrarian systems”) OR TS = (“local food” OR “local foods”) OR TS = (“pluriactivity” OR “pluriactivities”) OR TS = (“social learning” OR “social learnings”) OR TS = (“Farm management”) OR TS = (“livelihood” or “livelihoods” or “system approach” or “systems approach” or “household” or “households” or “R&amp;D” or “research development” or “extensions systems” or “extension system”) AND TS = (agricult* farm or farming or rural)</td>
</tr>
</tbody>
</table>

For the final query the list of terms used was extend. The second query yielded 71,265 bibliographic notices from the CAB database; and 21,887 bibliographic notices from the SCI database.
query were defined (Table 4.2). This systematic process was time consuming, but has advantages over a single researcher defining the terms used for the query.

The final query yielded the two extended corpuses of bibliographic notices. This final query yielded 30% more notices, either from the CAB or the SCI database. This extension is rather large and might imply that there is significant ‘noise’ in the extended corpus. However, it was decided that it would be preferable to cope with ‘noise’ rather than to risk missing important bibliographic notices. Through co-word analysis, co-occurrences would be analysed, using thresholds to avoid disturbances. Also, the impacts of significant noisy terms can be interpreted as an issue of domain definition. This approach is based on similar studies of scientific field of nanotechnology (Mogoutov and Kahane 2007) and of sustainable development (Barbier et al. 2008).

**A description of the IFSA community**

Characterising the IFSA community through the analysis of the proceedings of the six symposia held between 1996 and 2006, starts with some descriptive statistics. The number of authors contributing to the proceedings has strongly increased in 2002, which was held in Florence (Fig. 4.4).

With the number of authors, the number of institutions represented also increased (Fig. 4.5). Comparing the authors included in the IFSA Database and those included in the SCI Corpus shows that 5% of authors in the SCI Database also contribute to the IFSA proceedings. Significantly, these authors are involved in 36% of all papers included in the IFSA proceedings between 1996 and 2006, and indication that they may be the more senior researchers.

![Graph showing the number of authors and papers over time](image)

**Fig. 4.4** Both the number of authors and the number of papers doubled from the 2000 symposium (held in Volos) to the 2002 symposium, which was held in Florence
It is also interesting to look at the number of authors per paper included in the proceedings (Fig. 4.6). Some 38% of papers are sole-authored, with only a small share of papers having four or more authors.

The analysis of the database reveals that a large number of participants attended only one or two symposia (around 80% of authors contributed only once). This may be due to the fact that these participants are in the early stage of their career, e.g. doctoral students, who might not stay in research after completion of their
Table 4.3 The internationalisation of the IFSA community

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<td>1</td>
<td>4</td>
<td>4</td>
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</tbody>
</table>

The contribution of a country when many co-authors of this country contribute is counted only once. The table only includes countries which were represented at least four times in the period 1996–2006.

doctoral thesis. At the same time it indicates that the IFSA Symposia remains attractive and manages to regularly interest a large number of newcomers who contribute to the papers published in the proceedings.

To explore the extent to which the European IFSA is truly ‘European’, we have analysed the country in which the author’s institution is located. Authors whose institution is based in France consistently provide the largest group of participants, followed by the Germans and Dutch (Table 4.3). Despite this dominance, on average over 60% of participants came from a variety of countries, both from Europe and from overseas. Based on the affiliation of co-authors of papers included in the proceedings of the European IFSA, the centrality of France is also apparent (Map 4.1). The community is clearly centred in Europe, but with a clear international participation at the Symposia.

Finally, to tackle with the lexical composition of the papers included in the proceedings, we have realised a Descending Hierarchical Classification (DHC) of terms in the abstracts with the Alceste Software\(^1\) (Reinert 1990). This type of classification is used for textual data analysis, to statistically identify the main themes of one text or a corpus of texts. This analysis relies on the classification of frequent associations of terms in a sentence or a paragraph. It is based on the hypothesis that the distribution of words in a text is rarely done at random and therefore reflects a significant structure of meaning.

The IFSA Database proved to allow an analysis of very good quality according to the standards used with this software: more than 80% of the Elementary Context

\(^1\) See the web page [http://www.image-zafar.com/english/index_alceste.htm](http://www.image-zafar.com/english/index_alceste.htm)
Unit (e.c.u.) of the corpus is classified, and the repartition of terms is optimised in only four significative classes (Table 4.4).

Each of the four classes represents a textual assembly of meaning. The four classes divide the whole corpus of abstracts in four areas of distinctive areas of knowledge, which could be used to group areas of interest within workshops at symposia. However, this type of analysis does not allow the identification of innovative thematic groups which reflect emerging issues. As an example of the terms included in a class, the composition of Class 2 is provided (Table 4.5). Class 2 refers to abstracts that focus on the socially situated production of knowledge (i.e. around terms such as facilitating, training, learning, diffusion, transfer). The set of terms included in the class allows for an interpretation.\textsuperscript{2} Such an interpretation requires the participation of experts from the field, and indeed, interactions with experts always constitute an important aspect of the analysis of the data proposed by the machine and the analyst.

\textsuperscript{2} This interpretative work is also benefiting from an access to main repeated utterances of short expression that the software is proposing.
Table 4.4  Lexical description of the four classes obtained after a descending hierarchical classification of the abstracts included in the proceedings of the IFSA symposia 1996–2006

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>e.c.u.</th>
<th>Analysable terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Describes a vocabulary dealing with problems of rural and agricultural areas with a clear emphasis on the way family farming is performed in difficult or marginal environment. It is also clearly the main class that deals with cattle and grazing.</td>
<td>405</td>
<td>6,793</td>
</tr>
<tr>
<td>2</td>
<td>Describes a certain type of vocabulary dealing very clearly with the issue of learning and participation in rural development, extension activities, knowledge transfer situation and research intervention. It also refers a lot to reflexivity and interdisciplinary.</td>
<td>580</td>
<td>9,733</td>
</tr>
<tr>
<td>3</td>
<td>Describes a certain type of vocabulary dealing very clearly with socio-economical and anthropological approaches of belief, knowledge, rationales and markets in relation to global context of knowledge society or to public action (CAP, standards, globalization).</td>
<td>652</td>
<td>10,758</td>
</tr>
<tr>
<td>4</td>
<td>Describes a certain type of vocabulary dealing with agri-environmental terminology largely centred on fertilization issues and agronomic question of cropping system in a context of sustainable development (water quality, biodiversity, landscape, erosion).</td>
<td>184</td>
<td>3,149</td>
</tr>
</tbody>
</table>

Table 4.5  The list of terms of Class 2

learn. (115), extension+ (96), participatory (36), particip+ (57), programme+ (31), project+ (109), research+ (196), train+ (33), co (29), develop+ (165), experience+ (45), act+ (69), advisor+ (19), approaches (35), communic+ (27), facilit+ (22), group+ (41), implement+ (41), methodolog+ (37), stakeholder+ (37), team+ (17), RD&E (11), teach. (11), approach+ (49), challenge+ (35), collaborat+ (18), design+ (35), dialogue (15), discuss+ (39), involve+ (42), knowledge+ (65), process+ (69), reflect+ (21), service+ (28), teacher+ (10), universit+ (19), FSR (6), INRA (6), PLA (7), achiev+ (6), agent+ (13), aim+ (34), argue+ (11), assist+ (8), austral+ (16), background+ (7), behaviour (17), beneficiaries+ (6), bottom (10), brandenburg (10), communit+ (32), consult+ (7), cooperat+ (13), course+ (15), disciplinary (9), educat+ (20), establish+ (22), fund+ (16), include+ (22), including (19), industry (19), initiat+ (18), inquir+ (7), interdisciplinar+ (16), managing (9), operat+ (25), organis+ (32), paper+ (88), partner+ (15), pilot+ (7)

The number in parenthesis indicates the number of times the term has been found in the abstracts;  
paper+  means  paper  or  papers ;  learn.  means  learn ,  learnt , or  learning

Mapping the scientific domain using co-word analysis

Visualising co-word networks through maps

This second part of the analysis takes a look at the wider scientific context linked to issues that are also addressed at IFSA symposia. The co-word analysis focuses on co-occurrences of terms in any corpus of bibliographic notices (e.g. author, year,
journal, keywords), and in our case from the CAB Corpus and the SCI Corpus. For the analysis, the ReseauLu platform was used. The ReseauLu approach is based on the construction of a matrix of term-associations occurring in bibliographic fields, and on the mapping of co-occurrences of indexed terms that are provided by a systematic parsing of the given database (Cambrosio et al. 2010). The ReseauLu mapping algorithm is object-oriented, it optimizes the positioning of objects in a two-dimensional space focusing on the existence of strong links between nodes. The positioning of nodes and links in maps is not random, but results from an optimization process using a step-by-step positioning that depends on explicit rules, based on concepts from network analysis (structural equivalence, centrality and closeness of nodes).

Thus, maps, i.e. the nodes and the links between nodes can be read in two ways: (1) by sizing up the overall image and identifying the main clusters of nodes that structure the space, and reflect on the distribution of links between nodes; (2) by paying attention to the local composition of an individual cluster; what are the main nodes within this cluster, what links connect which nodes, etc. To aid the interpretation, the size of each node is proportional to the number of times the term occurs in the corpus. However the links do not provide any measure of intensity, they only indicate the existence of a link. Thus regarding the links, they can contribute to identify ‘heavy nodes’, which will have many links.

**Authors, journals and keywords**

When comparing the authors included in the IFSA Database and those in the WoS Databases, it was interesting to note that the IFSA community is not visible as a distinct network of co-authors. Moreover, the authors that are prominent in the analysis of the SCI Corpus, tend not to publish in the proceedings of the IFSA Symposia. It thus seems that authors presenting at IFSA symposia are distinct from authors publishing in peer-reviewed journals whose abstracts were included in the SCI Corpus (Fig. 4.7). Due to this fact it was not useful to establish a benchmark of the IFSA Database and the SCI Database terms of authorship, though these results have been presented to the community (Barbier et al. 2008).

An analysis of the journals was performed, to inform a discussion regarding a potential publication strategy. For this analysis, the network of cited journals is used (composed of the set of cited references of all papers included in the SCI Corpus). The generated map groups the journals by disciplinary domain (Map 4.2), and Four ‘academic polarities’ can be distinguished:

- Journals focusing on soil sciences form the largest pole. This reflects the large size of this scientific community in agronomic research, with the Australian journal having a significant impact on this pole.

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3The mapping of authorship of the FSR domain is available at http://ifsa.boku.ac.at/cms/fileadmin/Books/2008_BarbierGarandel.pdf. The map is too large to be included in this text.
The comparison of the authors included in the IFSA Database and those included in the SCI Corpus seems to indicate that these are two distinct groups. This may be linked to the fact that IFSA Symposia attract many young researchers, e.g. doctoral students, which may not proceed to publish in peer-reviewed journals, as they may pursue careers outside of academia.

Within the network of cited journal – based on an analysis of the corpus extracted from WOS SCI database – four main poles and two minor poles can be distinguished.
• The second pole assembles agro-eco-system research, research addressing weed sciences, and agroforestry.
• The third pole comprises journals focusing on soil fertility and plant-soil interactions based on ecology and applied biology;
• The fourth pole is represents applied ecology and includes the prestigious journals Science and Nature.

To assess the networks between keywords that enable to identify thematic domains, the keywords included in the CAB Corpus were analysed. The resulting map of keyword co-occurrence identifies following five clusters (Map 4.3):

• Cluster 1 focuses on cropping systems (yield, rotations, fertilizing);
• Cluster 2 focuses plant protection and pathogens;
• Cluster 3 assembles issues of farming systems, sustainability, and policy;
• Cluster 4 focuses on nature conservation (land use, grassland, biodiversity);
• Cluster 5 focuses on production economics, farm management and livestock.

Map 4.3  The network of keywords that characterises publications on agriculture and farming, with five main thematic clusters (CAB Database)
It is also interesting to see which terms link two clusters, as the keywords may indicated concepts which bridge to thematic or disciplinary clusters. For example, the keyword ‘organic farming’ is located at the intersection of cluster 2 (plant protection) and cluster 3 (sustainability). Similarly ‘simulation models’ links cluster 1 (commodity production) to cluster 5 (farm management); the keywords ‘tillage’ and ‘ploughing’ link cluster 1 (commodity production) to cluster 2 (crop management and weed control). Such bridging terms are at crossroads between domains, often not specifically belonging to one cluster.

To further analyse this network of keywords, it can be useful to ‘zoom in’ on one specific part of the map, thus paying attention to the inner structure and composition of one cluster or of two neighbouring clusters (Map 4.4). The detailed analysis of a specific area of the map enables us to assess the proximity of certain terms. For example, ‘grasslands’ is fairly close to ‘species diversity’ and ‘nature conservation’ which can be interpreted as indicating that in many abstracts, the issue of conservation does not exclude use of grass for agricultural purposes.

**Shifts in keywords 1996–2007**

The analysis of clusters of keywords can be extended to include a temporal element, thus allowing insights into how a domain has evolved through time. ReseauLu enables us to generate a map based on heterogeneous networks, i.e. based on the co-occurrence of terms that belong to different bibliographic fields but that are

![Map 4.4](image-url)
present in the same bibliographic notice. A map based on the bibliographic field ‘year’ and the bibliographic field ‘keyword’ can reveal how the distribution of core keywords has changed over time.

In a first step, the analysis of the evolution of keywords through time was done only based on the corpus extracted from the SCI database (the SCI Corpus) to gather a rather academic evolution of keywords networks. The evolution of keyword positions through time (Map 4.5) shows an early discrete polarization in 1991, 1993 and 1995 of ‘nature conservation’ and ‘biodiversity’ (which re-emerges in 2006) in a large set of keywords liked to cropping systems. The second cluster of year (1996–2001) has many links to keywords such as ‘sustainable agriculture’, ‘sustainability’, ‘diversity’, ‘no tillage’, ‘erosion’. This shift towards sustainability issues may be linked to the effect of the Rio Conference (1992) onto the research agenda. The third cluster of years (2002–2006) shows a particular link to references of developing and emergent countries through keywords such as ‘food security’, ‘health’, ‘poverty’, ‘livelihoods’. The last cluster composed of year 2007–2008, with links to terms such as ‘climate change’, ‘reforestation’, ‘irrigation’ and ‘water’, while ‘organic agriculture’ appearing as a marker of transition from the preceding period.

The same method was applied to the corpus extracted from the CAB database. Instead of presenting the full map, we present a local view focusing on the keywords

**Map 4.5** The networks of year and keywords in the SCI Corpus, distinguishes four main clusters or years. Each cluster of years (circles) is characterised by a specific set of keywords that are found at its periphery (trapezoids)
that dominate in the years 2004–2006 (Map 4.6). This allows us to capture with more detail the issues related to agronomic research that dominated in that period. Starting on the right-hand side of Map 4.6, the panorama starts with the keywords ‘crop management’, ‘organic farming’ and ‘sustainability’, evolving towards a mix of crop protection issues such as ‘chemical control’.

Overall, considering both the analysis of the SCI and CAB corpuses, it seems that the keywords shift from classical agronomic approaches to crop production in the mid-1990s, towards taking into account sustainability-related issues towards the end of the end of the 1990s. However, the agri-environmental wave seems to have receded in 2001, being replaced by a focus on issues related to erosion and soil fertility. In the mid-2000s keywords linked to climate change become more dominant. There is an interest in organic farming in the early 2000s, but it is not particularly large. Organic farming may be linked to the quite recent emergence of keywords that can be linked to agro-ecology (see Wezel and Soldat 2009; Barbier 2010; Ollivier and Bellon 2010).

Conclusion

We used a bibliographic analysis of the proceedings of the IFSA symposia held between 1996 and 2007, to inform the discourse within the IFSA community about some key characteristics that can be derived from such a bibliometric analysis. Also, we performed a co-word analysis on data sets extracted from the CAB and SCI databases, to inform the IFSA community about how the wider context linked to agricultural research has evolved in a comparable time frame.

The analysis showed that the IFSA community is not present as a distinct and recognizable group (e.g. through co-author networks, or a cluster of keywords) within the SCI and CAB corpuses. This might be somewhat surprising, since the keywords used to extract the corpus were selected based on the keywords used by the IFSA community in their proceedings, and enriched through additional suggestions by
IFSA experts. However, in the attempt to capture the wider context of (disciplinary) agricultural research, it seems that we might have overreached and ‘drowned out’ the specificity of Farming Systems Research. The European Farming Systems Research might have also been ‘drowned out’ by the analysis that focuses on publications with a world-wide authorship and readership. In this context issues such as global change, poverty, migration, and food security are dominant, although they play a subordinate role within European farming systems.

Nonetheless, the analysis indicates that, although the farming systems community may be relatively small compared to the large number of disciplinary-oriented researchers, it could be more visible within agricultural research if it had a more coherent and stronger publication strategy, e.g. through the consistent use of specific keywords. A stronger publication strategy would allow it to convey the specific strengths of the farming systems approach and the insights it generates.

The analysis of the proceedings of six IFSA symposia can also contribute to the discourse around the issue of the type of community it is. Is the European IFSA a scientific community? Certainly yes, since most of contributors belong to the scientific community or are working in close connection with researchers through field work, R&D projects and other types of collaborations. Nevertheless, one might also say that it has not been a scientific community driven by publishing in international peer-reviewed journals. As a result, the IFSA community has produced a knowledge that has not entered in dialogue with the type of knowledge that characterises publications found CAB and SCI databases. Of course, Farming Systems Research initially defined itself in opposition to mainstream agronomic research, it was developed based on the recognition of the weaknesses of disciplinary and reductionistic research approaches. Yet, the IFSA community might want to revisit the extent to which it separates itself from the ‘mainstream’, and search for types of cross-fertilization that might be fruitful.

Indeed, the type of issues addressed by scientists of both IFSA community and more largely by the agricultural research community indicates that the problems we are facing, e.g. climate change, food security, energy and sustainability are not going to be comprehensively addressed by one research approach. The IFSA community has developed important insights e.g. regarding the importance of participatory methods to achieve long-lasting change by encouraging social learning. In so doing, it has developed a range of tools for participatory research. Similarly, it has generated novel understandings regarding the systemic aspects of farming. These insights might be relevant to a wide variety of researchers who are currently not aware of them. By including publications in peer-reviewed journals more prominently in its publication strategy, the IFSA community would make these valuable research results, insights and tools more widely accessible.

Acknowledgements We thank especially Benoit Dedieu, Bernard Hubert and Marianne Cerf for their availability in the hectic times of their own activities. We also want to thank Jean-Marc Meynard, the Head of the SAD Department of INRA, who brought a financial support to this research. Thanks also to those who proposed comments and critics during the Clermont-Ferrand symposium, and to the Board of IFSA, which has welcome the results of this research. We would like to thank Ika Darnhofer for her careful editorial work, which considerably helped to clarify the
presentation of our work. The final thank you is for Jean-Philippe Cointet, who does a lot to design new algorithms and methodology of visualising graphs like in the Map 4.2.

References


Chapter 5
Methodological themes in Farming Systems Research and implications for learning in higher education

David Gibbon

Abstract  Many innovatory Farming Systems Research approaches emerged as a response to narrowly focused disciplinary science and the top-down technology transfer models of the 1960s. These approaches included: the move from disciplinary to trans-disciplinary thinking and practice, rapid survey techniques including agro-ecosystems analysis, farmer participatory learning and action, farmer experimentation and innovation and new linkages between research and extension. Many of these methodologies were first developed in countries of the South, but they have also been incorporated into research and higher education systems of the North. Over the period of the European IFSA Symposia, more systems of interest have emerged, such as: trans-disciplinary social learning, the analysis of multi-functionality in rural livelihood systems, and the search for sustainability through adaptive management of farming systems. Key contributors have continued to build on the legacies of systems pioneers and have ensured that those new to Farming Systems Research can learn the basic principles, which remain grounded in the history of the movement and in progressive, systemic thinking.

Introduction

During the early discussions about developing a European focused conference on Farming Systems Research and extension, it was evident that the ‘community’ of systems researchers came from very varied backgrounds and experience. Some had extensive experience in developing systems research in countries of the South, as part of existing inter-institutional linkages, through programmes with National
Research Agricultural Systems (NARS), and through the Consultative Group of International Agricultural Research Centres (CGIAR), or as part of International Aid programmes. A major innovation was the desire to move from disciplinary to interdisciplinary thinking and practice within agricultural higher education and research institutions and in Farming Systems Research in practice. Box 5.1 illustrates the elements of this changing thinking which has characterised this change. The transition has not been without problems and resistance in many of the more conservative agricultural educational and research organisations, but this author is convinced that the early exposure to the key principles of systems thinking is essential for all present and future systems researchers.

**Box 5.1: From disciplinarity to trans-disciplinarity**

*Disciplinarity.* In disciplinary science and practice, it is possible and legitimate to isolate a component and reduce the problem and elements that can be manipulated through controlled experimentation with a high degree of precision.

*Multi-disciplinarity.* In multi-disciplinary science and practice, a more complicated problem is addressed by linking a number of relevant disciplines to consider various disaggregated parts which together add up to make the whole. The presumption is that you can know the whole works by looking at the constituent parts.

*Inter-disciplinarity.* In inter-disciplinary science and practice, the problem is addressed in context as a system. It is recognised that effects in one part of the system affect other parts, and the function of its whole cannot only be perceived by looking and aggregating information about separate components. Hence, scientists have to work together as a team, with negotiated task protocols, to share understanding and interpretation of how they see the system working and the dynamic interrelation between elements and structure.

*Trans-disciplinarity.* One definition of trans-disciplinarity is that it is a new form of learning and problem solving, involving cooperation among different parts of society in order to meet complex challenges of society. Solutions are devised in collaboration with multiple stakeholders. Through mutual learning, the knowledge of all the participants is enhanced.

(Source: N. Powell, personal communication 1998).

Some researchers have been involved in significant changes in systems thinking in their own countries, notably the SAD group of INRA in France and Hawkesbury College (now part of the University of Western Sidney) staff and students in Australia (Bawden 2010a). The contributions from these groups have had a profound impact on systems thinking and education in agriculture in many areas of the world and also on the themes and content of many of our farming systems conferences. Interestingly, one of their key contributions in the early discussions was the importance
of experiential learning as an integral part of higher education in agriculture. This has been systematically downgraded in many countries (notably the UK) to the detriment of generations of graduate students.

In a paper for an Extension Education conference, Jiggins and Gibbon (1997) set out some differences and implications of discipline-based and inter-disciplinary-based education systems (Table 5.1 and Box 5.2).

The implications of these differences are that these approaches lead agriculture in very different directions as the following box suggests.

**Box 5.2: Discipline-based vs. inter-disciplinary education**

*Discipline-based* education in agriculture leads to research which is characterized by:

- a focus on biophysical parameters abstracted from context
- a purpose and objectives taken as given and undisputed
- designed solutions
- the definition of potentials within given parameters
- invariate, absolute results
- control over – and manipulation of – the environment
- attempts at social engineering

*Inter-disciplinary* education leads agricultural research in the direction of:

- embedded action and structural change
- negotiation of potentials and objectives within the frame of human intentionality
- adaptive learning and adaptive management
- acceptance of multiple perspectives
- improvement of the outcome of the interplay of competing meanings
- ambiguous, fuzzy, conditional results
- teams, groups, coalitions, platforms, networks
- co-evolution of societies and environments

(Source: Jiggins and Gibbon 1997)
The link, then, between educational training at higher degree level and research competence, is integral and essential for any systems researchers. Many researchers, trained in disciplinary science, still have great difficulty in making the transition to inter-disciplinary thinking and practice and need to be challenged to think in more constructive ways when planning new programmes which need common conceptual frameworks for collective action. In a series of workshops at a European agricultural university, academic staff of different disciplinary backgrounds, were challenged to construct a metaphor for inter-disciplinary Farming Systems Research and to interpret this for operation. Some of the results were rather predictable and not very challenging, but the figure below was produced by a truly mixed group who captured the essence of an inter-disciplinary systems team and how it might interact with its environment (Fig. 5.1). The group also explored how the web (network) idea could be explored further.

A constant feature of all the IFSA symposia has been, in addition to papers from scientists and practitioners from European countries, the contributions from colleagues from Australia, New Zealand and North America (9% of papers) and also from colleagues who have been working in developing countries of the South (about 9% of the workshop papers). Some of the latter have been researchers from these...
countries and others have been researchers based in developed countries who have been contracted to work in southern countries. These papers add a great variety to the meetings, and show that the Eurocentric focus of the symposia need not be inward looking and that we still have much to learn from outside our primary region.

The farming systems ‘community’, then, has been made up of people who have very different histories, on-going commitments and interests and the conference and workshop sub-themes have reflected this rich diversity. Yet another important factor is that at each conference, a significant number of authors and attendees have been new to the “Farming Systems Research and Extension family” and therefore might not always be aware, until now, of what has gone before.¹ For these reasons, the content of each conference has reflected very diverse views, enthusiasms and traditions, which have been captured by local and international scientific committees.

The movement of the location of the conference around Europe has also been a strength as it has facilitated both a shift in the makeup and focus of the workshops, a reflection of the different country strengths and approaches to farming systems thinking and enabled participants to experience a rich diversity of field study visits where systems research and extension is taking place. This is particularly appropriate now, as many European funded research projects are multi-institutional collaborations which are designed to stimulate trans-disciplinary interaction and learning in different national settings. Despite this background of change in location and actors, there have been a number of recurring methodological themes which characterize many of the meetings and which are enriched through the broadening and deepening the contexts of systems research.

The early history of Farming Systems Research

The early history of Farming Systems Research and extension since the 1960s has been well documented (Collinson 2000; Norman 2002), and the origins and development of systems thinking in agricultural research is also well known (Checkland 1981; Bawden 2010b). Farming Systems Research and Extension (FSR/E) development was well served by the early symposia in the USA in Kansas State (1981–1986), Arkansas/Winrock (1987–1989), Michigan State (1990–1992) and Florida (2002), and also the international meetings in Montpellier (1994), Colombo (1992) and Pretoria (1998).

With the move to form the European IFSA, the French group have played an important role as they, unlike most other European member countries, had already built a systems perspective into their national research system in 1979 (Bonnemaire 1994; Brossier and Hubert 2000; see also Cerf 2010; Brossier et al. 2012, this book).

¹This has now been addressed by the work of Universität für Bodenkultur, Vienna, who have collected all the proceedings from eight of the nine conferences and made them available online (see: http://www.ifsa-europe.org/). This is a very generous gesture and gives all systems researchers (new and old) a valuable and accessible resource.
Other countries (notably the UK) never formally incorporated systems thinking into their agricultural research and extension systems and established a hierarchical system of research institutions and universities where most strategic, natural resources and social sciences research was carried out. More applied and adaptive research was carried out by the Ministry of Agriculture (now Defra) at research stations and husbandry farms where crop and livestock systems research was conducted (see Bingen and Gibbon 2012, this book, for more recent changes to this).

This chapter is based on two main strands. The first are the key elements of Farming Systems Research which are considered to be fundamental to an understanding of why the field is still important for the next generation of researchers and therefore needs to be embedded into the education of future scientists. Secondly, a selected overview of the papers with strong methodological elements presented at the biennial European IFSA conferences since 1994, and including the International Symposium held at Montpellier in 1996. The highly flexible structure of the meetings has enabled groups systems of researchers and extensionists to form communities of interest around key themes and debates, in which they are engaged, within and across their research environments. Some of these groups have developed a high degree of cohesion through several meetings and have generated some very significant contributions to learning and methodological developments. One such is the LEARN group which has run the last five meetings and sustained a major European research project. Their story, and the methodologies which evolved and emerged from these discussions, are discussed in Blackmore et al. (2012, this book) and Hubert et al. (2012, this book).

Another group which has survived through all the conferences, emerged from Niels Röling’s (and his colleagues) ideas around the concept of the agricultural knowledge and information system (AKIS), which later developed to include ecological knowledge (Röling and Engel 1991; Röling and Jiggins 2000). This originally represented publically funded agricultural research, extension and education, but it has evolved in parallel to the LEARN group and has expanded in scope with the introduction of privatization in research, extension and changes in roles of research in stimulating innovation (von der Heiden et al. 2006). Successive conferences have developed this thinking and Cristóvão et al. (2008) made a useful review at the Clermont-Ferrand symposium.

It is important to note that throughout the IFSA conferences, most papers contain information and critiques on the research methodologies used, so this overview does not attempt to be a fully comprehensive review of all systems-related methodologies, or even to suggest that Farming Systems Research encompasses a unique and specific collection of methodologies. An attempt was made early in the sequence of conferences, to hold a regular ‘systems methodologies’ sub-theme, but this has only occurred at the Edinburgh (1994), Volos (2000), and Florence (2002) symposia. Later it was not thought to be especially important to hold separate methodology workshops.
Some other recurring methodological themes

Over the 18 year history of the European IFSA, there have been several recurring themes in which some of the fundamental principles of FSR/E are embedded. We felt that it might be useful to highlight some of these for the benefit of readers who may be new to FSR/E history.

Participation and the principles of participatory methodologies

Participation of stakeholders in the process of research and extension has been one of the leading themes of FSR and there have been many attempts to define exactly what this means in the context of any research programme. The true participation of all stakeholders in all stages of a research process has often been difficult for many researchers and decision-makers to accept and they might sometimes interpret the word with different meanings. At the root of this unease is the concern about power relations and who controls the process (Table 5.2).

It is important to note that different kinds of participation (for example relationships between researchers and farmers) may be appropriate for different purposes or in different circumstances (Fig. 5.2).

Participatory methodologies have rapidly been adopted within research and extension systems over the past 30 years and have also been taken on in many fields,

**Table 5.2  Modes of participation (After Jiggins, personal communication)**

<table>
<thead>
<tr>
<th>Mode of participation</th>
<th>Type of participation</th>
<th>Degree of outsider control</th>
<th>Potential for sustaining local action and ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-opted</td>
<td>Manipulation by selective interests: representation by the powerful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-operating</td>
<td>Outsiders control the agenda and direct the process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consulted</td>
<td>Outsiders analyse local opinion, decide on the process and action</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborating</td>
<td>Local people work together with outsiders; responsibility remains with outsiders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-learning</td>
<td>Local people and outsiders develop opportunities to learn together through facilitated action research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collective action</td>
<td>Local people set the agenda and process, develop controls over action, resume ownership</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
including rural and urban development, forestry, fisheries, health and community planning. There are four common principles which unite all these contexts:

- A systemic and group-learning process
- The acceptance of the multiple perspectives of stakeholders
- Facilitation leading to transformation
- Learning leading to sustained action

These four principles have usually been accompanied by a shift from verbally-oriented methods (formal interviews and written recording) to visually-oriented ones (participatory diagrams and visualizations). Diagrams and visualizations are central to participatory learning as they bring together people who have different literacy skills and who might not share a common language onto an equal platform for discussion and analysis (Pretty and Hine 1999).

A key, integral component of participatory approaches has been the explicit focus on gender analysis. This results in a better description of the farm system as a whole and also gives a greater understanding of the process of technical innovation (Feldstein and Jiggins 1994). According to Jiggins (2000): “Gender adds a little complexity for a lot of insight, while participatory process and techniques enable farming systems researchers to engage more effectively with members of farm communities”.

**Indigenous knowledge and farmer participation in the research processes**

A starting point for all FSR/E has been the participation of farmers in the research process and the acceptance that their knowledge has an important contribution to
make to analysis and learning in science. Farmer experimentation and the importance of local knowledge are also accepted as making valuable contributions. This means that farmers become additional researchers as they explore the same and sometimes new, problems that are examined more formally by researchers in on-station, sub-station and on-farm trials (Fig. 5.3). Farmers may run several kinds of informal trials in several locations and these make complementary contributions to the overall research process.

There have been major contributions to knowledge in this area, from the Farmer First (Chambers et al. 1989), Beyond Farmer First (Scoones and Thompson 1994) and Farmer First Revisited (Scoones and Thompson 2009) series of workshops, from the ILEIA readings in Sustainable Agriculture (Haverkort et al. 1991; Hiemstra et al. 1992; Alders et al. 1993; Van Veldhuizen et al. 1997) and also excellent reviews by Okali et al. (1994) and in Scoones and Thompson (2009). This type of research was also discussed in the early IFSA conferences (Portela 1994; Leaver 1994; Norman and Tubene 1996), and has re-appeared in the more recent meetings (Kummer et al. 2008). Participatory systems oriented research design (Verhagen et al. 2006; van Eijk et al. 2010) has remained a core theme throughout this body of work. In the 2010 meeting, the development of greater farm resilience through farmer experimentation has been highlighted (Milestad et al. 2010). This meeting has also re-emphasised the use of diagramming, symbols and causal mapping, which were part of the original Participatory Rural Appraisal (PRA) tool kit, as key methods for analysing complex situations with farmers and other actors and stakeholders (Gouttenoire et al. 2010; Schmid and Patzel 2010).

While researchers have adapted and applied many of the principles of their methods and their learning from developing countries into their own research systems in Europe, few have tried to apply this as directly as Vaarst et al. (2006), who have
conducted parallel research using the Farmer Field School approach, both in several countries of the South, and in Denmark. This builds strongly on farmer knowledge and learning in a structured context in relation to livestock management and development.

**Scales of analysis and intervention**

One question that systems researchers have faced has been on which scale is it appropriate to begin the analysis of systems. Conway had addressed this issue in his very early work on agroecosystems analysis in Thailand and Northern Pakistan 10 years before our meetings began (Conway 1985). In the Montpellier symposium, Osty raised a series of questions on methods and scales of intervention from field, family farm, locality and agrarian system and how to deal with the interface between these levels of analysis. He stressed the need to consider all these scales and to accept that the researcher or observer is part of the process of analysis (Osty 1996). This is something that many agricultural researchers who come from a natural science disciplinary training background still find hard to accommodate.

Fragata (1996) was also concerned about scales of analysis and the problem of costly diagnosis which took too long. He was concerned about the generation of large amounts of useless information; a problem common to many FSR/E research and development teams who are beginning new programmes.

The issue of scale continues to focus systems researchers minds as the area of the required ‘impact’ grows and the expectations of funders also grows. Landscape scale research projects are more common now and they can call for a very different systemic approach and the development of multinational and multi-institutional networks (Ison et al. 2004; Tiemann and Siebert 2008).

**Change from technology transfer to multiple source innovation models and decision making in landscapes**

Farming Systems Research approaches emerged as a response to conventional and formal top-down technology transfer models that were shown to be inappropriate and irrelevant for many resource-poor farmers who managed small, complex, multifunctional systems in many developing countries (Chambers 1983). After many years of applied systems research experience, it was evident that similar principles could be applied to many farm environments and systems in the developed countries. Much of this evidence has come from working with farming learning groups (Röling 1994) the development of experience from on-farm research (Guzmán et al. 1994) and the emergence of multiple source innovation models (Biggs 1990). Le Gal and Milleville (1996) stressed the need to adopt a diversity of research
approaches which aim to help farmers’ (and others’) decision-making at several levels of aggregation. Morris et al. (1998), using an interdisciplinary systems perspective to examine the strengths and weaknesses of new technologies, noted the crucial importance of incorporating people and policy related issues into the analysis. The approach stimulated critical reflection among the professionals involved and highlighted the power relation problems between professionals and non-professionals which still persist today in many settings.

In a reverse of the classic transfer of technology model (from researcher to farmer), Sortino et al. (2008) discuss the case for a ‘return of techniques’ used by farmers in non-modernized systems. These techniques are low capital intensive and the authors argue that they might need a reassessment in today’s economic and ecological climate. In a modern-day version of Biggs innovation paper (Biggs 1990), Knickel et al. (2008) found that modern innovation processes require an appreciation of the multi-functionality of rural communities in a changing economic environment. Many of these studies have been captured well by the International Assessment of Agricultural Knowledge, Science and Technology for Development Report (McIntyre et al. 2008) which was presented by Hans Herren in the opening plenary session of the Symposium in 2010. This thorough analysis of modern agriculture concluded that ‘business as usual’ is not an option for future sustainability and that many of the recurring themes of the symposia: the need for systems thinking, inter- and trans-disciplinary analysis, a future based on small scale multifunctional farm systems, critical reflection and social learning, are all keys to the development of more sustainable agricultural systems (Herren 2010).

Learning systems and communities of practice

The outputs from the LEARN group at several conferences is covered in detail in Blackmore et al. (2012, this book) and Hubert et al. (2012, this book), so there is no need to single out particular methodologies for discussion here. The LEARN Group is a multi-institutional group that evolved from EU multi-country systems research projects (e.g. SLIM2) and from the biennial European IFSA Symposia coming together of many of the researchers involved (and many more). The first meeting of this group was a pre-IFSA meeting at Hohenheim in 1998. A series of workshops on learning and social learning have followed at subsequent symposia. There have, of course, been several complementary papers on social learning systems that have been presented in other workshops and a number of relevant publications have appeared outside the conferences (Blackmore 2010; Ison 2010).

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2SLIM: Social Learning for Integrated Management and sustainable use of water at catchment scale, see: http://slim.open.ac.uk/
Case studies

The analysis and use of case studies is an important technique in systems researchers’ repertoires and there are many examples of case studies which have been reported in all the symposia. Early discussions centred around the use of case studies and participatory research and the importance of researchers learning to be part of the research system under study (Brossier and Chia 1994; Leaver 1994). Within the symposia there are good examples of case studies which illustrate ways in which large, inter-disciplinary teams can undertake participatory planning and can be managed in a constructive manner (Aenis and Nagel 2000). Some papers have also shown how both time and spatial dimensional modelling can be handled effectively (Osty and Lardon 2000). In others, an integrated analysis of farming systems has been undertaken by rural communities in search of greater sustainability of their rural livelihoods (Topp et al. 2000).

Modelling

The modelling of farm households has always been an interest for many systems researchers. Some have been critical of the limited utility of classical, economic modelling which tended to ignore household decision making (Edwards-Jones and McGregor 1994; Matlon 1996). In an earlier review of the European context, Spedding (1994) considered that biological modelling of production systems took a too limited account of environmental representation.

In more recent times there has been a renewed interest in qualitative modelling by the systems community and in developing simulation models. Zébus and Paul (2000) developed a qualitative farm system simulation model in order to help public decision makers better understand farmer behaviour. Malevoti (2002) examined a decision making model for rural households (EPLAV) based on the relationships among: events, perception, learning, adaptation, valuation, and also among members of the family, between family and environment and family and observer. A novel way of supporting the design of grassland based beef systems capable of coping with climatic variability was designed by Martin et al. (2010) This combined plot scale diagnosis and farm scale simulation. Finally, Danuso et al. (2010) developed a model to manage farming systems under energetic, economic and ecological perspectives, using the dynamic simulation approach. A review of a range of modelling approaches can be seen in Feola et al. (2012, this book).

Environmental adaptation and sustainability

From the beginning of the European IFSA meetings and the growing use of FSR/E as an analytical tool, there has been an ongoing concern about the wider role of
farming within the management of natural resources and the maintenance of sustainable environments. These concerns pre-date the symposia and come from influential writers such as René Dumont in the 1960s and 1970s (Benoit 1994). At the Hohenheim symposium the overall theme focused on environmental perspectives in rural and farming systems analyses (Doppler and Koutsouris 1998). As environmental issues became more important in influencing agricultural policies, researchers became interested in how practices might become more efficient and inputs reduced (Park et al. 1998). Van der Ploeg et al. (1998), in a three country study, found that the socio-economic conditions of farmers had a strong influence on environmental behaviour.

These discussions began a debate about the need to use a trans-disciplinarity approach to address environmental issues more seriously (Lemon et al. 1998). This discussion has continued and broadened in subsequent meetings to explore meanings of sustainability on wider scales. Spoelstra et al. (2002) examined transitions towards sustainability through sustainable technology development. This involved the use of future visioning and back-casting with stakeholders in order to develop societally desirable livestock systems. The use of scenario development continued in future meetings. Ramos’ (2004) study of rural landscapes in southern Portugal highlighted the confusion over the new CAP legislation which decoupled payments for production and those for environmental management. This study pointed out the lack of coherence among policy instruments due to the absence of a clear vision and guidelines on what ‘desirable’ rural landscapes should look like. It explored a series of alternative scenarios (Ramos 2004). Many EU multi-country research programmes are now concerned with the monitoring and evaluation of agri-environmental footprints in landscapes by engaging stakeholders more fully in the process of assessment of change. Knickel and Kasperczyk (2008) showed how this could be achieved using a method which measured the agri-environmental footprint (AFI). This also built stronger links and feelings of responsibility between stakeholders in managing the landscape. In the most recent symposium, collective action by farmers was shown to be an effective way, both of managing water and other natural resources, but also in stimulating social learning among the farming and wider community to manage a water catchment in more sustainable ways (Mills et al. 2010).

There was a strong endorsement for methodologies which embraced trans-disciplinarity in the Vienna Symposium. A workshop was organized on this topic in which ten papers were presented on research in Austria, France, Belgium, Germany Netherlands, Kenya and Denmark (Freyer et al. 2010). This would seem to validate a systemic and constructivist research approach in which scientists from academic institutions, farmers of many different philosophies and practitioners from civil society institutions are brought together to create common understanding of problems and visions for the future and to develop alternative pathways towards more sustainable farming and agri-food systems.

Sustainability assessment tools continue to dominate discussions about future pathways in farming systems and in research focus both in conventional farming (van Passel and Meul 2010) and for organic agriculture (Gafsi and Favreau 2010). Gafsi’s approach takes account of agro-ecological and socio-territorial specificities of organic farming.
The 2010 meeting also hosted a new grouping of scientists who were interested in applying methods and procedures, many of them interdisciplinary, for building more sustainable farming systems (Marta-Costa and da Silva 2010).

**Adaptation, flexibility and liveability**

In recent symposia, authors have looked more closely at the adaptive abilities of farmers and communities in developing greater resilience under changing conditions (Darnhofer et al. 2008) at the farm level. Approaches take into account:

- farm long-term trajectories (Moulin et al. 2008) and farmers logics of action (Cialdella and Dedieu 2010) through which they maintain their farming activity and connect long and short term adaptation (Lev and Campbell 1987)
- inter-annual variability of practices and system operation under perturbations (climatic, prices volatility, family ruptures) in order to identify the system flexibility sources (Ingrand et al. 2007).

Multifunctional farms were particularly important in this respect in stimulating greater resilience in the local economy (Milestad and Björklund 2008). In a more general sense, diversity (of activities, of resources, of animals) is a core element of farming systems that gives adaptation capacities. Improving the liveability of the farming system and working conditions appears as a critical point for farming futures (Crawford et al. 2010), settlements of new generations and gender issues (Branth 2002; Schmitt and Inhetveen 2010). Room for manoeuvre is also necessary to incorporate innovations (Mak 2001), in order to face new combinations of activities and a changing labour force. Methodologies have been developed to analyse work organisation, efficiency and flexibility (Madelrieux et al. 2009; Hostiou and Dedieu 2012) connecting the workforce to practices and equipment or to understand the ways farmers combine agricultural activities to private or associative times. Work either builds one’s professional identity or facilitates relations with others (colleagues, local people) and with animals (Fiorelli et al. 2010); it is far more than a sole production factor!

**Concluding discussion**

The history of principles and methodologies which have dominated the IFSA meetings is varied and shows that there has not been one body of knowledge or even a simple collection of methods which characterise FSR/E. However, we can summarise some core strands which are embedded in the approach and which have characterised our meetings. These are:

- Multi-institutional and international sources of research innovation, from national programmes to international centres to non-government agencies to farmers.
5 Methodological contributions

Farmer participation and knowledge, both natural and social, in driving the research processes.

The need to analyse, both from a gender perspective and change at several scales in order to make sense of the complexity of farming and landscape management systems.

Transitions from top down transfer of technology models to multiple source innovation and the management of landscapes by communities and stakeholders in ever-changing processes.

From disciplinary approaches to inter- and trans-disciplinary thinking and practice.

The evolution of social learning and communities of practice as the basis of research and development.

The use of detailed case studies as complementary elements in the systemic analysis of change.

The importance of sensitive environmental management and improved working conditions as the foundation for sustainable landscapes and livelihood futures.

The richness of these diverse methodologies and methods illustrates the importance of recognising that there is not one standard ‘toolbox’ for Farming Systems Research and extension, but a ‘basket of methods’ from which researchers can draw upon whichever methods are appropriate for any specific need or context (Fig. 5.4). Systems thinking, stakeholder participation as equal partners and interdisciplinarity remain as the core underlying principles of Farming Systems Research. Younger researchers who are new to farming systems thinking might usefully learn

Fig. 5.4 There is no standardized toolbox of methods within Farming Systems Research. Rather, there is a rich and diverse basket of methods from which researchers can choose what is appropriate for their specific research question and research setting. This implies the challenge to the researcher of knowing about, and understanding the utility of, many different methods, and how to choose between them.

• Farmer participation and knowledge, both natural and social, in driving the research processes.
• The need to analyse, both from a gender perspective and change at several scales in order to make sense of the complexity of farming and landscape management systems.
• Transitions from top down transfer of technology models to multiple source innovation and the management of landscapes by communities and stakeholders in ever-changing processes.
• From disciplinary approaches to inter- and trans-disciplinary thinking and practice.
• The evolution of social learning and communities of practice as the basis of research and development.
• The use of detailed case studies as complementary elements in the systemic analysis of change.
• The importance of sensitive environmental management and improved working conditions as the foundation for sustainable landscapes and livelihood futures.

The richness of these diverse methodologies and methods illustrates the importance of recognising that there is not one standard ‘toolbox’ for Farming Systems Research and extension, but a ‘basket of methods’ from which researchers can draw upon whichever methods are appropriate for any specific need or context (Fig. 5.4). Systems thinking, stakeholder participation as equal partners and interdisciplinarity remain as the core underlying principles of Farming Systems Research. Younger researchers who are new to farming systems thinking might usefully learn

3Chambers (1983) probably first coined this expression when talking about the range of emerging participatory methods.
something of the history and principles behind these methods as a normal part of their research methods training at graduate level.

Any reader can refer to the original papers⁴ and find out exactly how any of these methodologies were applied in practice and how they may relate to the principles and the adaptation of earlier methods and practices.

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⁴Downloadable from: www.ifsa-europe.org


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Part II
State of the Art and Key Issues
Chapter 6

How should we farm? The ethical dimension of farming systems

Richard Bawden

Abstract  If Farming Systems Research is to truly embrace sustainability as the overall context of its mission, then the inclusion of ethics (and especially systemic ethics) is an imperative. There are matters of responsibilities of producers to the ecological integrity of the land that they farm as well as to the manner by which they use resources. There are matters of equity and fairness and trustworthiness to the consumers of their products, and matters of the well-being of animals under their care. There are, furthermore, particular responsibilities that farming systems researchers have to the way that they conduct their scientific inquiries and develop and promote the types of technologies that they help to generate. These issues raise questions that call upon consideration of rights and wrongs, of means as well as ends, of good and evil, and of what it is to be virtuous. These are ethical questions about what ‘should be done’ with respect to the further development of farming systems that ought to condition the answers to questions about what ‘could be done’. This chapter will discuss the significance of the moral/ethical dimensions of agriculture and farming, as well as of agricultural sciences. It will show how the implementation of the principles of sustainability ethics ‘ought to’ shape Farming Systems Research.

Prologue

As a sequel to the last time that I wrote anything substantial about Farming Systems Research (FSR), this chapter has been an extraordinarily long time in gestation! Fifteen years have passed since my article On the Systems Dimension in FSR was

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published in the Journal of Farming Systems Research and Extension (Bawden 1996). I wrote that somewhat critical and, some might say provocative essay while on sabbatical leave at Michigan State University in the USA from the University of Western Sydney which was my home institution in Australia. It was my friend and MSU colleague (the late) Professor George Axinn who, as the editor of the Journal of Farming Systems Research and Extension (JFSRE) at that time, invited me to write what he referred as a ‘lead article’ for the journal. In common with a number of others within the Farming Systems Research movement, he was concerned at what he perceived to be an all too common lack of scholarly rigour among practitioners within that movement particularly with respect to their conceptual notion of ‘systems’ – the contested and often ambiguous ‘word in the middle’, as I was to refer to it in the subsequent text. He asked me to review the Farming Systems Research literature and comment!

I am sure that there were those within the Farming Systems Research community of practice who thought that it was very presumptuous of me to have accepted the commission to write that piece: I could not, after all, claim virtually any personal practical experience as a formal farming systems researcher working participatively with farmers in their fields. What I did have however – and that to which George, as editor, was appealing in his invitation – was a long history of thinking about, working with, and writing about so-called systems (or systemic) approaches to agriculture and rural development. I was (as I remain) convinced of the benefits of applying systems principles like wholeness, inter-connectedness, embeddedness and emergence to the ‘real world’ and to the messy complex issues that seem to characterise life within it. Also I remain seduced by the benefits of systemically integrating ways of thinking, feeling and acting into a systemic way of being as if I myself am a critically reflexive researching/learning/knowing system (or a vital component in one that comprises other researchers too). In this sense – to paraphrase the late American President John F. Kennedy – “Ich bin ein FSR practitioner” after all: And that certainly is the perspective that I will assume from here on in, so adding credence to my personal statement of the time that “[i]n the face of the daunting challenges of the need for continuing growth of global food production without compromise to environments or community, we have little choice but to continually seek ways of improving our praxis as responsible, ethically defensible and hopefully, systemic practitioners” (Bawden 1996).

Introduction

My basic assertion in that JFSRE contribution was that Farming Systems Research practitioners could significantly improve the quality and relevance of their approach to research “by paying more attention to [the] issue of ‘systems’ and what it might mean to both their theory and practice” (Bawden 1996). The context that I set for that contention was that in order to meet the demands of sustainability as a vital and emergent perspective for the responsible development of farming systems, any
claim for improvement “must be evaluated as much for its ethical defensibility as for its social desirability, as much for its ecological responsibility as for its economic viability, and as much for its aesthetic acceptability as for its technical feasibility” (Bawden 1996). This multifaceted basis for evaluative criteria (reflecting of course the original design intentions of those doing the work) itself represented a systemic challenge of considerable relevance, magnitude, and moment.

Today, a decade and a half down the track, I see no reason to fundamentally change either of those two basic propositions. In fact I strongly believe that they have an even greater relevance, poignancy and urgency now than even then. What they do deserve, however, is further clarification and perhaps amplification particularly with regard to connections between ethics, sustainability and systemics. I believe that these inter-connections are of particularly vital importance to all agricultural researchers but to Farming Systems Research practitioners in particular because of their claims of systemic appreciation. The adoption of sustainability by those in this research community as a vital context for their work, adds even further weight to that argument. As I shall posit later, the quest for sustainability can be considered nothing less than a quintessentially moral imperative.

Before I go any further with this, let me head any of my potential critics off-at-the-pass who might assert that because I am neither a moral philosopher nor an applied ethicist I am in no position to comment about such matters. As my preemptive response therefore, let me state that I have made it my business over the years – especially since 1996 as it happens – to seek out those who are qualified in this arena, to work with them where and whenever possible. I have also read widely from the significant body of literature relevant to ethical dimensions of agriculture and rural development that they have recommended to me. So let me invite those who would criticise me to follow my lead and, as their opening gambit, to access the outstanding contributions made to the field of food and agricultural ethics, over many years, by the American philosopher Paul Thompson with whom I have been privileged to collaborate on a number of occasions. He and his extensive writings have been a seminal influence on my own understandings of issues in and procedures for investigating the ethics of agriculture (cf. Thompson 1995, 1998, 2007a, b, 2008).

Prominent too on my bookshelves are Ethics and Biotechnology (Dyson and Harris 1994), Animal Liberation (Singer 1975), Robert Zimbahl’s recently published Agriculture’s Ethical Horizon (Zimdahl 2006), David Gaspar’s Ethics and Development (Gaspar 2004), Ethics for Life Sciences edited by Michiel Korthals and Robert Bogers (2004) and Life Science Ethics edited by Gary Comstock (2002). The latter monograph is of particular relevance as a source of practical methods for exploring ethical issues using case studies and class exercises in a wonderfully evocative manner to illustrate both the nature of ethical issues and methods for approaching them with a particular emphasis on discourse and on the significance of validity in ethical argumentation. The Shorter Routledge Encyclopaedia of Philosophy edited by Edward Craig (2005) is a rich resource for reading about ethics as a whole, and where it fits within philosophy at large, while in her book The Ethical Canary, Margaret Somerville explores the question of particular relevance
to scientists of whether or not society should set ethical limits on scientific advances (Somerville 2004). The journals *Agriculture and Human Values* and *Agricultural and Environmental Ethics* are also an invaluable source of information. Finally, one of the most accessible sources of material with respect to ethics in food and agriculture is to be found on the webpage of the Food and Agriculture Organization (FAO).  

So, how should I now proceed?  

Certainly I do not intend to attempt to provide a synthesis or synopsis of the essential features of moral principles and ethical protocols that are described in the literature or to review their application to Farming Systems Research practitioners. Given the quality of the literature cited above, that would be not only a redundancy but would indeed represent a presumption on my part. I will instead try to highlight the key issues with which I myself have grappled over time in coming to my own stance of increased moral and ethical consciousness.

**An ethical stance**

The stance that I have personally come to adopt in pursuing ethical aspects of the development of farming systems is that, as a *systemist*, I have no moral choice but to concern myself with ethical aspects of agricultural and rural development – both in terms of what I do as well as how I go about doing it. Whatever I do has consequences for which I must accept responsibilities. So ethical awareness is one of a number of critical dimensions that I call upon to help *me being me* as I go about living out my life that, perforce, includes the way by which I conduct my professional practices. Moral consciousness plays a vital role in the way I make sense out of my experiences of, and come to judgments about my actions in the world about me. It is a central influence on me as I try to live the ‘good life’: The considered life, as Socrates called it. Ethics is the cognitive/affective domain where I confront normative questions about what I believe is right and what is wrong and what is good and what is bad. It is the domain to which I appeal when I need to consider matters such as virtue and duty, responsibility and rights, fairness and goodness, dignity, respect and autonomy. So the relevance of moral consciousness and ethical competence here is directly related to that assertion that I made back in the 1996 piece with respect to the need for the embrace of multicriteria that include ethical defensibility and aesthetic acceptability in the planning, conduct and evaluation of any Farming Systems Research that is characterised by a serious and rigorous systemic appreciation.

From this personal position, it will be obvious that I believe that there is an imperative for all who are involved with research into farming systems to concern

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themselves with critical reflections on the ‘rightness’ of their actions and the virtue of their conduct, the duties and obligations that they have in respecting the rights of others and of nature writ large, and of course, to the ‘goodness’ of the consequences of their work. And in this single somewhat terse paragraph, I have captured the essence of what are generally accepted and promoted as the three distinct (yet clearly closely inter-related) ways by which “ethical principles can be developed to determine whether an action is right, good and proper” as the authors of the FAO report on the ethics of sustainable agricultural intensification have put it (FAO 2004). Comstock provides a quick entrée into the formal theories related to these three approaches while also identifying the major figures known for their contributions to each one in turn (Comstock 2002). In the first place there is the so-called utilitarianism (with its foundations identified with the nineteenth century Englishmen Jeremy Bentham and John Stuart Mills) or consequential ethics perspective that concerns itself with the balance between good consequences over bad ones. In contrast, in rights-based ethics or deontology (identified with the German philosopher Immanuel Kant d. 1804) actions are adjudged from the perspective of the respect that is afforded to the rights, autonomy and dignity of others regardless of consequences. A third ethical perspective, so-called virtue ethics (identified with the contemporary Americans Alasdair MacIntyre and Carol Gilligan but drawing on traditions established by the ancient Greek philosophers) focuses on patterns of conduct that are considered virtuous with respect to the right, good and proper thus emphasising the importance of the character of the ‘actor’ as well as the nature of the act.

To set the scene for what I have to say here with respect to the relevance of ‘the right, the good and the proper’ to Farming Systems Research practice, I need to return briefly to the substance of that 1996 original piece On the Systems Dimension in FSR.

A brief reprise – back to 1996

A key conclusion that I came to in the JFSRE essay was that most Farming Systems Research practitioners rarely appeared to critically adopt – or in their writings explicitly appeal to – formal systems principles or theory; nor apparently did they use them to inform their research, extension or development practices in any rigorous scholarly manner. I could find little evidence in the literature that I reviewed at that time that indicated that there was any profound appreciation among Farming Systems Research scholars and practitioners of the significant idea that both the methods by which farming systems were researched as well the object being researched, merited rigorous and critical scholarly systemic attention. As I pointed out in the text, the distinction between a researching system or system of inquiry on the one hand and a researched farming system on the other actually represented two quite different traditions within the systems movement. Where the latter was equivalent in both intention and approach to the so-called hard systems tradition with its
emphasis on the technical and economic performance of systems ‘out there in the world’, the former was more appropriately approached from the *soft systems* tradition where the focus is on the nature of the system of inquiry itself. This included a focus on the very nature of human nature and the significance in that, of human values. For convenience, I referred to work on ‘farming systems out there’ as *first generation FSR*, and recognised that there were certainly some within the Farming Systems Research movement who clearly did approach their work from this perspective. Evidence in the literature of an appreciation of *second generation FSR* however, from the ‘soft side’ of systemics as it were, was far less compelling. This I suggested was both a very significant conceptual oversight and a limiting methodological deficiency particularly when it came to the matter of setting sustainability as the context for the search for responsible ethically defensible critical improvements to ‘farming systems’.

Upon reflection, I did not pursue either the logic or the significance of this argument in the detail that both deserved. These were serious omissions that I need to rectify this time around. As Paul Thompson has argued so persuasively, the quest for sustainability involves not just questions about what *could be made* to persist but also, and essentially, what *should be allowed* to persist (Thompson 2007b). This, without any shadow of a doubt, clearly emphasises that the move from the essentially reductionist, instrumental, linear and positivist approach of conventional agricultural research to the holism and post-positivism of Farming Systems Research with its embrace of sustainability as an ethos, represents nothing less indeed than a profound shift in paradigms: And this in turn has profound methodological implications.

Not content in 1996 with making the distinction between first and second generation Farming Systems Research, I went further and argued for the development of a *third generation FSR approach* which I referred to as Critical Farming Systems Research (CSFR) that reflected the ‘critical turn’ within the systems movement representing a third systemic perspective on the quest for systemic improvements in farming systems.

Again I was somewhat remiss in not really developing the notion of criticality then or of emphasising its relevance to Farming Systems Research practice. I should at least have explained that to be critical in this context, is to be empathically reflexive: To be ethically concerned. On this point of view, there are at least three domains of critical concern that are indeed of crucial relevance to Farming Systems Research: (a) concern for the well-being of the intended beneficiaries of Farming Systems Research work (in the broadest possible sense of the stakeholding constituency that perforce extends beyond the farm gate), (b) concern for all of the potential consequences of such work (unintentional as well as intentional) that again can extend beyond the immediate system-of-interest, and (c) concern for the integrity of the practices themselves and that of the practitioners. I should also have stressed the fact that the embrace of these matters means that the boundaries of any system-of-interest are not ‘given’ features but are constructs of those who nominate them. They are judgments and as such represent expressions of value, prejudice and knowledge (Ulrich 1993) and therefore must be open to critical review through
debate among all relevant stakeholders as a part of any ethical process of design where the outcomes of any activity that might follow from the implementation of the designed activity, can affect people. Ulrich (1996) calls this process of inclusive ethical discourse, ‘boundary critique’.

As Midgley (2000) has emphasised, the critical systems tradition has been developed in response to the need for a much more explicitly value-informed, ethical approach to dealing systemically with complex socio-cultural problematic issues. There is not a community or society on earth that is not replete with moral issues that arise not just from the search for responsible choices to be made in the course of ‘normal’ everyday life, but also in response to distortions of power that are associated with exploitation, greed, corruption, armed conflict and so on. The inclusive constituencies of Farming Systems Research endeavours are no exception.

In the 1996 article I did argue that a critical perspective was specially appropriate to endeavours in agricultural and rural development where any claim for improvement within a sustainability context would need to meet criteria for such value-laden matters as ethical defensibility, aesthetic acceptability and social desirability in addition to the more instrumental (and conventional) measure for success that are conventionally confined to matters of technical feasibility and economic viability. Such a third generation Farming Systems Research perspective evokes the critical necessity for a multi-criteria approach to both the motivation for, and subsequent evaluation of the quest for improvements to (betterment of) farming systems: A veritable juggling act of eclectic factors of judgment with respect to what constitutes improvements (Fig. 6.1).

As a final feature of the JFSRE piece, I explored the significance to FSR practitioners of learning to be systemic which called for a transcendence from merely learning about systems thinking and systems practice into a coherent praxis. And in doing this I clearly admitted to the difficulties associated with that goal, related as they are, to the need for personal and collective intellectual and moral development and indeed to the transformation of worldviews by individuals and whole communities alike and to the paradigms that prevail.

Here I must admit to a third important omission (or really a very weak exposure) in the original narrative that I need to redress here, as it is central to my entire argument: The influence that the values that we hold have on the way that each of us comes to ‘see’ the world about us – the normative or axiological assumptions that we each adopt that are crucial contributors to our own particular worldviews and to the particular paradigms to which we subscribe. In writing of the nature of paradigms in 1996, I argued that they could be usefully distinguished with reference to four different sets of assumptions or beliefs which I nominated as assumptions about (a) the nature of reality (ontological beliefs), (b) the nature of knowing and knowledge (epistemological beliefs), (c) the nature of human inquiry (methodological assumptions) and (d) the nature of human nature – which I failed to label.

I also failed to pursue this latter dimension – axiological beliefs – with any particular rigour.

So here is a natural segue back to the present discussion of ethics (which are key aspects of our axiologies).
Why ethics?

So how _should_ we farm? Or perhaps more to the immediate point, how _ought_ we to practice Farming Systems Research in a manner that fully embraces concern for that particular question? How do we even approach these questions as a feature of research? And how do we respond to them? How vital to farming systems researchers is the honing of a moral sense and if vital, how can sophisticated ethical awareness be developed from that basic sensitivity? How might these axiological aspects of human nature be incorporated into researching methodologies from which they traditionally have been formally excluded – even apparently by those which claim to have adopted systemic perspectives? It won’t ever be easy for as Thompson (2007a)
has reminded us, the paradigmatic reductionist legacy of positivism that has for so long characterised science – including, and perhaps most notoriously, agricultural science itself, remains pervasive. It has put researchers among those in society who are most resistant to critical introspection with regard to ethical norms, values and responsibilities: In their professional practices at least. This then extends to a firm reluctance for them to actively engage with the citizenry as participants in, and contributors to the moral discourses that are essential to community understanding and thus to public judgment. And this poses a very real threat to democracy itself. Here is a crucial domain for competency development at a time of apparent moral decline when, as Lawrence Busch (2000) has persuasively argued, we all too readily abdicate our moral responsibilities to a number of different institutions like science, or the state, or the market – or, even more potently perhaps, the church (Fig 6.2).

But firstly we do need to address the question of why any of this matters at all within an FSR context? Why, as farming systems researchers should and ought we to concern ourselves with shoulds and oughts with respect to the work that we do? And even if we do agree that we ought to, can’t we achieve this simply by appealing to qualified ethicists or alternatively by merely assuming the high moral ground that what we do is intrinsically right, good and proper – and brook no critique? Few on
earth would deny that through our work in agricultural research, we have brought enormous benefits to countless millions. Indeed it is highly probable that those millions would not be countless except for our efforts. More food has led to more people which has, in turn, led to the demand for more food! Agricultural research work has surely been a sustained and resilient act of outstanding virtue has it not? And this must be even more patent given the explicit embrace of a systemic, non-reductionist approach adopted by farming systems researchers? Is not what we do as agricultural (and most especially Farming Systems Research) researchers intrinsically ‘good’ with respect to our vital role in the quest for ever-increasing supply of agricultural commodities and services to meet the ever-growing demands from an ever-augmenting human population? Should not the methods that we develop and apply to modernize and intensify farm production, be unconditionally adjudged ‘right and good and proper’? At worst, with our hands over our hearts, can we not state that while we accept that all has not always gone exactly as we have intended or had planned, that the ends that we have achieved have justified the means by which we have achieved them? Who is to state otherwise?

Well, moral philosophers and applied ethicists would certainly be among the first (and best informed) to challenge that claim. Regardless of consequences, actions they will argue, need to be judged with reference to respect for the rights of others and that must include members of other species right through to nature in all of its wholeness. “A thing is morally right when it tends to support the stability, integrity and beauty of the land” argued Aldo Leopold more than 60 years ago “and it is wrong when it tends otherwise” (Leopold 1949). Means as well as ends are central to any claims with respect to the ethical defensibility of our work and so a reliance on so-called utilitarian or consequential perspectives where ends tend to justify means should not be the only way by which we do defend what we do. There are also those deontological matters of the rights of others and of our duties and responsibilities to them through our conduct.

The fact of the matter is that we agricultural researchers have not been renowned for our moral sensitivity or ethical conduct beyond those arguments that the very bases for our existence can be classified as doing ‘good’ work in helping to feed the world, in helping to assure security of access to safe food, in helping to reduce poverty in rural communities, in helping to increase the wellbeing of farmers and the members of their families, in contributing to the improvement of human health, in respecting the integrity of nature as well as valuing it for the resources it supplies.

Well I am not so convinced that we are on solid grounds in making this claim! Take the matter of consequences for instance.

**Unintended consequences**

In the cold hard light of day, we would have to admit that the benefits of the modernization and intensification of agriculture through the practical application of our work as agricultural scientists have not come without some significant harm to both the socio-cultural and bio-physical environments of the world about us. For all of its
impressive achievements in productivity growth, especially over the past 150 years or so of what we might refer to as the modern age, the development and application of agricultural techno-science has not proceeded without blemish. The list of unintended negative consequences that have accompanied the positive outcomes is as long as its manifestations are globally pervasive – and we all know it.

We are all aware that the deleterious impacts that some farming practices have had on the environments in which they have been conducted, from time to time and in place to place, are undeniable. We are all witnesses to the erosion, desertification, salinization, acidification, pollution and impoverishment of soils alone. We know about the loss of biodiversity through the habitat destruction through ardent monoculturation and about the loss of migration corridors for wildlife. We fully appreciate that some agricultural practices represent little more than mining the natural resource base for its resources; and not just in the immediate on-farm environment by an individual farmer but further afield across entire water catchments or ground water reserves by many different producers. And we are very conscious of the multitude of undesirable, often humanly tragic socio-cultural impacts that range from the displacement of labour through capital substitution and the consequent disempowerment of unemployment, the concentration of land ownership and its impacts on a new landless sector of society. We also know about the unequal distribution of benefits of technological innovation, of bankruptcies and other financial hardships associated with market failures, of the decay of rural communities through outmigration, and of the ultimate terrible horrors of farmer suicides where, both tragically and ironically the agent of death has been those very agricultural biocides that had been purchased as farm productivity enhancers.

Another supreme irony here is that much agricultural research today is focused on repairing the damage that has resulted from the (mis)application of earlier ideas and technologies yesterday. In this manner, modern techno-scientific agriculture can be presented almost as the archetype for the claim by the sociologist Ulrich Beck that because of the way that we have (mis)treated nature, we are “concerned no longer exclusively with making it useful, or with releasing mankind from traditional constraints, but also, and essentially, with problems resulting from technodevelopment itself” (Beck 1992). And this finds no clearer expression perhaps than the contribution being made by farming practices to truly global problematiques like the anthropogenic impacts on climate change or the emergence of antibiotic resistant strains of pathogenic bacteria or the spread of zoonotic diseases. While consequences such as these, along with so many more that could have been catalogued here, might well have been unintended as outcomes of the practical applications of the research findings of we agricultural scientists, they have often not been unforeseeable. Use a lot of biocides and they will inevitably act as a selection pressure for the emergence of resistant strains of pests. Use a lot of irrigation water and water tables will invariably fall and the rate and volume of river flows will decline. Knock down all the trees and nesting sites will be lost, water tables might rise and the exposed soil might bake in the sun or blow away in the wind. Restrict the freedom to move of chicken or pigs, cattle or sheep and the odds of aggressive behaviour as well of self-harm by the animals will be markedly increased as will the risk of epidemic disease outbreaks among them (Fig. 6.3).
All of these instances represent easily foreseeable consequences of the use of technologies that have developed from the application of scientific research that has privileged ends over means. Yet to our considerable and essentially indefensible dis-credit, we are all too frequently aware of that while doing little about it.

Many will argue, of course, that all of these scenarios represent the misuse of technologies by farmers rather than reflect any inherent inadequacies in the technoscience that led to their development. But the conduct of farmers themselves as well as the character of their farming practices must surely be a central focus of any research programs that concern themselves with improvements in farming systems as whole systemic entities! Farm management is itself a technology in the broadest sense of that word and we have a duty of care.

**Duties and responsibilities**

From this perspective alone, we farming systems researchers can certainly be accused of failing to discharge our duty of care: Of failing ourselves to act in an ethically responsible manner by not considering the potentially negative consequences of
the outcomes of our work or at least sharing knowledge with the citizenry about the potential harmful ‘side-effects’ or ‘co-lateral damage’ that they might cause. But there is more to it than consequences as we have already seen. In encouraging the increased intensification of agricultural practices such as crowding housed animals much more closely together and restricting their abilities to behave in ways that are natural to them, are we not denying them their rights? When farming practices that we have deigned will not persist into the future because of some inherent design limitation, are we not denying the rights of future generations? By a similar logic, we could also be accused of being insensitive to moral consideration in the way that we sometimes (often?) treat our experimental animals or the land that we use for our field trials. The same might be said for the all too frequent cavalier advocacy for the use of recombinant DNA biotechnologies in agriculture which is based on the assertion that they are ecologically benign under circumstances where such statements are clearly unsupportable by limits imposed by experimental design – and indeed our ability to know. Even the very use of rDNA technologies in agriculture in the first place raise questions to do with the right, the good and the proper: As one commentator has put it, biotechnology has the potential to “throw up a host of what are often referred to as moral and ethical concerns” (Straughan 1995). And where do our duties and responsibilities lie in the conduct of any research that focuses on the ‘farming’ of animals destined to provide organs for xenografting into humans, or on the genetic modification of food, or on growing crops that have known harmful effects like the established link between lung cancer and tobacco?

These are all matter of very considerable significance to all of humanity and not just to Farming Systems Research practitioners and their immediate ‘client base’ of intended beneficiaries. Our responsibilities are much more broad and systemic than we might have believed to this point.

The very fact that in our scientific work we explicitly state that we act from a ‘non-normative’ position, where we claim that what we do is free of the expression of any values, represents an abdication of our moral responsibilities while knowing all too well that that is impossible. Of course we bring values to bear in the work that we do: For whom among us is without a conscience? Who would deny that in our everyday lives we are constantly appealing to our own personal beliefs and assumptions – as well as to those of the cultures in which we are embedded – in making choices between what we hold is ‘right’ and what is ‘wrong’, between what is ‘good’ and what is ‘evil’, and what is virtuous conduct and what is not. We do not – indeed we cannot – leave our conscience outside as we enter our laboratories (in the broadest sense of that word as it describes the places where we do our work). We don’t just close the door behind us on our human character, even if, in our commitment to ‘scientific objectivity’, we make the pretence that we can. We are, as an evolutionary psychologist has reminded us, moral animals that are unable to escape an intrinsic nature bestowed upon us through the evolutionary path that we have followed (Wright 1994). In this manner we tend to innately and even instinctively follow a code of rules termed a natural law ethics. We accept as a norm, that we have a fundamental responsibility to respect the rights of our fellow human beings and also to extend that respect to other species as well as to nature itself in all of its
glorious wholeness and beauty – to capture the spirit of Aldo Leopold. It is a natural tendency for human beings to be empathic.

As scientists then, our often expressed positivistic commitment to the objective pursuit of knowledge through dispassionate observation and precise measurement and on the interpretation of such ‘discovered’ facts as an expression of truth and ‘facts of the matter’ therefore amounts to what is essentially a gross rhetorical distortion of our own personal humanity. A fiction – a lie even! It flies in the face of human nature.

Who among us has no moral sense – no critical ethical awareness?

Sustainability and a critical ethical perspective

It is one thing to be sensitive to the moral dimensions of particular matters and to be aware that our everyday experiences in the world trigger concerns that are frequently manifest through emotions such as discomfort or fear or suspicion or outright anger, that can also be expressed through particular behaviours. It is, however quite another for us to ‘surface’ these and critically explore them from a formal ethical, codified perspective: To seek to articulate and understand them and to be aware of their implications for our conduct both professionally and personally. What I am arguing here is that I believe that it is our responsibility and indeed our duty as agricultural researchers, to move to this critical position such that we can work out what it is that we ought to do under any particular circumstance where moral dimensions are present and ethical judgments need to be made.

And that, I contend, will be on most days of our lives. One only needs to read the daily newspaper or watch the television to be subjected to an absolute tsunami of evidence that we face a multitude of issues of moral significance at every level of social organization. Whenever possible, it is our responsibility as citizens alone to engage in debates and discussions about them as we attempt to come to common consensus about what are the right, good and proper ways to proceed.

As mentioned earlier, it has not been my intention here to go into any great detail with respect to ethical theories or to catalogue the details of ethical protocols. There is a literature that I have cited by those who are far more qualified that I am that is readily accessible. Having come this far however, I do need to briefly revisit some of the comments that I have made above and to elaborate a little more thoroughly on the formal principles of ethics as I understand them and as believe, they are relevant to Farming Systems Research practice. The development of critical ethical awareness is the step that follows the honing of moral sensitivities.

We could, of course, do worse than simply follow the four ethical cannons that are commonly accepted as the foundations of the ‘good life’:

- to aim to do no harm (the principle of non-maleficence),
- to aim to do good (the principle of beneficence),
- to aim to be inclusive (the principle of equitability), and
- to aim to be fair (the principle of justice).
Let me expand somewhat on this basic schema firstly by returning to sustainability and re-asserting my submission that in adopting this stance as a perspective or context for work aimed at improving farming systems, Farming Systems Research practitioners have formally adopted a moral stance that therefore dictates their need to develop ethical competencies. An essential feature of the idea of sustainability is that, quite unlike productivity, it is highly contested concept. There have been almost as many definitions proffered as there have been writers proffering them! But as some see it, this is a strength rather than a weakness. Aidan Davison captures this position brilliantly in the very last paragraph of his outstanding book *Technology and Contested Meanings of Sustainability* (Davison 2001). In that final passage of his absorbing work, he argues that the ideal of sustainability inevitably gives rise to an agenda of good questions that “draw out and give substance to our disquiet and our hopes”. Responses to these questions, he continues, are essentially contestable “demanding of us not categorical certainty but the capacity to articulate what we feel to be most worthy of being sustained in our lives”. The connection here between feelings, values and reason in argumentation is of immense importance in underlaying the ethical foundations of sustainability as a context for agricultural research and development. And it has a particular resonance to us as systemic beings.

A central pivot to my entire argument here is that the process of critical ethical inquiry includes an embrace of the affective (feelings and emotion) domain of learning and researching as well as the axiological (value-based) and the cognitive (in the narrow sense of word as it relates to reason) dimensions. This construct representing a systemic conjunction of values and emotions along with reason is, of course, a violation of all that is espoused within the positivist tradition that has for so long characterized agricultural research methodology (as with most research in the natural sciences). More complex than that is the argument that moral values are not something that we can work out rationally at all but are “irreducible aspects of the phenomenal world, like colour...moral value is a form of experience irreducible to any other kind, or accountable on any other terms” (MacGilchrist 2010). There are even those who present a forceful case in support of the provocative argument that deontological judgments tend to be driven by emotional responses that arise unconsciously thus rendering any approach from this perspective an exercise in moral rationalization rather than moral reasoning (Greene 2007).

The contestability of sustainability is a theme that Paul Thompson also pursues and further expands in his seminal article in which he specifically addresses agricultural sustainability – a field of scholarship in which he has been involved for two decades and more. As he puts it, it is not surprising that “sustainable agriculture programmes are constantly subjected to criticism and debate about what, precisely, they should be doing” because the very notion of sustainability is indeed contestable (Thompson 2007b). Agricultural sustainability “means different things to different people” was the way that Douglass (1984) put it in one of the very first accounts of the concept. He suggested that at least three different constituencies – or ‘schools’ – could be recognised among those calling for more sustainable approaches to agriculture: (a) for those of the productivity school, the primary focus of attention was on the sustainability of the productivity of farming enterprises to meet the demands
of an ever growing global population; (b) this was insufficient for those in the 
steewardship school, who argued that such productivity must be set within an ecol-
ogical context which highlighted the need for productivity gains to be placed within 
a context which privileged the sustainability of “biophysical ecological balances” 
while condemning “non-harmonious practices”; (c) for the third group – the community 
school – farming practices must be placed within an even more comprehensive con-
text which embraced factors that contributed to the sustainability of the “vitality, 
social organization and culture of rural life”. Drawing on the work of Cotgrove 
(1982) and Miller (1983) on relationships between ‘cognitive styles’ and ‘environ-
mental problem solving’, I would go on to suggest that the three ‘schools of agricul-
tural sustainability’ identified by Douglass, could be recognised as expressing three 
different ‘worldviews’ (Weltanschauungen) which I nominated as technocentric, 
ecocentric and holocentric respectively (Bawden 1997). Together these different 
perspectives could also be presented as a set of unfolding ‘waves of development’: 
Each ‘wave’ or developmental stage invoking the need for and expression of ‘higher 
levels of intellectual and moral appreciation’ with an imperative for ‘higher levels 
of epistemic development’ as the focus for integrating sustainability into agricultural 
education (Wals and Bawden 2000).

Thompson, in his explication of the importance of an ethical perspective on the 
matter, makes and pursues the extremely useful distinction between what he refers 
to as an approach based on concerns for resource sufficiency and one that provides 
a focus on functional integrity. Those who adopt the first approach as the conceptual 
framework for their research and development activities seek to minimize or even 
maintain a balance between the rate of use or of the depletion of resources on the 
one hand with the stock or pool of the resources that are available on the other. 
Sustainability thus becomes a relative estimate of the length of time that any 
particular practice might persist or could be engineered to persist into the future. 
Thompson argues that this approach from an ethical perspective is essentially an 
expression of utilitarianism – of means to ends where the emphasis is on optimiza-
tion rather than sustainability. In a functional integrity approach, in contrast, the 
spotlight of concern is turned on to the capacity of the system under review (in our 
case a farming system) to reproduce itself over time. Now the focus is on the system 
 itself and not merely on its inputs and outputs and the underlying ethic is one of 
responsibility of maintaining systems functions so that they will remain viable and 
therefore available to future generations as an expression of concern for their rights. 
It also reflects a profound concern for the innate integrity that many claim for nature 
itself. Together these dimensions comprise a firm foundation for conduct that can be 
 adjudged virtuous.

As we systemists appreciate of course, in order to ‘reproduce themselves’ 
systems must be able to recognize the (often turbulent) nature of the environments 
(the supra-systems) in which they are embedded and the nature of their intercon-
nectivities as a network of mutual influences. They must have the capacity to learn! 
As researchers, participating with stakeholders in the development of farming 
systems, we have the duty to play a key role in this ‘learning’ process. In fact from 
the perspective of a critical FSR researching practice, we can see ourselves as
How should we farm?

Crucial elements of the learning or knowing sub-system (Bawden 2007) of any farming system which is the focus of our work. In this role we have the responsibility of learning not just about the co-influences between the farming system and its bio-physical environments but must also attend to those between the system and its socio-cultural supra-system. Actions at the system level need to be evaluated with respect to Thompson’s distinction between what should be allowed to persist and what could be made to do so (Thompson 2007b).

Discourse about improving farming systems within a sustainability context will involve critical Farming Systems Research practitioners (Generation Three) in conversations with a much more extensive constituency than just those directly involved with farming – and with a much broader spectrum to the discourse that will engage practitioners in critical conversations that extend significantly beyond (while also including) issues to do with technical and economic measures of productivity gain. As is illustrated in the conceptual map (Fig. 6.4) discussions will need to focus on

![Conceptual Map](image)
social, political, economic, cultural and technological areas of influence (in both
directions) as well as those involving the natural bio-physical environment. These
discussions will need to explore both the needs and wishes of those concerned with
each sector as a central to the ethical dimensions of project design as well as to identify
the possible consequences (‘bad’ as well as ‘good’) of any proposed actions to change
the system under review. Matters of the right, the good, and the proper will need to be
addressed across the entire map if the conduct of the Critical Farming Systems Research
practitioner is to be adjudged ethically responsible and ultimately virtuous.

Many of the issues that will need to be addressed are not simple black and white
matters but complex dilemmas where differing reactions reflect a host of different
worldview assumptions: Different beliefs about truth, knowledge, reality, nature,
and most importantly, about human values. One person’s terrorist is another’s freedom
fighter, as they say – more to the point, benefits to one person through improvements
in farming system performance, might turn out to be a dis-benefit to others. The
arena is one of inherent contestation including initial decisions about who should be
included in any discourse in the first place. Who sets the boundary, and how? Finding
consensus on the right, good and proper actions to take under circumstances where
these differences are patent, will demand the participation of many different stake-
holders in inclusive and critical discourse about what ought to be done

This broad constituency of stakeholders must include not just those who are, or
will have to be, involved in planning, taking and evaluating appropriate ‘improve-
ment’ activities, but those likely to be affected by outcomes from them. This includes
those (and indeed those things) who/that cannot speak for themselves – from the yet
unborn and the disempowered, right through to nature herself! This will be no easy
task involving as they do matters of boundary judgments and critique. Extending
arguments originally proposed by Churchman (1971, 1979), Werner Ulrich has
developed a conceptual framework and protocol that has very considerable practical
application to Critical Farming Systems Research (Ulrich 1983). There is no space
here to do justice to his ideas and methods so again I recommend that readers access
identifies four different groups of sources of influence on a system of interest:
*motivation, power, knowledge,* and *legitimation.* Within each of these he further
differentiates between *social roles* (beneficiary, decision-maker, expert, and
witness), *role specific concerns* (purpose, resources, relevant knowledge and eman-
cipation) and “*key problems* in dealing with the clash of different concerns that is
characteristic of social reality” (measure of success, decision environment, guaran-
tor assumptions, and prevailing worldview) (Ulrich 1996). In a recent publication,
in which he presents a very useful practical application of critical heuristics as a tool
for evaluation, Reynolds (2007) usefully identifies these three latter aspects of the
schema as representing *stakeholders, stakes and stakeholdings* respectively.

Each of these categories stands for an element of boundary judgment that needs
to be questioned both from a descriptive sense (Who is the client of the system of
interest? What is the purpose of the system? Who has the power? And so on) and
from a normative position (Who ought to be the client? What ought to be the purpose
of the system? Where ought the power lie?). Comparisons between the is and the ought modes will reveal sources of disagreement and contestation that will need to be addressed.

It is such logic that provides the motivation for including ethical competencies into the profile of farming systems professionals where the very nature of the work involves interventions into the lives of others who may well hold to beliefs and values that differ significantly from those of the researcher and whose views need to be accommodated and emotions tempered.

Conclusion

Much has indeed changed since 1996 when On the Systems Dimension of FSR was published.

Not the least significant of these changes is the fact that there are now a billion more mouths to feed in 2011 than there were back then; with the population of the globe growing over that time from 5.8 billion to 6.8 billion, with many more to come yet before it evens out. (Even more telling perhaps is the fact that in the year of my birth, in 1939 – the year, coincidentally that John Steinbeck wrote his classic novel The Grapes of Wrath about the impacts of both drought and floods on the people of rural America – the global population stood at a ‘mere’ 2.3 billion which represents a truly staggeringly 300% increase over my lifetime to date). But even as demand for food and other agricultural commodities and services continues to grow, there are some very disturbing signs that that demand will be increasingly difficult to meet through a supply that will be ever more constrained by a host of potentially limiting factors. Weather events as associated with climate change are obviously very significant in this regard but, as recently observed by Julian Cribb (2010), so too are matters such as the availability of, and access to resources such as water, labour, credit, energy, technology and land itself, the degradation of the bio-physical environment, and economic, trade and political influences. The challenge facing “the world’s 1.8 billion women and men who grow our food” Cribb argues, “is to double their outputs of food – using far less water, less land, less energy, and less fertilizer”. And of course, in this age of multi-functional farming, this is just one area of challenge of the systemic development of agriculture as a whole.

In the face of the hugely innate uncertainties and vitally complex changes that will continue to characterise the many facets of the world as it unfolds into its future, farmers must do what they have to do meet these challenges in a manner that is ethically defensible as well as ecologically and socio-culturally sustainable. In a third generation critical systemic approach (CSFR), the ethical imperative will be up front and central with concerns for what ought to be done explored from the very start of any inquiry, and explored in parallel with questions about what is being done or what could be done to improve a situation of interest as it is transformed into a system of interest. It perforce demands participation not just in planning, conducting and ex post evaluation of projects, but also in inclusive discourse that focuses
explicitly on the ethical dimensions of any system of interest under review. What constitutes an intended improvement to such a system is fundamentally an ethical question which is therefore open to critical review as much by those who might be affected by the outcomes of any activity as well as by those who will be actively involved in it. It crucially involves judgments about the boundaries of both discourse and action. While the underlying ethical commitment here is to the improved well-being of human beings including, wherever appropriate, their empowerment and emancipation, a critical approach to FSR practice extends the inclusivity of well-being beyond humans to embrace the rest of nature itself. And this means that in any discourse aimed at seeking critical improvements in the ethical sense, there must be those who will speak for those (and those things) who cannot speak for themselves. Witnesses or guardians will be essential in this regard.

Step forward the third generation Farming Systems Research practitioners to help in the quest of what is right, good and proper.

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Chapter 7

Systems practice: making the *systems* in Farming Systems Research effective

Ray Ison

Abstract The purpose of this chapter is to explore and unpack three issues with significant practical implications that have bedeviled the understandings and practices of those who concern themselves with FSR (Farming Systems Research) or might do so in the future. The first issue is R&D practice itself – what do we do when we do R&D... or any form of practice for that matter? Secondly what constitutes ‘systems practice’ and where does the concept ‘system’ fit in this practice? Finally, what might be involved in institutionalising systems practice as a key ingredient of systemic and adaptive governance, is explored. It is argued that at this moment in human history we need to abandon old frames and engage with re-framings that give rise to practices that are better suited to our circumstances. Only by doing this is there some prospect of making the ‘systems’ part of the historical framing of FSR a hope for the future rather than a relic of the past.

Context

It is not my purpose here to explore the history of Farming Systems Research (FSR); others have done that (e.g. Packham 2011; Collinson 2000; Wilson and Moren 1990) or provide perspectives in this volume. My primary purpose is to explore and unpack a set of intellectual tensions with significant practical implications that have bedeviled the understandings and practices of those who have concerned themselves

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with Farming Systems Research or might do so in the future (e.g. Flora 1988).1
In writing this chapter I draw heavily upon my own experience and recent scholarship
(Ison 2010a). The tensions I am concerned with are not restricted to the arena of
FSR but plague all fields where systems scholarship is brought to bear. My contention
is that if future practitioners appreciate what is at stake and act with awareness
about their own choices and commitments then it will be possible to build a more
robust, resilient and diverse set of practices based on systems thinking and practice
that are better able to address the many complex issues we confront today.

The tensions I speak of were present when as a young academic I took responsibility,
at the invitation of Richard Bawden, my then Head of School, to be the local organizer
for an ACIAR (Australian Centre for International Agricultural Research) international
symposium ultimately published as ‘Agricultural Systems Research for Developing
Countries’ (Remenyi 1985). This was a significant event for me. One only has to
re-look at the various papers to recognize that we were successful in assembling
some of the most experienced thinkers and practitioners of the time. It is also possible
to see how persistent some differences and tensions have been, and how little success
there has been, despite the optimism, in institutionalising these approaches in ways
that have contributed to on-going R&D (research and development) effectiveness.

Drawing on early experiences and my own research and scholarship I address
three issues in this chapter that in my view need re-framing (sensu Schön and Rein
1994) if future R&D practice is to be more effective. The first concerns R&D prac-
tice itself – what do we do when we do R&D... or any form of practice for that
matter? Secondly what constitutes ‘systems practice’ and where does the concept
‘system’ fit in this practice? Finally, I want to explore what might be involved in
institutionalising systems practice as a key ingredient of systemic and adaptive
governance. My contention is that at this moment in human history we need to
abandon old frames and engage with re-framings that give rise to practices that
are better suited to our circumstances. Only by doing this is there some prospect of
making the ‘systems’ part of the historical framing of FSR a hope for the future
rather than a relic of the past.

Before addressing my three issues let me first say something about framing
and re-framing. Frames are used to negotiate or engage with situations we find
ourselves in by determining what requires attention and what can be ignored. Frames
thus have an evolutionary and biological basis as well as a social and cultural
basis. A frame can be understood as the context through which a person interprets
their world. A person’s frame is also sometimes known as his or her perception,
perspective, worldview, mental model, script or schema (Isendahl et al. 2009;
frame’, which they see as an individual’s personal choice devoid of interactional

1 In using Farming Systems Research I make no claim that this terminology is the best descriptor
nor that it should be conserved. My own preference is for the prime descriptor to be Systems
Practice following by the domain or context descriptor e.g. systems practice – food security or
systems practice – farming innovation etc.
consequences and ‘framing’, which to them is the calculated construction of a frame for oneself with the intention of benefiting a specific audience, such as the public, a constituency or during negotiations.

Reframing can be understood as the purposeful attempt to change one’s own or someone else’s frame. Schön and Rein (1994) suggest that intractability of conflicting frames is based upon the diverging sense of ‘obviousness’ held by opposing sides in a dispute, but all too often disputes are subliminal, at the level of unexpressed framing assumptions. These authors explain that when situations are purposefully framed, or reframed, a transition occurs in the way people think about and engage with such situations. Drawing attention to framing and doing some reframing are ways out of the conceptual trap described by the late Russ Ackoff as doing the wrong thing righter, rather than doing the right thing.¹

Doing R&D

One of the constraints of Farming Systems Research has been that three terms, all in need of some reframing, were run together i.e., farming, systems and research and, too often, taken for granted. For users of the term it becomes even more demanding conceptually when ‘farming systems’ is used as a compound noun or as an adjective (to describe a type of research practice). These linguistic difficulties hide a myriad of conceptual difficulties including how boundary judgments are made about a ‘farm system’ (and how if might differ from say, a livelihood system), whether systems are “real” or context sensitive constructs and what it is we do when we claim to do research. In this section I wish to unpack what it is we do when we claim to do R&D. Following Ison and Russell (2007) I will use R&D as a noun not an acronym or abbreviation. We chose to use R&D in this way to acknowledge that R and D are part of a systemic whole and to break out of the pervasive linear framing associated with R then D as in a sort of technology, or knowledge, transfer pipe (Ison and Russell 2011).³

To understand practice in general (and R&D or systems practice in particular) it is first necessary to understand practice as a particular relational dynamic. Figure 7.1 is what is known as a heuristic device, something that is designed to explore a situation – many of the figures I use have a heuristic intent i.e., they do not set out to describe or claim ‘this is how it is’ but are designed to be used as a way of challenging old, and developing new, understandings.

¹ Ackoff (2004) attributes this distinction to Peter Drucker; he relates it to the difference between reformation (changing the means of achieving an objective i.e. doing things right) and transformation (changing the objectives being pursued; i.e. doing the right thing). See http://www.phibetaiota.net/2009/10/about-doing-right-things-righter/; also http://www.pegasuscom.com/levpoints/ackoff_a-lifetime-of-systems-thinking.html
³ In some papers we have used RD&E, where E is for extension.
I now invite you to spend some time interpreting Fig. 7.1 in the light of activities that you have already carried out as part of your own R&D practice. In the first instance I will focus on you, the practitioner (P) depicted in Fig. 7.1 by the woman in the middle of the thought bubble. As a unique person you have both a biological and social or cultural history. Because of this it is not possible that we come to new situations theory (or framework) free (I have depicted this as the learning cycle in the practitioner’s body). You may or may not be aware of these ‘theories-in-use’ or what Russell and Ison (2007) describe as ‘traditions of understanding’ out of which we think and act. For example “systems” as a theoretical arena and source of concepts and explanations may not yet be part of your history.

In some ways F can also be understood as the ‘ground’ on which the practitioner stands either knowingly or not. In some research traditions, particularly in the social sciences, considerable effort is invested in making purposeful choices about what theoretical framework(s) to use for a given piece of research. Naturally choice of F also influences the choice and use of M, method. Historically, those operating in the natural sciences have tended to regard themselves as coming to the situation (S) theory free; claims are made to objectivity and theory informed processes of interpretation have too often been ignored (Ison 2008).

To summarise, my interpretation of Fig. 7.1 thus far includes a practitioner (you) with a framework of ideas (F) which might be chosen (e.g. Systems) or hidden from you because you have not really thought about them. Figure 7.1 goes on to depict a

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4 Or other forms of practice such as policy practice, evaluation practice etc.
practitioner engaging with a situation (S) through the combined use of an F and a method (M). My own experience of R&D practice is that in the dominant modes of practice the situation is the ‘be all and end all’ of concern e.g. the farm; the animal; the gene; the nutrient deficiency. Reflexive concern with the situation is constrained by isolated disciplinary perspectives (Pearson and Ison 1997) and the widespread use of the ‘problem metaphor’ i.e. the pervasive choice to frame situations as ‘a problem’ without awareness of how it came to be called a problem and whose interests were served by this framing choice. What I mean by reflexive and reflective practice is outlined in Box 7.1.

Box 7.1: Reflection and Reflexivity

When did you last step out of your day to day activities, even momentarily, and think about what you are doing? Perhaps by attending a seminar, conference, over a cup of tea with colleagues, a workshop, training event, business lunch, on a long drive or by attending to your breathing before an important presentation? All of these can be sites for reflection on what we do.

But reflection can move to another level – we can pause to think about why we do what we do. At its simplest reflexivity can be understood as a higher order form of reflection.

As outlined by Alvesson and Sköldberg (2000) reflective practice pays attention to two main forms of action: (i) careful interpretation and (ii) reflection. Reflection involves pausing to consider what is being done in terms of the thinking and actions by an individual or group and exploring the possible consequences for all involved or potentially affected by an action.

Reflexivity starts to operate when in one’s daily practices you move beyond reflection and interpretation (first-order processes) to reflection on reflection or interpretation of interpretation (second-order processes). Reflexivity concerns both what and why.

A key aspect to reflexivity is seeing yourself as always part of the situations you are in and acting with awareness that this is always the case.

In our Open University (OU) course ‘Managing systemic change: inquiry, action and interaction’, which is a core course in the Systems Thinking in Practice (STiP) Masters program, we ask students in the first instance to think about their situation of concern (S1) as their participation in the course itself in which they are developing their practice so as to become better at managing systemic change in a situation of concern to them (S2). Our aim is to provide experiences which develop their reflexive systems practice capabilities. The course explains how choices that are made to frame and understand situations are critical to the type of practice that happens.5

5 In this chapter I draw upon Ison (2010a) which is studied as part of this course as well as material prepared in conjunction with my colleague Chris Blackmore for the course (OU code TU812) study guide.
Method and methodology are sometimes used interchangeably although it is not advisable to do so. Method means a way of teaching or proceeding, derived from the Greek ‘méthodos’, meaning ‘pursuit’, or to ‘follow after’; thus today it commonly means any special procedure or way of doing things (see Ison 2010a). From this the adjectives methodic, or methodical, arise meaning something done according to a method. In research and practice fields, there is often confusion between method and methodology – in literal terms the latter means the logos, or logic of method. However, the place of methodology in everyday practice is not as clear as in, say, research practice, but even then confusion often exists. On the other hand, whenever we act we usually employ some tool, technique, or method and often sequence these in particular ways.

For some time I have found the definition of methodology as the logos of method too limiting. When I ask what does this mean in practice then I usually find that someone has claimed to be using methodology through a written description (such as a paper) or in a claim after use in an interpersonal or organisational situation. For me both these ways of claiming use of, or the doing of, methodology lack a means for experiential verification and thus fail to address the critical difference between espoused theory and theory-in-use:

Argyris and Schön (1974) assert that people hold maps in their heads about how to plan, implement and review their actions. They further assert that few people are aware that the maps they use to take action are not the theories they explicitly espouse. Also, even fewer people are aware of the maps or theories they do use (Argyris 1980).

For this reason I claim that what is or is not methodology can only be claimed in reflection, i.e. after the event (or ex post) by a group of theory-informed users concerned with the degree of coherence, or congruence between espoused theory and practice. That said all can aspire to act methodologically as part of everyday living. Think about using a street directory to find out where a friend lives: this involves knowing how a directory is organised, knowing how to use an index, reading map coordinates, and then taking the right directions and turns. So when you successfully arrive at your friend’s house you could claim that you have mastered a particular method – street directory using. Systems approaches in particular invite a focus on method, but it is even more important to move beyond method, to the enactment of methodology.

In the example of a Street Directory it might be used methodically (i.e. as method) or methodologically (i.e. as methodology). An example of the latter would be if, in response to experiencing the Directory as poorly designed, a more effective one was developed based on a redeployment of the underlying concepts or the invention of new ones. Of course you may regard street directories as yesterday’s technology with the advent of ‘sat navs’ and phone applications. In many ways developers of new mobile phone applications and the like save us the effort of having to think and act methodologically. On the other hand as innovators they have to imagine

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themselves into the lives and situations of potential users if they are to develop new applications that are commercially successful. This is a version of acting methodologically (see Ison 2010a).

Technique, tools, method and/or methodology are usually inextricably wound up in what we do. Thus to respond to the question what do we do when we do R&D, it will be important to know something about the techniques, tools, methods and methodologies with which you are familiar and to reflect on how they are incorporated into your overall practice dynamic.7

I have now discussed P (practitioner), F (framework of ideas, or theories), S (situations) and M (method or methodologies) in relation to Fig. 7.1. But there are still other features to be appreciated from this figure. For example if you are engaged in purposeful practice then it is feasible, some might say sensible, to learn about change in one or more of the different elements e.g., Was my choice of framing of the situation adequate? Was change in the situation appropriate? Did I have the right set of ideas? Was the method used well? You could also consider your practice as a type of performance in that your effectiveness could be related to how well you combine the different elements, P, F, S, and M to create a performance that was suited to the context. Hence the question: Was my performance effective? can be asked. What constitutes an effective performance arises through a relational dynamic as does that of a band, for example: i.e., an effective performance is an emergent property of a relational dynamic between members of the band, with different histories and instruments creating a performance in a given context in relation to an audience (which changes over time).

There is one final feature of Fig. 7.1 that I want to draw to your attention. This is the person standing outside the thought bubble. This is the practitioner (you) again. In this depiction the practitioner is adopting what can be described as a second-order or reflective perspective on their own practice. Something is second-order when it is applied to itself e.g. learning about learning, the practice of practice, understanding understanding etc., (see Box 7.1). Questions that arise from this second-order perspective include ones like: Is this P, F, M, S dynamic an adequate way to understand practice? Or: What is missing or hidden from ‘view’ in this particular way of thinking about practice? For example, one limitation of this heuristic is that it can lead the reader to interpret practice as a solitary or individual activity. However, as explained in Ison (2010a), my own understanding is that we are never outside social relations and humans live in language; in other words there are always others in a situation and most of our practice is done with others even though I have chosen not to depict this added complexity in this figure.

In everyday practice, ‘situations outside of our selves’ are generally the main concerns of non-reflective practitioners. Mainstream practice seems to privilege a concern with situations over the other elements of practice (and thus change) depicted in Fig. 7.1. In my experience most practitioners involved in managing and affecting change seem to have little awareness about the choices that can be made.

7 And it is a trap to think of tools and techniques as existing outside a practice and purpose dynamic.
to frame situations. And this lack of awareness constrains managing change systemically (Ison 2010a). For example, in a major research project concerned with social learning and the management of water at catchment scale (SLIM) we chose to frame water catchments as social, or human activity, systems in which sustainability was understood as an emergent property of stakeholder interaction, and not a technical property of the ecosystem (Ison et al. 2007)

**Systems practice**

In the previous section a model of practice as a relational dynamic was presented (Fig. 7.1) but little has been said about what differentiates everyday practice from systems practice. Let me start this section by making the claim that what is or is not systems practice arises in the social dynamics or relations of those who concern themselves with the question. You may or may not regard yourself as understanding, or having done some, ‘systems practice’ – note these are not the same. For example, many write about systems practice without having done any – yet we might claim that the authors understand systems practice because they have had their papers accepted for publication (which is in itself a process developed in a particular historical configuration of social relations involving journals, referees, editors etc.).

At the Open University some of us adopt the use of Systems with a capital S to note the intellectual – the theoretical and practical – field of scholarship associated with systems thinking in practice. Unfortunately few of those present at the 1985 meeting I mentioned earlier had a well-developed, comprehensive appreciation of the intellectual field of Systems scholarship (Fig. 7.2). It could be argued that this continues to be the case within the bulk of the community who associate themselves with Farming Systems Research or FSR-related events and activities.

Figure 7.2 is best read from right to left (more or less). The diagram is a sort of trajectory diagram of systems approaches. Down the right-hand side is a set of contemporary systems approaches which are written about, put into practice and sometimes taught. Some names of people (systems practitioners), associated with particular approaches and lineages, have been added, though the choices are far from comprehensive (see Ramage and Shipp 2009; Reynolds and Holwell 2010; Blackmore 2010 for more detailed backgrounds). If one does a search, most of the systems approaches listed in the grey-shaded area of the figure could be found with a reasonable literature associated with each. They can be understood as more-or-less contemporary forms of approach to systems practice.

On the left, seven formative clusters are identified that have given rise to these contemporary systems approaches. By following the arrows backwards it is possible to get a sense of some of the different lineages, though rarely are they as simple as depicted here. This figure has many limitations and it is not possible to describe all these influences or approaches in detail but it does capture a way of understanding the ‘Systems field’.

The approaches on the right are also organised from top to bottom in terms of what are perceived, by me, to be common commitments, or tendencies, of a majority
of practitioners within the given approach. These ‘commitments’ relate to seeing systems as ‘real entities’ (ontologies) or heuristic devices (epistemologies). These terms and their differences and implications are discussed below.

Some of the limitations of this figure are explored in Ison (2010a:29). For example, many people after seeing an earlier version of this figure became concerned that something, or someone, was missing. If this is also the case for you, then it helps to make the point that, like all disciplinary fields, Systems is not a homogeneous field – how it understands itself, just like physics or psychology is contested. This is also an Anglo-centric set of lineages and much more could be added from Spanish, German, French, Brazilian, Italian and other systems traditions. So, please feel free to take this figure and adapt it as you see fit as your study of Systems deepens. Or develop your own ‘model of the field’ – mine is not the only one as Fig. 7.3, prepared by Richard Bawden (2007), shows.

The idea of the adaptive whole is one of the key images central to most accounts of Systems (Checkland and Scholes 1990). This image reveals certain key features which continue to be useful such as that of holism, the concept of a whole and the changing nature of the whole in relation to a context – which can be described as a

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**Fig. 7.2** A model of some of the different influences that have shaped contemporary systems approaches and the lineages from which they have emerged (Source: Ison 2010a)
co-evolutionary dynamic (Collins and Ison 2009a). What it conceals however is the observer (person or group) dependent formulation – bringing forth – of a system through the distinction of a whole in a context by the act of making a boundary judgment (Fig. 7.4).

Figure 7.4 depicts one of the key practices associated with systems practice. It is the act, or practice, of distinguishing or formulating a system, in a situation as a way of thinking about and acting in that situation. The woman in Fig. 7.4 is conceiving of the situation in a particular way known only to her. She could be thinking about fish for dinner, and hence her conception of what her system of interest does (its purpose) is to produce fish. By seeing ‘a system to produce fish’ she is focusing first on what the pond is for from her perspective. She is creating a ‘system of interest’. Equally she may be thinking in terms of protecting endangered species, or of creating a garden pond. Systems of interest are devices related to purpose, so that the boundary and subsystems will be different in each particular system of interest. Systems of interest even in the same situation are also likely to differ somewhat because each is constructed or formulated by one or more people who have different experiences and backgrounds and possibly purposes.

The key systems concepts that are involved in formulating systems of interest are:

- making boundary judgments
- creating the levels of system, subsystem, suprasystem
Systems practice

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• distinguishing a system from an environment – that outside the system boundary – which I understand as creating a relational dynamic between system and environment mediated by a boundary, rather than ‘a thing’ called ‘system’
• elements and their relationships
• attribution of purpose to the system
• monitoring and evaluating the performance of the system against named measures such as for efficacy, efficiency, effectiveness, ethicality

Following the logic behind Fig. 7.4, the adaptive whole is not the system but the person(s) + their system(s) of interest learning their way to new understandings and practices which are systemically desirable and culturally feasible. The point I am trying to make here is that a system of interest is a chosen way for someone to know about and thus act in a situation. To move to this perspective for some involves making what is known as an epistemological shift – a shift in their way of knowing about systems. The nature of this shift is depicted in Fig. 7.5. I appreciate this shift as an expansive and ethical shift in that it opens up more choices for pursuing purposeful action to change things for the better. This can be understood in terms of Fig. 7.5 – when one is aware of the different ways of “seeing systems”, and that how to “see systems” are purposeful choices that can be made in context sensitive ways, then the range of practices at our disposal expands (i.e. both choices in Fig. 7.5 are available, the difference being that in the right hand case a choice is made to act as if systems exist). On the other hand, maintaining a commitment to a “systems are real” perspective traps those who hold it into a more limited range of practice options.

I claim that the lack of epistemological awareness and thus flexibility around the concept and practice of Systems in Farming Systems Research has constrained innovation and change, and as a consequence this has limited institutionalisation of, and investment in, practices that are informed by systems thinking and practice.

Fig. 7.4  Key elements of systems practice as a process – within a situation a system of interest comprising a system (with subsystems), boundary and environment is ‘brought forth’, or distinguished, by someone as they engage with the particular situation (Source: Ison 2010a)
Before considering why it is that systems practice, even in the context of Farming Systems Research, has not become mainstream, let me return to the question of what constitutes systems practice. From my perspective providing a definition is inadequate because in social relations a definition in the social domain is too often interpreted, knowingly or not, as a demand or exhortation to do things my way! Instead, under the aegis of the question: what is it that we do when we do systems practice, I would claim that we make connections of different types and quality with a particular history – of the types depicted in Figs. 7.2 and 7.3 – and incorporate concepts into our language games (following Wittgenstein) as explanations and doings which in the social relations we inhabit (including our own reflections) enable claims to be made, or not, that what we do is systems practice.

Institutionalising systems practice

In the water field, historically dominated by engineers and water technologists, Milly et al. (2008) outline how historically, ‘stationarity’, the idea that natural systems fluctuate within an unchanging envelope of variability, ‘… is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning’ and ‘finding a suitable successor is crucial for human adaptation to changing climate’. The same arguments pertain in the field of Farming Systems Research and
Systems practice related fields. The application of traditional governance mechanisms such as regulation, fiscal and market instruments and education or information to traditional framings of situations as knowable and fixed ‘problems’ has also proven inadequate in situations better framed as “wicked” or as Ackoffian “messes” (APSC 2007; Ison et al. 2007; Armson 2011). Performances and designs built on stationarity and fixed knowledge forms give rise to systematic (i.e. linear, step by step) practice rather than systemic practice that is relational, recursive and circular and characterised by learning and adaptation (Ison 2010a; Ison et al. 2011). As outlined by Steyaert and Jiggins (2007), in situations characterized by uncertainty, complexity, interdependencies, conflict, multiple stakeholders and thus perspectives and where history, and thus pathway dependency, matters a key focus of practice becomes how situations can be transformed, for the better, through social learning.

Arguments for investment in ‘social learning’, as an alternative environmental governance mechanism, rest on similar conceptual assumptions to those arguing for the ‘death of stationarity’ (Collins and Ison 2009b). Coping with the complex crises of our times will require new forms of social learning and political engagement to dramatically enhance capacities for institutional innovation (Ostrom 2010). Findings from a major R&D effort in West Africa by Dutch agricultural researchers exemplify the point I wish to make (Hounkonnou et al. 2012). Reflecting on this work, plus over 40 years of R&D activity by some of the researchers involved, they conclude that the main necessary condition for agricultural development is an enabling institutional context. They initially attempted research based on a PTD (participatory technology development) approach and found that as a stand-alone effort it was insufficient to deliver lasting innovation. They observe (Hounkonnou et al. 2012):

Farmers might be knowledgeable, skilled, motivated, and empowered, and have participated in developing technologies that are perfectly suited to their circumstances and farm management objectives, but if opportunity is lacking, technologies that fit smallholders’ circumstances allow only marginal improvements. That, at least, is the conclusion from eight carefully researched field experiments with PTD in Benin and Ghana in the CoS programme …. As a consequence, the researchers involved started to experiment with institutional change at higher system levels than the field and farm. Smallholders themselves have insufficient power to change the rules, norms, procedures, laws and so on – in brief, the institutions – that limit their opportunities.8

Perhaps not surprisingly, I have arrived at similar conclusions to these Dutch researchers but based on experiences in different contexts and in relation to different situations.

Just as agricultural innovations lack conducive institutional settings for ongoing success so does ‘systems practice’. Understandably why this is so is a systemic issue of some complexity (see Ison et al. 2008), but there are five settings in particular that militate against the institutionalisation of systems approaches. These are: (i) the pervasive target mentality that exists in many countries and contexts and which gives

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8CoS refers to a Convergence of Sciences research program.
rise to systematic rather than systemic practices; (ii) living in a ‘projectified world’ in which the ‘project’ has become one of the most pervasive institutional arrangements through which we organize our activities. Projects as currently understood favour systematic practices at the expense of systemic. In Ison (2010a) I outline how systemic inquiry could become an antidote to projectification because, as a form of systemic practice, it starts by accepting uncertainty. This in turn changes the underlying emotional basis of those who participate so that they are open to the circumstances of the situation; (iii) ‘situation framing’ failure; (iv) an apartheid of the emotions (by this I mean that the emotional basis of being human which underpins all that we do when we do what we do, has been institutionalised out of scientific discourse about the doing of science) and (v) institutional complexity (see Wallis and Ison 2011 where this issue is further explicated).

I argue that in domains such as systems practice, integrated agricultural research for development (IAR4D), and mainstream R&D there is a need to take an institutional and design turn. For example, institutions for development, or water governance, or ecosystems services can be designed systemically in context specific ways that build local ownership (stakeholding) and provide contributions to the sustainable livelihoods of key stakeholder groups such as the rural poor. There is growing recognition, and evidence, that in the context of the governance of human-environment interactions, a panacea or blueprint for a single type of governance institution (i.e. a universal class of institution) that is applied to all environmental issues is likely to fail when confronted with pervasive uncertainty and contestations over what is at issue. I go further and contend that the globalization of Higher Education and R&D is also generating perverse institutional arrangements, such as universal metrics, that create, or have the potential to create, a form of systemic failure.

My recent research has been concerned with how to transform current water governance paradigms which are based on inadequate management and resource framings (Collins and Ison 2009b) to a governance regime which is systemic and adaptive and places new institutional innovations, such as ecosystem services, and their livelihood impacts, centrally rather than peripherally – in effect creating a new political economy of water governance (the same need could be claimed for IAR4D). New capacities, particularly for trans and interdisciplinary and systemic action research (see Ison 2008, 2010a where these terms are explicated) are urgently needed with supportive institutional arrangements.

What next?

FSR arose primarily as a reaction to the inadequacies of R&D based on narrow disciplinary perspectives and the increased recognition that farmers and local people were inside the system boundary (see Packham 2011). These were conceptual, and sometimes practical, innovations that delivered many benefits. But in aggregate the potential benefits remain constrained by an R&D system with the
wrong measures of performance (for researchers and funders). There has also been a failure to develop the requisite variety of institutional arrangements to secure an on-going learning and adaptation paradigm staffed by professionals with an appropriate mix of capabilities including doing systems practice and working in inter, trans and action research modes. However this situation can be remedied without losing the benefits of disciplinary expertise as long as future practice is primarily context (rather than discipline) focused (e.g. McCown et al. 2009; Stirzaker et al. 2010). The starting point for this shift is to address how and by whom R&D situations are framed and the practices that follow from this choice. I see much potential for the further development of systems practice capability as (i) a key enabler of social learning in which those with stakes in an issue jointly “construct” and transform what is at issue through learning that happens through changes in the understandings, practices and social relations of those involved and (ii) as a source of expertise to make potentially useful systemic concepts like a socio-ecological system operational in a systemic and adaptive governance regime. Unfortunately the situations of most contemporary concern are unlikely to be transformed by ‘business-as-usual’ approaches (Ison 2010b).

From the perspective of developing rigor, systems practice, although a trans-discipline, could itself benefit from some of the institutional arrangements that are useful in other disciplines – this has been achieved for “design”, another synthetic, praxis-based trans-discipline, but as yet the demand pull for systems practice capability has not been strong enough to lead to the investment and institutional innovations that create a viable trajectory in the organisations associated with R&D. I sincerely hope this book will contribute to greater ‘demand pull’ by facilitating innovations able to reposition the ‘systems’ in Farming Systems Research so that future R&D is more effective in meeting the needs of our times.

References


Chapter 8
The role of action-oriented learning theories for change in agriculture and rural networks

Chris Blackmore, Marianne Cerf, Ray Ison, and Mark Paine

Abstract Links between learning theories, action and practice are explored in order to focus on the idea of action-oriented learning theories. The nature of learning theories is examined and their role in changing practices associated with issues of food and farming systems or resource management. Levels and cycles are distinguished as key dimensions of learning theories that can be used in designing learning programmes using individual or group-based approaches. The relationship between learning, change and practice is considered and which kinds of learning theory might be used in different situations in which issues of change are to be addressed. Examples are provided from the European LEARNing project. Difficulties are revealed in whether and how ‘learning researchers’ make explicit their theoretical perspectives in relation to issues of learning and change in given situations. A conceptual framework is therefore developed, intended to be used as a heuristic device to support researchers in reviewing their perspectives.

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Introduction

The beginning of the twenty first century has seen unparalleled rates of change in our environments and, in the context of the concerns of this book, we do not need to look far to see evidence of these changes in food, agriculture, environment and rural areas. For instance, an increase in extreme weather events associated with climate change has led to more floods and droughts in many parts of the world. Their consequences have included loss of life and livelihoods, rising food prices and threats to food security (IPCC 2007; U.K. Government Global Food Markets Group 2008). Changes in land use are also evident, for instance where crops are being grown for biofuel (Jones et al. 2010) also in areas such as the Argentinian Pampa where soybean extends to the detriment of livestock production. Human activity is now clearly linked with planetary level changes as critical thresholds of human activity (e.g. for climate change, rate of loss of biodiversity and interference with the nitrogen cycle) are being crossed with increasing calls for changes in governance that will support adaptation and more sustainable ways of life and mitigate harmful effects (Park et al. 2008; Speth 2008; Rockström et al. 2009).

Multiple interpretations of these and related changes and how we should respond have long been a feature of working with learning theories and their associated methodologies in the context of attempting to learn our way to sustainability. These interpretations are evidenced in previous publications of the LEARN group (e.g. LEARN 2000) and conferences of the European Group of IFSA (International Farming Systems Association), where for many years there has been a strong focus on researching learning and change. However, what appears to be lacking in this work to date is a framework to help take an overview of how learning theories and situations might be brought together to manage change and learning as well as to produce new insights on learning and change issues. This is perhaps not surprising because the boundaries of our activities, theories and situations are themselves changing as we try to accommodate more complexity in the agricultural world in constructively addressing issues of learning and change (Fig. 8.1).

In this chapter we propose a framework which hopefully will support exchange in the learning community of farming systems’ researchers and practitioners. Its aims are to clarify the theoretical perspectives we adopt to support learning activities as practitioners and researchers who are involved in change management. The chapter does not provide a review of learning theories, because these are available elsewhere (e.g. Ison et al. 2000; Blackmore 2007; Wals 2011). We will instead answer the question: how can I be explicit about the way I bridge a learning theory and a situation of change in which I want to achieve practical outcomes as well as scientific understanding? Further to our experience with the LEARNing project,1

1 LEARNing in European Agricultural and Rural Networks: institutions, networks and governance (Contract no. HPSE-CT-2002-60059) was an interdisciplinary project involving eight European countries and Australia. It ran from 2002 to 2005. Based on interactive approaches and stakeholders’ participation, the project aimed to build a research agenda for social sciences on R&D in European agriculture. The main emphasis was to engage stakeholders in a new way of learning to tackle emerging issues like multifunctionality, food safety, rural development, and environment.
we suggest some questions which we believe ought to be addressed by a learning researcher so that exchanges amongst those involved in researching and managing learning and change issues in agricultural and rural networks might further develop their work. We conclude with some observations of contemporary issues impacting on learning and change in agricultural and rural networks which we speculate will challenge our current theoretical frameworks, particularly with respect to uncertainty and change in political and local social contexts.

What do we mean by learning theory and how does it relate to action and practice?

By theory we mean how we construct and organise concepts to form a coherent explanation of a phenomenon we want to understand. For example, if we were behavioural psychologists we might represent learning using operant conditioning – concepts about stimulation (e.g. rewards and punishments) and concepts about the learner’s response to stimulations (e.g. repeat or avoid) which would be organised so that learning behaviour would be described in terms of a conditioning process that is based on new stimulus-response routines. To hold such a view of learning requires a certain view of the learners and the world within which they act. It is also based on a particular view of knowledge and truth.

Such a behavioural perspective is currently absent within the works carried on in the European Group of the International Farming Systems Association (IFSA). Indeed, it is noticeable that this community views learning mainly as the way people make sense of their actions with respect to particular situations or issues, whether in everyday life or in a professional capacity, with a view to taking further action on the issue. From this perspective, practice and learning are emergent properties of
people’s actions. They are also constitutive of each other. Learning is understood as a process which emerges from acting in an uncertain and changing environment and which might result in the emergence of new practices or new perspectives on situations. Learning is experiential or/and social and is considered as occurring in an action-oriented practice rather than in classrooms. To quote Wenger (1998) “the concept of learning is not absent from the… office, but it is used mainly for trainees…. One reason they do not think of their job as learning is that what they learn is their practice …. What they learn is not a static subject matter but the very process of being engaged in, and participating in developing, an ongoing practice.” Learning is not the purpose of a dedicated practice, but occurs while developing new practices or new perspectives on situations.

In this text, we will consider that a practice is the generally accepted and shared, habitual, taken for granted ways of performing an activity, with its attendant values, understandings, communications and cooperative routines. For practitioners learning becomes visible through their practices. Indeed, learning is seen as the human response to tackle issues that require change. The main idea therefore is that learning is a key process to face variability, uncertainty and transformations in one’s environment.

**A focus on action-oriented learning theories**

In most of the work undertaken on learning by researchers who belong to the farming systems community, learning theories have a twofold purpose. One is *utilitarian*, meaning that researchers use a learning theory to develop their methodology when they wish to ground their participation in collective action to confront situations of change. The second purpose is *comprehensive*, meaning that learners use and adapt theory to capitalise on learning as it occurs in the process of transformation. They purposively seek change in themselves and the theories they use as part of a systemic transformation. In this chapter, we will mainly discuss the need of a framework to bridge a theoretical perspective and a situation from a utilitarian point of view, e.g. to try to find out why we choose a learning theory in a given situation of change, rather than showing how farming systems researchers have contributed to the evolution of learning theories.

Learning is a ubiquitous phenomenon: it can be seen as part of everyday discourse, or as part of specialist practices associated with certain professions. Indeed, historically ‘learning’ was the province of philosophers, psychologists and teachers who were interested in how it happened or how to create the circumstances for students to learn. For some time now ‘learning’, as a focus for study, has been of much broader interest. ‘Learning’ has become a concern of fields such as management, ergonomics, cybernetics, organizational studies, action research, rural development and natural resource management. There are now many intermediary learning theories that have built on earlier work which described basic principles of learning.
This diversity of theories has meant that it is not always possible to appreciate which views of ‘learning’ have most informed practitioners in research and change management. Yet many learning theories still underpin what researchers choose to observe and ignore when they try to understand the way individuals or collectives adapt to or anticipate change and transform their practices.

If one accepts that learning is a natural part of human life, then those who are concerned with improving the capacity to deal with a changing environment, and the capacity to act collectively or individually in this changing environment, are more likely to succeed if they can articulate what aspects of ‘learning’ they are interested in and why. This raises ethical questions about the nature of knowledge and the purposes for understanding ‘learning’. Changes in behaviour, changes in a learner and changes in learners’ relationships with others and/or their environments may all provide evidence of learning, depending on how one focuses on specific learning and on how learning is theorised.

### Changing practices and applying learning theories

To choose a relevant theory when acting as a facilitator or a participant in a collective action addressing issues of change one has to be able to match specific features of learning theories with the required changes at a practice level. There are many practices in society and numerous studies have been made of professional practices in various organisations and work situations to investigate the learning dynamic operating in professional organisations (Howard 1994). Here we are focusing more on practice as it relates to rural activity – a special type of practice that stipulates the actions, materials, concepts and values that practitioners employ to address issues of food and farming systems or resource management. LEARN (2000) and the SLIM project on social learning in the context of Europe’s water (Blackmore et al. 2007) provided some useful case studies and reviews of learning theories as they applied to practical situations like the performance of weed control, olive production or cattle reproductive management practices, the advisory work for strategic management and water management at catchment scale. A number of questions arose from these studies such as:

- How do new practices emerge?
- What role do cultural and historical conditions play in this emergence?
- How are power issues dealt with during the adaptation and developmental process that is associated with learning?

These questions started to be addressed in some studies. A first way to address them has been to mobilize Wenger’s work (1998), and adapt it to agricultural and rural work situations (Blackmore 2004; Attwater and Derry 2005; Oreszczyn and Lane 2006), to illustrate the emergence of new practices. Wenger (1998) talks of a “community of practice” (CoP) that arises when a group of people share a need to take
action on some issue and choose to work together to change the situation. Three features determine how these communities of practice emerge. The *domain* or sphere of activity distinguishes between practices. Second, *community* is about people engaging in discussion and discovery to build new competencies – a type of social learning. Third, *practice* is about taking action, where the ‘tricks of the trade’ are employed to deliver a competent performance. For instance, Blackmore (2009) distinguished a range of related domains, communities and practices in her research on learning systems in the context of environmental decision making. The UK New Forest community associated with managing the forest was one example of a CoP that she encountered.

But the emergence of new practices was not always addressed according to Wenger’s theoretical approach, specifically when situations of change imply interdependency among multiple practitioners to find a way out. This was for example clear in the cases studied in the LEARNing project, some of which are detailed below. Such cases typically involved multiple practitioners and people concerned by the issues at stake, practitioners taking action in pursuit of their particular goals. Therefore, attention was then paid to cultural and historical conditions, and power asymmetries. They were seen by the researchers involved in the case studies as important issues to reflect on to facilitate the emergence of new practices. This has been achieved through ‘critical engagement’ or by means of ‘mediating tools’ (such as metaphors, intermediate objects or concepts) or by building an invitation to develop a multi-voiced perspective on the situation and the problem at stake. Interdependency among practices was made clear in most of these case studies, resulting in the need for changing different practices so that they could interact in ways that will be relevant for each individual while also achieving outcomes that are beyond the reach of each practice acting independently. It should be acknowledged however, that this ‘win-win’ emergence of new interdependent practices needs to deal with power issues and also means vision building.

In a rural context, issues like the management of water resources in catchments are typically dealt with through negotiation among different interdependent practitioners and collective action and are no longer left to engineers to solve. Cases from the SLIM project, that considered social learning in managing water resources at catchment scale, provide examples, such as the case of a pro-active multi-stakeholder collaboration that emerged in the Benelux middle area (BMG), where farmers and horticulturists worked with water boards to find an alternative to a ban on sprinkler irrigation that would still help to avoid depletion of groundwater (Jiggins et al. 2007). An effective adaptive process would see the practices of these various professions coming together to build strategies of action in the catchment. Here, it was argued that these professions also share vision building and reflexivity that influence the building of strategies – each practice changing as a consequence of sharing in the catchment management with others.

In saying that vision building and reflexivity are sometimes required to support the emergence of new practices, what does this imply in terms of learning processes, and which learning theories then become useful? To decide, we suggest that it can be useful to more explicitly identify two main dimensions in the learning theories we use.
Levels and cycles: key dimensions of learning theories

A first dimension concerns what is referred to, in many studies, as levels of learning. Many authors have proposed to distinguish different levels in learning to give account of the relations between practice and learning whether for individual or collective action. For example, Bateson (1972) distinguished three levels of learning:

- Level I: routine learning that takes context as given;
- Level II: learning about the context of level I, i.e. learning about learning;
- Level III: learning takes another step back to learn about the contexts of level II.

Argyris and Schön (1978/1992), in relation to change, distinguished first order (learning is linked to a change in the strategy) and second order (learning new values). Mezirow (1990) distinguished learning to use efficiently one’s frames to act, learning new frames, changing the perspective on action, changing mental habits. Kitchener (1983) distinguish three levels in learning which Ison et al. (2000), in studying the practice of rotational grazing, extended to four levels: pre-cognitive (routine), cognitive (rule based), metacognitive (reflective practice), and epistemic cognitive learning.

- Pre-cognitive level: the practitioner repeats actions without question, because he or she has already made sufficient sense of the task to succeed without thinking, each subsequent act reinforces this understanding.
- Cognitive level: the practitioner is a learner, primarily concerned with attributing the changes in farm performance to the use of a particular rotational grazing practice.
- Metacognitive level: the practitioner is more concerned with working out ways of changing the rotational grazing practice itself.
- Epistemic level: the practitioner makes an inquiry into what it means to be a learner who is changing in an environment of change (the farm performance and the practice of rotational grazing).

A second dimension concerns the process of learning. Many authors have represented it as a cycle which links action and reflection on the action, as typified in experiential learning (e.g. Kolb 1984). Identifying a learner’s preference for acquiring and processing information provides a basis for designing learning programmes using individual or group based approaches (Paine 1995). Argyris and Schön (1978/1992) also develop a cycle approach to facilitate critical thinking about the relationship between learning processes and change management practices. Engeström (1987, 2005) has also elaborated on managing change within organisations and activity systems or networks (in fields like education, medicine, farms or agribusiness firms) describing this as a cycle of expansive learning. This latter approach puts emphasis on the role of mediation by cultural and technical tools and by others in the learning process. Indeed, the role of action and of ‘others’ (individually or collectively) has been differently addressed in designing these cycles.
We could elaborate on these and other perspectives, but this would add little more to our main line of reasoning. Why have so many learning theories emerged? We claim they are an intrinsic part of the learning endeavour itself. As the learning level assumes a greater depth of inquiry and the learning process acquires more sophistication in the elaboration of cycles, then the learner engages more actively in the development and use of learning theories. It therefore follows that a framework that facilitates this selection, adaptation and use of theories will support more effective change management (Fig 8.2).

Before proposing such a framework however, we first need to make a clearer statement about the relationship we identify between learning, change and practice.

The relationship between learning, change and practice

If we were wanting to ‘model’ the relationship between learning and change (and practice) we could say that they are intertwined in a common cycle – practitioners recognise that a particular event is provoking a new context and creates some
unforeseen problems for their practice which will require a learning response (either by themselves or others) that will in turn result in a change whether in themselves or in their environment. In practice this relationship is not so simple and how learning and change are related depends on what kinds of learning and what kinds of change are being considered. The relationships between for instance technical change and farmers’ learning can be very variable and are very much dependent on context (e.g. Collett 2011; Chantre 2011).

The distinction between first order and second order change is one example where learning is particularly relevant. First order changes tend to be routine changes where the overall ‘status quo’ in a situation is still retained, whereas second order changes are more profound changes in context that lead to new ways of acting. For instance, a gradual increase in on-farm energy use efficiency is likely to be a first order change, whereas a move to a new source of energy for farming practices and on-farm generation of energy for ethical, environmental and economic reasons is likely to be second order change. Learning is involved in both kinds of change but it is of different kinds. Levels and cycles of learning are key dimensions which are used to distinguish various change processes. First order change will be mainly carried on at pre-cognitive and cognitive learning, while second order change means metacognitive and epistemic learning. Usually, situations of change can move from first order to second order over time, or the reverse. So the question remains open: How to tackle the challenge of coping with the unexpected in practice and how to adjust and develop our learning theories according to the situations of change we are involved in?

In the LEARNing project, to enable us to contrast the situations we studied in various countries, using various learning theories, we chose to depict our work through common dimensions that enabled us to recognize diversity and contrast in various situations. The situations were ones in which the participants involved (including the researchers) were keen to start a reflexive process to identify some new learning issues and research questions to contribute to the building of a common research agenda for R&D in industrialised countries agricultures. Indeed, some of the specific theories and approaches that were seen as relevant to help us consider how to improve these situations of change were those of experiential learning, communities of practice, social learning, participatory learning, soft systems approaches, theories of knowing in activity, system and organisational settings and collective action. It still remains unclear to what extent our ability to manage change was linked to the issues of the change process and what was linked to our ability to observe and comprehend the phenomenon in each case study (here characterized at the level of a given country2). Looking back on the work undertaken in the IFSA community, we have to admit that this remains quite an opportunistic choice which is linked to our own history and research tradition; to the work constraints in the situation; and to the way we and others engage in the situation. For instance, this was clear in the LEARNing project, and we acknowledged the need to better identify what we meant by ‘situations of change’ and by ‘using learning theories’ to facilitate change in practices.

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2 For countries like France, different situations of change were selected.
Figures 8.3, 8.4, and 8.5 provide examples of some of the LEARNing case studies. (There were seven cases in all, three are provided here to give an idea of their diversity.) They are the authors’ interpretations of some of the data presented in the final report of the project (Hubert 2005). As such, these figures show the characteristics of ‘promising configurations’ for research and inquiry in which some of the LEARNing researchers engaged. Such configurations are briefly described in the middle of the figures. They were situations of change in which the participants (involving the researchers) accepted to start a reflexive process on what had been learnt by them as practitioners in the situations and on the changes which had occurred. Participants involved in contrasting the various situations at European level found it useful to clarify in which historical, political and social contexts this reflective process took place. These contexts are briefly described on the left side of the figures. Finally, researchers also discussed the kinds of theories they found useful in particular contexts and for particular purposes and the methodologies they develop to facilitate learning processes and reflexivity in the situations. Those theories and methodologies are briefly described on the right side of the figures.

Change in the different examples was analysed as emerging within some social contexts which are disturbed by a range of political or organisational evolutions within a particular historical context. In each social context, which here means the situation in which work is carried on jointly among researchers and some practitioners and stakeholders, the participants explored how they understood the evolution
Fig. 8.4 The case study from Greece involved a situation where a local development agency and local farmers were developing a rural project. Change issues arising from the particular historical, political and social contexts of the situation are addressed using a theory of conventions for collective action and methodologies associated with experiential learning and participatory action learning.

Fig. 8.5 The case study from UK involved a situation of emerging complexity among organisations and changing stakeholders in policies relating to agriculture, food, environment and rural issues.
of their political contexts to give sense to their individual and collective action and how they faced the uncertainty (reflexive stance on the learning process). Broadly speaking learning was here seen as emerging in relation to problems and opportunities experienced in processes of change as well as in relation to the emergence of a new perspective on the situation which enabled the participants to take collective action. Nevertheless, it was clear enough when comparing and contrasting these case studies, that in each situation, participants had to address a diversity of issues (linked to various contexts). They also chose various learning theories and methodologies to address them (Hubert 2005).³

It should be noted that not all the theories which the researchers acknowledged as a basis for understanding and coping with learning issues in collective action will be recognised as just ‘learning theories’ (for example, Greece and the ‘theory of conventions’, Koutsouris 2000). It clearly appears that the researchers worked with different theories (Fig. 8.6).

Even at the end of the project, it remained difficult to clarify if this was linked to the diversity of contexts, of situations of change we were working in, or if it was linked to our own personal background in learning theories. Indeed, we still found it difficult to make explicit our ways of bridging our theoretical perspectives and changes and learning issues at stake in a given situation. It started to become clear that we had not got to the point where we were able to discuss our practices as learning researchers, e.g. the way we choose to get involved in situation of change, the way we transform our theory for a utilitarian purpose etc. The following section is an attempt to suggest how this could be achieved.

³Seven country teams took part in this stage of the LEARNing project.
Bridging a theoretical perspective and a situation for the purpose of managing change and learning

Here we make a demand for reflection in research in conjunction with interpretation at several levels: contact with the empirical material, awareness of the interpretive act, clarification of the political-ideological contexts, and the handling of the question of representation and authority.

Alvesson and Sköldberg (2000:238)

The brief overview of what was done in the LEARNing project above indicates that one question still has to be addressed: how does one navigate through the many, often opposing, theoretical and methodological positions available for undertaking research on learning issues in agricultural and rural situations where change and uncertainty are the main features to be addressed through individual or collective actions? Researching learning requires a capacity to account for the learner and the observer of the learner, the latter being a learner too. Following this line of reasoning soon exposes many layers of interpretation surrounding the social interactions that involve learning and change.

A need to define our position as a learning researcher in a situation of change

Our position is aligned with that of Alvesson and Sköldberg (2000), who acknowledge that culture, perception, subjective cognitions, political drivers and ideological bias permeate the interpretations of events and acts observed and co-constructed by researchers in general. Researchers’ results and reports are coloured by all these forces. This does not mean that there is no existence or materiality beyond the egocentricity of the researcher. On the contrary, these forces are part of the social world that we aspire to and observe as we share in it with others. Our concern is more pragmatic: how do we position ourselves within our world of work so that the devices, methods and research practices that we develop would enable us to learn something new? The key to answering this question lies in our ability to unravel the layers of interpretation to which we refer.

A cardinal rule in researching learning is being aware of who you are in the learning and research process. This awareness extends to clarity about your theoretical and methodological perspective. Alvesson and Sköldberg (2000) propose to organise research methodology around four interpretative levels (or thought styles) that can be distinguished according to their predominant focus:

- **Metonymy**: an atomistic handling of data that gives precedence to data and the way it is handled when interpreting events;
- **Hermeneutics**: where the meaning of symbols is paramount, placing the use of metaphors as central to the research exercise;
• **Critical theory**: with prominence given to the over-riding political and ideological systems that determine the social world;

• **Post-modern irony**: this has the rhetorical figure dominating the interpretation of learning events. Here focus is primarily on the narratives of actors.

We suggest that a fifth interpretative level is also involved, which we propose to call ‘*interpretative intervention*’. At that level, the researcher favours a reflexive stance that focuses on the learning experience arising from the axes of intervention. For us, this interpretative move through experiencing changes with others and the building of means to reflect on that experience is the primary focus of the learning researcher.

Although each researcher involved in the LEARNing project had the opportunity to drive the work carried on in each case study according to his (her) own interpretation level, nevertheless, the move towards the Research & Development agenda was considered as requiring an interpretative move at different scales (local, national, European), each scale requiring specific means to learn something from the experience (see Elzen et al. 2012, this volume; Hubert et al. 2012, this volume). Nevertheless, we did not choose to make explicit the learning theory which underlined either the process or the learning level which we were trying to achieve when building this research agenda. The project became an opportunity to be more aware of our various theoretical perspectives on learning, as well as our styles of thinking about the social world as pointed out above. At times these different styles were mutually exclusive (or contradictory), but because they emphasize different aspects of the social world relevant to addressing learning and change issues. They could co-exist (and often do!) in particular work situations. Our experience was that such multiple perspectives can either enrich or undermine a team’s appreciation of learning and change. We recognized that it depends on how transparent the theoretical and methodological assumptions have been made, and the extent to which the team manages to foster mutual respect for alternative perspectives. Following our journey through the LEARNing project, we wish to put more emphasis on the need for an explicit statement about what constitutes an appropriate perspective for a particular task or circumstance; researching learning is not an ‘anything will do’ undertaking.

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**A need to make explicit the changes and the learning challenges at stake in a change process**

We should recall that learning situations vary in relation to a number of well-known parameters like the complexity of the problem or issue, its scale and significance, and the resources available to make a difference to the situation. These parameters are typically accommodated by those who, in that learning situation, have a responsibility to orient and manage the change process. When the objective is to learn from what is happening during the change process however, and therefore choose a learning research approach which is along the fifth level of
The role of action-oriented learning theories for change interpretation (interpretative intervention), we suggest the use of the following framework. In doing so we recognise that this framework is probably only likely to be of interest to someone in an interpretative mindset.

This framework provides eight questions which the learning researcher has to respond to in relation to the different levels of learning which might be required along a process of change (Table 8.1). The responses to the questions are examples, not an attempt to be comprehensive. The point here is that a learning theory can be evaluated for its relevance to a specific learning situation using the framework. For instance, if we are suggesting that where there is a high level of uncertainty about what constitutes knowledge (dimension 2) then a theory that takes account of epistemic learning needs to be sought. We also suggest that when the alignment of participants is primarily motivated directly by the issue or the task then a theory that takes account of pre-cognitive learning is probably relevant. In practice different responses to the questions, different orders of change and different levels of learning might be in focus alongside each other in the one situation. These responses and levels are not mutually exclusive, i.e. we are not suggesting that a focus at one level of learning excludes another and indeed many researchers of learning use a combination of focuses and theories. Our intent is to suggest that the questions might be common to all but the response to the question and its associated level of learning will vary with the particular change situation or challenge and with different stakeholder perspectives.

Table 8.1 could however be used to discuss the eight questions (i.e. along the lines of the table) with the participants in a given situation. This might support the discussion of the change and learning process and the actions which will be needed to enable participants to find their way out. Note that we have suggested that the kinds of change associated with pre-cognitive and cognitive learning are likely to be associated with first order change and metacognitive and epistemic learning are more likely to be associated with second order change – distinctions discussed earlier in this paper. This suggestion is purely intended to help in recognising different kinds of change, there may be instances in some situations where some kinds of cognitive change, for instance, could be considered second order rather than first order so this boundary between first and second order change in a particular context might not always apply.

If one is involved in developing a research methodology that is part of a more encompassing learning process, one has to cope with the uncertainty which is inherent to collective action: most of the time hypotheses cannot be formulated at the beginning of the process. It might also be difficult to definitively answer the questions that guide the project at the start and which may have provided the initial theoretical perspective to select an interpretative intervention. So Table 8.1 could be used when dilemmas arise in a given situation and need to be overcome to further develop the learning process. One can then assess if new features of the learning situation, new learning outcomes or dependencies have emerged which might require a change in the theory used to back up the intervention process. This table was developed after the LEARNing project, as something we learnt from managing it,
<table>
<thead>
<tr>
<th>Questions</th>
<th>Level of learning</th>
<th>First order change</th>
<th>Second order change</th>
</tr>
</thead>
<tbody>
<tr>
<td>What constitutes desirable change?</td>
<td>Preconscious</td>
<td>Taking action on the issue, challenge or opportunity</td>
<td>Building new theory to take action on the issue, challenge or opportunity</td>
</tr>
<tr>
<td></td>
<td>learning</td>
<td></td>
<td>Building awareness of the issue, challenge or opportunity</td>
</tr>
<tr>
<td>What is the status of knowledge in the learning situation?</td>
<td>High degree of certainty about what constitutes a fact</td>
<td>The validity domain of what constitutes a fact is questioned, also certainty remains on what constitutes a fact</td>
<td>Uncertainty on what should be considered as a fact in the situation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High controversy, high ambiguity, high level of uncertainty</td>
</tr>
<tr>
<td>What motivates alignment of participants?</td>
<td>The issue or the task</td>
<td>Agreement on the way to handle the task</td>
<td>Agreement on the need to find out the problem to be solved</td>
</tr>
<tr>
<td>To what extent is participation required?</td>
<td>Competitive culture</td>
<td>Co-ordination is required due to interdependency in action</td>
<td>Collaboration is required due to cognitive interdependency to find out the problem</td>
</tr>
<tr>
<td></td>
<td>High degree of autonomy</td>
<td></td>
<td>Collaborative culture</td>
</tr>
<tr>
<td>How dependent is the action on reflexivity?</td>
<td>Rapid response required; high penalties for procrastination; narrow windows of opportunity</td>
<td>Answer can be delayed but has to take place in short term</td>
<td>Exploration is needed, multiple goals and world views have to be acknowledged</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Complex situation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Extensive ambiguity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multiple goals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Numerous dilemmas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prevalence of paradoxes</td>
</tr>
<tr>
<td>How facilitation and mediation are performed</td>
<td>Instructional</td>
<td>Distributive</td>
<td>Co-analysis</td>
</tr>
<tr>
<td>How is learning performance assessed?</td>
<td>On achievement of outcomes</td>
<td></td>
<td>On effectiveness of process</td>
</tr>
<tr>
<td>How is the knowledge retained?</td>
<td>Heuristically</td>
<td>Heuristically</td>
<td>Formal protocols, principles, models and theories</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Formal protocols, principles, models and theories</td>
</tr>
</tbody>
</table>

The researcher can use this list of questions to identify a way to address change and learning issues when involved in a given learning situation. Generic answers to these questions are suggested in the text, but these can be refined and improved by any researcher who uses this grid. It should be noted that in a learning situation, answers to the questions can move between the various levels. The table is primarily a tool to reflect on researcher engagement and participation at various moments.
some dimensions of the approach were also reviewed within some of the case studies (e.g. in France, Netherlands and UK) with partners in the projects. It provides a potential means to facilitate reflexivity on the learning process. In line with this purpose, the table can be used to mediate the different learning ‘theories-in-use’ (to refer to Schön’s distinction, 1983) and enable participants to be explicit about their use and recognise which theories are appropriate to their own contexts.

Finally we also have to question ourselves as research participants about our own pathway: how are we building our own questions and organising our own answers to these questions? We have therefore come full circle, to revisit ourselves as researchers before, during and after the learning process. Are we ready to apply in our own practice what we suggest to others? How do we profit from interacting with others to be more reflexive about our own practice and to develop new frameworks of understanding? How do we capitalize on all our experiences?

Conclusion

Researchers who are concerned with issues of learning and change in agricultural and rural networks to be addressed through individual or collective action face many challenges to their current theoretical perspectives, particularly with respect to uncertainty and change in political and local social contexts. The nature of these uncertainties and changes has been shown in some of the case studies of the LEARNing project and other examples in this chapter. Today’s societies are increasing the data and information content provided to learners through new technology, but this is not necessarily transformed to knowledge and understanding. This is because the capacity to comprehend information is in part dependent on adequate theoretical perspectives being employed in a way that relates concepts to practice. We have argued that it is important to be able to make the different dimensions of these perspectives explicit to navigate through the many, often opposing, theoretical and methodological positions available for undertaking research on learning issues in agricultural and rural situations.

The framework offered in this chapter is intended to accommodate most contemporary learning situations in which change in practice underpins our ability to cope with complexity and uncertainty. It is however amenable to critical scrutiny and improvement through application in the increasingly volatile, complex and uncertain environment characterising change in the rural sector.

Acknowledgements We wish to acknowledge the special group of people who constituted the LEARNing project. Their critical engagement, personal warmth and friendship made all that is written here possible. They included: Christophe Albaladejo, Isabelle Avelange, Marc Barbier, Rémi Barré, Marco Barzmann, Nathalie Couix, Nathalie Girard, Bernard Hubert, Janice Jiggins, Sofie Kobayashi, Alex Koutsouris, Jozsef Kozari, Catherine Mognenot, Jet Proost, Ewa Rockika, Niels Röling, Nadarajah Sriskadarajah, Pierre Stassart, Patrick Steyaert and Severine van Bommel.
References


Chapter 9

Learning in European agricultural and rural networks: building a systemic research agenda

Bernard Hubert, Ray Ison, Nadarajah Sriskandarajah, Chris Blackmore, Marianne Cerf, Isabelle Avelange, Marc Barbier, and Patrick Steyaert

Abstract Six key themes that emerged from the European Union (EU) funded LEARNing project designed to develop and test a systemic approach to research practice are reported. The focus was on the learning and knowing processes experienced by individuals, groups and institutions that emerges from collective action and results in changes in practices or in the potential to change practices of those involved. The authors, drawn by the idea that the key to understanding knowledge is to be found in ‘how we know what we know’, or, in other words, in the processes of ‘learning and knowing’ present these themes: processes, theory, evaluation, institutionalisation and social and professional practice as a basis for further innovation in the conduct of R&D and as a basis for future capability-building of researchers.

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Introduction

Learning and knowing experienced by individuals, groups and organisations that emerge from collective action and result in changes in practices or in the potential to change practices is a dynamic transformational process. These dynamics are essential to the building of social and individual capacity for action, making them a key element for adaptation or for inducing change, and thus innovation, in a situation. Creating a purposefully designed ‘space’ or ‘platform’ which brings together experiences of those involved in purpose-driven learning and knowing processes allows for the creation of synergies and meaningful working linkages, which is potentially of great value to theoreticians, practitioners, and policy makers addressing the challenges to act with relevance in an uncertain world. In this new context of uncertainty and complexity, researchers need to commit to genuinely active and interactive partnerships with other stakeholders. The new demands require that researchers move toward a trans-disciplinary approach (Gibbons and Nowotny 2001; Nowotny et al. 2001; Pohl and Hirsch Hadorn 2007, 2008), where scientific disciplines establish working linkages with other sectors of society – other citizens and policy makers. However, it is now 20 years since Gibbons et al. (1994) identified this need yet research and development (R&D) remains largely traditional and conservative in its praxis.

New understandings are needed when moving from a focus on the traditional objects of study in agriculture and rural development, toward new forms of collective action, networks of stakeholders, consultation methods, controversies, modes of building and running socio-technical norms, developing markets, public sector action, etc. How to make this shift is a research question in itself with important, but integral praxis considerations. There is a need for new approaches that provide insights into the ways in which the interactions between the various forms of scientific and lay knowledge build identity of products and individuals, and how they affect the potential for change and innovation.

We report on research conducted under the auspices of the 5th Framework Programme of the European Commission (DG Research). The LEARNing project: ‘Learning in European Agricultural and Rural Networks: Institutions, Networks and Governance’ set out to produce a Research Agenda for Social Sciences in relation to the new stakes agricultural and rural sectors have to face in Europe in the future. It was done through a participative approach involving different stakeholders from these sectors. Over almost 2 years seven research teams coming from Denmark, France, Greece, Hungary, Poland, The Netherlands and United Kingdom were involved in the project. Two additional teams, from Belgium and Australia, not formally involved in the EC project, also committed to the research process and joined the others from the beginning. The overall project had many of the elements of a purposefully designed ‘learning system’ (Ison and Russell 2000), including (i) the valuing of multiple, partial perspectives; (ii) articulation and pursuit of a common purpose; (iii) context sensitive local design (responsible autonomy) and (iv) monitoring and adaptive learning.
The chapter is arranged such that in the next section the context and approach of the research is explored and the research situations elaborated. Conceptual and practical lessons learnt in relation to researcher roles and positions and the nature and demands of research partnerships are then drawn out. In part five how the experiences from diverse contexts can be mutualised or scaled-up within an overall social learning approach is addressed. In the penultimate section the consequences for future research-policy relationships, particularly agenda setting including a specific agenda arising from the reported research is addressed. We conclude by exploring some of the systemic implications of the research themes that were generated.

**Context and approach**

*A strong emphasis towards rural development in the EU context*

The project comprised researchers who in the main were concerned with the future of rural areas and the place which farming activities could play in industrialized countries, in particular – although not exclusively – the European countries. Their concern arose from the successive EU Common Agricultural Policy (CAP) reforms and their acceleration in recent years, which has at times caused vehement debate which challenged the very existence of a CAP at EU scale.

This observation basically reflects the lack of political vision on the role of agriculture in industrialized countries, most of which had – and in some cases still retain – strong agricultural roots. Following the success of the CAP, founded on a relatively closed European interior market over 40 years and an unprecedented effort towards agricultural ‘modernization’, the certainties that enabled this ambitious policy to be pursued are now being challenged – with no ready answers – by the globalization processes of free market conditions, the development of international exchanges and the attendant negotiations within the framework of WTO, as well as by the rise of environmental problems on both local and global scales, problems that relate to climate change and energy consumption, the use of water resources and their quality or erosion of biodiversity (landscapes, fauna and flora, genetic resources, etc.).

In most cases, agricultural modernization was driven by intense efforts in research, education and training and the organization of agricultural producers, with the result that a few million peasants were downsized to a few hundred thousand agricultural producers. Supported by purposeful and protectionist governmental policies that promoted credit schemes and instituted technical advisory services, Science and Technology stood at the very core of this profound change, based on a top-down approach to knowledge, from science to technology, which was then to be transferred to the end-of-the-chain recipients, i.e. the peasants, through a remarkably efficient system of training and technical support (see Fig. 9.1).

Throughout the period, the ‘countryside’ was thus considered as a ‘world apart’, distinct from the urban universe, entrusted with a capital mission defined and supported
Specifically targeted laws and regulations thus reinforced the priority given to land farmers over landowners, original credit systems were developed, financial procedures to encourage investment and production were designed at national and, later, EC levels, while Science and Technology were required to focus exclusively on yield improvement, at times to the detriment of working conditions and environmental impacts. This privileged alliance with the farming profession developed to the detriment of other societal players such as other inhabitants of rural areas and environmental or consumer associations.

If one considers only the performance criteria set by this policy, then the results have been positive: plentiful and cheap food at the disposal of European consumers. Famines no longer occur in Europe even though grave malnutrition problems are increasingly alarming the people in charge of public health; even though some consumers complain about the standardization of food products; even though in some areas and regions, tap water is no longer drinkable; and even though landscapes are becoming homogenized to the detriment of the basic functions of ecosystems, in particular those ensuring the capacity for dynamic adaptation to environmental change. The rural world itself has changed as well: new non-farmer residents have settled there; among farming couples, the wives, sometimes even the husbands, no...
longer work on the farm. They have jobs in the town in administration or services where they mix with colleagues from other cultural backgrounds and are accustomed to working conditions that differ considerably from the usual activities and tasks of the farming community.

This complex of issues is now back on the agenda and political authorities experience some difficulty in dealing with them, lacking as they do a clear vision that founded the CAP some 40 years earlier. Thus, in the agricultural situation of industrialized countries the rise of highly efficient technologies regarding technical yields and work productivity, leading to a palpably higher total production, has been attended by a hitherto never experienced decrease in the agricultural population. To quote only the exemplary case of France, the peasant population dropped from some four million in the 1950s to only 400,000 farmers nowadays, a trend that is expected to continue. In essence, knowledge on the management of living matter has shifted over a half century from the rural areas to the laboratories. This shift does not go without giving rise to some acute questions about the quality and safety of food products or about environmental quality. Whereas knowledge and skills that were generated in the countryside were more or less efficiently mastered by the ‘practitioners’ of nature, the peasants, a disruption has now occurred: the skills and know-how of the new generators of knowledge focus on management of protocols and laboratory manipulations. How then is knowledge generated in the laboratory to be reconnected with the knowledge and know-how of those who act daily on the biophysical and social processes?

In a rural world that has become totally different, a world in which fewer and fewer farmers coexist with increasing numbers of other residents busy with other, mostly urban, activities, how can the cultures and the established, stabilized and ‘teachable’ knowledge be reconnected with those that are derived from the know-how and experience of individuals and that are mostly expressed through action?!

How can this epistemic rift be overcome? This is one of the challenges which the LEARNing group set out to address by involving actors from different cultural and professional backgrounds in reflection intended to lead to research priorities which associate agricultural research and social sciences.

The research process started in December 2002 with a first meeting in Paris, where all country teams agreed on a process designed to scale-up from local promising configurations to European level research agenda production. Project researchers met five times: in Paris, France (December 2002), in Doorn, Netherlands (June-July 2003), in Łódź, Poland (May 2004), in Brussels, with the key participants from each case study (February 2005) and in Budapest, Hungary (March 2005).

1 We use quotation marks here because from an Anglo Saxon perspective teaching has often become associated with the linear model and the transmission (of facts) metaphor. Jane Wilkinson, in an interview with Chinua Achebe (1992) addressed this issue: “You said recently that the label ‘The Novelist as Teacher’ has haunted you ever since you used it as the title of an essay in 1965.” Achebe replied: “You are right. …. I was not thinking of the kind of teacher who prescribes. A good teacher never prescribes, he draws out. Education is a drawing out of what is there, leading out, helping the pupil to discover…to explore.”
In between, two separate local level events were held in each country: between February and June 2003 each team worked in its own country according to the work programme that was defined in Paris; and between July 2003 and April 2004 each country team repeated the process according to the agreed programme. The final Brussels meeting was conceived as an European conference organised in order to (i) promote exchanges between R&D practitioners and policy makers about their practices and the design of R&D, and (ii) facilitate the development of an European agenda that could be used by social scientists concerned with R&D in Industrialised Countries’ Agriculture (ICA) to address the issues emerging from the project.

**A range of relevant situations**

Each country research team engaged with others in a particular configuration that seemed relevant to their circumstances, as well as offering possibilities to develop locally relevant research agendas that could contribute to an overall research agenda when aggregated across contexts. In the end three main types of situational domains were investigated:

*Changes in production systems.* In many countries (Belgium, Denmark, France, Greece) important change was happening in production systems with the aim to develop less intensified farming models by choosing alternative ways, like organic farming. A key question in such situations was: how does this new issue play out in relation to researchers, policy makers and other professionals? New configurations began to emerge: partnership around these issues gathers farmers and advisors but also consumers; agricultural research has to take into account these different stakeholders committed to new food chains, with new specifications, qualification and certification processes.

*Changes in rural areas and in the role of agriculture.* The role of agriculture in rural areas was changing in France, The Netherlands, UK and Poland. In these countries agricultural activities were becoming only one of many different activities dealing within the countryside, with forestry, water protection and other environmental issues (biodiversity, landscape preservation, etc.) gaining significance. Thus a key question was: how does agriculture become involved in a multifunctional territory? Here, partnerships have to be expanded to include other stakeholders like local communities, environmental associations, water supply companies and foresters.

*Changes in agricultural advising.* As a consequence of the changes outlined above, agricultural advisors and extension services have to face new stakes in dealing with new topics beyond their traditional skills and know-how; they have to improve their capacity in connection with the new roles for agriculture and a greater diversity of production systems (Australia, France, and Hungary). Beyond farmers and extensionists and their institutions, this domain also addressed the higher education systems responsible for educating advisory or extension officers, as well as developed appropriate curricula for the training of future agronomists (agricultural engineers) and technicians, and retraining of existing ones. This necessitated the defining of the relevant new skills and competences.
A renewal of research position in social debates

In all situations reported by the Country teams the need for a change in the role of the position of research and researcher became apparent from the social debates generated by our initiative. This change can be schematised by a generic representation of the relationships between the involved stakeholders, including the researchers themselves. Figure 9.2 describes the traditional relationships (a) and the innovative ones (b) in which the researchers in LEARNing are engaging, in association with:

- Intermediary bodies, that is, institutions that organise action;
- Stakeholders, that is, individuals or groups holding defined interests with an explicit stake in R&D processes in agriculture;
- Citizens, that is, members of the public with a general interest in the well-being and sustainability of rural livelihoods, natural resources, food safety and quality;
- Policy actors, with whom intermediary bodies, stakeholders and citizens are invited to engage in the setting of R&D agendas.

In Fig. 9.2a, researchers are mainly relating to intermediary bodies and also give some advice to policy makers, in a traditional position of ‘expertise’. They have very few relationships with stakeholders and citizens, mainly considered as observed objects in their research.

This very classical situation has been disrupted by the recent tremendous changes – even crisis – that has happened in agriculture in industrialised countries: environmental issues (nitrogen pollution, biodiversity erosion, etc.), food safety (BSE, dioxin contamination, development of organic farming, etc.), changes in urban-rural relationships (housing, employment, landscapes, etc.). It needs new forms of research involvement to go with these changes, which commit citizens to new forms of action (NGOs in regard of environment or food), emphasize farmers practices, overwhelm the traditional extension services and create demands for new institutions in charge of new issues (water management, landscape preservation, etc.) and call for a renewal

![Figure 9.2](image-url)

**Fig. 9.2** Traditional research relationships (left) and innovative ones (right) in which the researchers in the LEARNing project are engaged. R1, R2, R3, R4 are different relationships in the research situation (see text for a full description)
of democracy in public action. Thus, Fig. 9.2b represents new ways of practicing research in such complex situations. Researchers in this representation are positioned as instrumental to the process and its outcomes, in four specific ways:

- as researchers external to the process, observing, recording, and analysing methods and processes for the co-creation of inter-active learning (R1),
- who through the LEARNing project are orchestrating invitations to engage in conversations and actions (R2),
- and who are looking at the ‘objects’ around which new actions and relationships among intermediary bodies, stakeholders, and citizens are mobilised (R3),
- as well as participating in the co-creation of the new actions and relationships (R4).

In the second Workshop participants used Fig. 9.2 to map the relationships that they had begun to build or strengthen in each case. The mapping revealed opportunities for initiating or strengthening additional linkages in the next phase of the project.

**A renewal of research partnership practices**

Following the relationship mapping specific elements related to the research process were elucidated, based on a strong commitment to partnership with stakeholders so as to involve them in a dialogue on the role of social science in innovation processes. This was done by facilitating learning among a range of partners based on consideration of the following elements.

**How to initiate the conversations and invite participation**

Would stakeholders recognise the rationale and aims of the LEARNing project as legitimate and of compelling interest in terms of their own ‘stakes’? In the experiences reported by the Country teams, this question was debated extensively within the research teams. In a few cases, the question had also been put explicitly to the stakeholder participants, as a means to legitimate the processes set in train, and in order to refine through discussion the nature of the engagement to which stakeholders were invited.

In each case, different procedures were followed to introduce the LEARNing project and invite participation. Typically, where new contacts were made, the protocols involved: construction of systems diagrams, by the research team, of the boundaries of the sub-systems of interest; a more or less formal stakeholder analysis, of the actors and intermediate bodies in each sub-system, and their existing relationships; preliminary identification, by the researchers, of the key stakes involved; construction of a preliminary mailing list, based on existing contacts and through referral; crafting and dispatch of a letter of invitation to engage in preliminary conversations; preliminary ‘round tables’; feedback reports to round table participants and launching of jointly planned activities.
The representation of our partners. It was recognised that whoever was invited to these exercises would determine how representative of the full range of potential stakeholders the emerging R&D agendas would be. The question was: what interests and stakes will be represented? Different and, as yet partial, answers can be offered to these concerns. We concluded that there was no attempt to standardise across the nine countries neither the actors, nor the stakes, in terms of what they might ‘represent’. The unity of focus is at a higher level, on the processes by which a wider set of actors can effectively be drawn into the R&D agenda setting for the social sciences in agriculture.

From dialogue to inter-action. The intention was not only to assist stakeholders to talk about R&D agendas, but to elicit agendas through inter-action. The emphasis is important. Scientific institutions, and many scientists, tend to think about ‘integrated research’ as primarily a communication problem, which can be overcome by more explicit and sophisticated use of communication tools and processes. There are multiple metaphors to describe how ‘integration’ could be achieved and any one of these could generate different forms of praxis. What integration is, and how it is done, is generally taken for granted or assumed to be resolved by simplistic structural, particularly, organisational changes (Morriss et al. 2002; Collins et al. 2005).

The research carried out by members of the LEARNing group over the last 15 years, has in contrast, surfaced the central idea that integrated research most effectively occurs when stakeholders collaborate in shared actions around a ‘socio-technical mediating object’ (LEARN 2000). What is this object? It is the material focus of inquiry, the physical embodiment of the issue that is at stake. It can be as different as ‘the Maraichine cow’ of the French Atlantic marshlands or the effort to make sectoral legislation governing natural resource management, commercial farming, and nature conservation work in an integrated fashion at a local area level (as in the Netherlands). However, it is not some essential characteristic of the object which is important, but its power to shape the processes of ‘stake-holding’ (the exercise of one’s stake), and the understanding of what is at stake, as actors engage in resolving problems, and improving messy situations, through action.

The researcher’s role. It is obvious that researchers in the LEARNing project played (at least) three roles: (i) as researchers, independent of, and external to, the processes observed; (ii) as individuals perceived by other participants as ‘expert resource persons’ – expert in a discipline, a theme, or as practitioners of particular research practices; and, (iii) as stakeholders, whose central stake is an interest in researching inter-active learning processes, and who are therefore positioned within the processes unfolding, and as participants in the activities initiated. In addition, some researchers are playing process management roles in ways appropriate to their own particular suite of activities. For example, in the Polish case, the researchers acted as moderators of the Focus Group Interviews.

Each identity confers different strengths and limitations. For example, the choice of the Dutch team to place itself as a participant in inter-active dialogue, with one stakeholder interest among others, limited their ability to impose formal research instruments on what was monitored. In this case, research techniques would favour those that rely on the formalisation of self-learning and participatory assessments (Fig. 9.3).
Mutualising the local experiences through cross-case exchanges: towards a research agenda on learning issues

The purpose of this phase was to elaborate a first proposal of an agenda for social sciences-based R&D processes in Industrial Countries’ Agriculture in which the place of research on learning and associated processes would be specified. This was thus important for the momentum of the project and we decided to give as much space as possible to discuss the country-team reports based on their experiences over the first year. At Lodz, a full day and a half was devoted to intensive cross-national exchanges and discussions among researchers about the work done, based on a presentation of work by each country-team followed by a critical review from a colleague from another team.

In this phase reflexivity was operating at two levels – in our joint reflections upon what we had done and, in the process, the co-creation of a generative meta-narrative which joined the similarities and differences into an effective discourse. Particular understandings of social learning, as both a process of transformation of situations through stakeholder engagement (SLIM 2004; Ison et al. 2004, 2007; Steyaert and Jiggins 2007), and as a governance mechanism, informed our work in this stage as explained below. With understandings of social learning as a duality (Ison et al. 2012) the practice we were trying to build combined both process and entity, just as an orchestra can be understood as an entity – something to invest in – as well as a social dynamic combining different individuals and instruments, but where the overall aim is to create an effective performance, one that is relevant to the context of concern. The building of a research agenda potentially suitable to be funded can be understood in this light.
Opening the ‘black box’ of learning in multi-stakeholder configurations through cross-national exchanges

To make cross-national exchanges effective it was necessary to move beyond a simplistic use of ‘learning’ in the different situations; more subtle and nuanced distinctions were needed to understand the diversity and the wealth of what could emerge from such interactions between heterogeneous participants. As well as unpacking theory (see Blackmore et al. 2012), these included:

- The dimensions of learning: as an object (the content of learning), as an action (the process) and as policy (the agency effect)
- Learning as a process: the role of systems of activities, and more precisely the interdependency of various communities of practice (COPs), especially when collaborative action is concerned in the scene of agricultural and rural change;
- The place of individual reflections in learning (role of narratives, interplay between individual and social learning processes);
- The role of intermediate objects and concepts in the process of knowing: objects and quasi-objects used in translation processes, and consequently transformations of human actors and ability to commit to change.

One important conclusion arose from our discussions: We noticed how much the issue of collaborative action and learning were interwoven and dependent on situations in which changes were happening in industrialised country agriculture. One reason seems to be the need for clarification, and despite some theoretical difficulties, to assess and somehow evaluate learning as an outcome of a process. We came to the conclusion that this process was not only itself path-dependant in a course of action, but also performed by humans positioned in their own life, and finally affected by pervasive constraining or enhancing structural effects in a given social context. Therefore, we came to raise the question about the causality or at least the co-definition of learning, collaborative action and changes in situation (Fig. 9.4). This insight became one of the structuring elements to organise the design of the subsequent research agenda.
As well as needing to explicate underlying theoretical and praxis issues it was necessary, as we progressed, to imagine ways of institutionalising the thinking and practice we were enacting. In other words, what we were doing had to be capable of purposeful use by others, particularly policy makers and research funding agencies. In doing this, we drew on earlier experiences of many in the team with social learning research (SLIM 2004; Ison et al. 2004).

**Reflecting on the notion of Social Learning**

Social Learning appears at the confluence of three complementary standpoints: Social Learning as a process (Fig. 9.5), Social Learning as a part of governance mechanisms in a knowledge-based society (Fig. 9.6) and Social Learning as both a social and a cognitive phenomenon leading to innovation. These three complementary standpoints are explored below.

*Social Learning is a process* (Fig. 9.5) that needs time and takes place in concrete situations with regard to those concerned and their willingness to interact, what issues are at stake and in which general (political, economic, social) frame. It relies on the history of the relationships between the different stakeholders, including the research team involved. This history will determine the relational capital at the beginning of the process as well as its potential to increase during the process itself.
Confidence, clarity in goals and debates, quality of the collaborations, identification of the steps within the process, including phases of co-operation and phases during which each keeps his or her own business apart are all important factors.

The process dimensions of Social Learning highlights the question of multicultural groups and interactions between different social structures, including the risks of
domination of one group by some and the exclusion of others. Networking is therefore a key issue which in turn raises the following questions:

- How to create networks with individuals or institutions?
- How to facilitate networks of networks (as in the Netherlands case study)?
- How to set up a “hub” to connect networks that have to be related?
- How could a Community of Practice or an Epistemic Community emerge from this according to shared practices, values, goals, needs for collective action?

Social Learning as a co-ordination or governance mechanism to complement market, regulatory and education or information provision and associated institutions is proposed by many authors for use in situations characterised by uncertainty where the complexity of the situation is likely to be made worse by traditional approaches (Fig. 9.6; Ison et al. 2007; Collins and Ison 2009).

Collective and concerted action are at the core of Social Learning, as a means to respond and manage change when the issues are uncertain and the goal is not well defined as is mostly the case nowadays in the agricultural sector and rural areas. The rationale for Social Learning is promoted by the application of the subsidiary principle and by new incentives for participation of concerned lay persons in designing solutions to the issues they have to face (Hatchuel and Weil 1999). The experiences of country teams raised questions about how such procedures could be institutionalised through multi-organisation levels so as to take into account political, social, economic and ecological standpoints and finalise actions that could be implemented in concrete situations.

This dual movement of policy implementation via decentralised procedures that rely on agreements at various levels of action-decision and content densification, based on more or less stabilised knowledge, brings up the key questions of mobilising, producing and sharing knowledge between various interdependent levels of organisation. Policies use knowledge based on institutionalised epistemologies that need to become transparent. Since knowledge also originates from an effective action relationship, there is a high stake in understanding how knowledge production operates between various actions and decision scales, from the individual, to the group, community, organisational and political levels.

For institutions, the knowing process is based on the stabilisation of norms and rules, particularly when these are in the process of being transformed: the question of the requirements for stabilisation and the modalities of formalisation of these stabilised forms need to be researched. Care must be given to learning and redefining positions and roles built by the institutional framework and conversely to institutionalising of collective action, that is to say the capacity of institutions and policies to be changed by collective action.

The third strand relates to the theory(s) of learning that underpin Social Learning. As outlined in Blackmore et al. (2012) if Social Learning approaches are to be successful it is important that researchers and/or facilitators as well as policy makers appreciate the theoretical underpinnings of Social Learning. Social Learning stands on social theories of learning which are inclusive of, but not reduced to, historically
simplified cognitive accounts of learning. In Social Learning approaches, an appreciation of the theoretical and practical entailments of different learning theories, or learning processes, is essential when the researcher’s role is to intervene as an agent of change, committed to a collective action which is leading to innovation that is technical as well as organisational. In this understanding, the research team is not tasked \textit{a priori} with introducing knowledge to find a solution, as in a classical situation of ‘problem solving’, but is involved in an interactive co-production of knowledge to re-build questions in a situation of ‘problem finding’. To do this the research team has to contribute with awareness of its different disciplines and fields of competence as well as the epistemological preferences of the individuals.

A move to Social Learning approaches responds to the simplistic models of human communication and action that have operated in agriculture and rural development domains for many years. Social Learning enacts an alternative metaphor for human communication that follows the Latin root, \textit{in formare} – information is something formed within, it does not come from outside in a deterministic or transmitted sense. These issues have become the concerns of second-order cybernetics (the cybernetics of cybernetics, in which the observer has to be accounted for as part of any explanation). Despite the implications, the second-order cybernetic tradition is not well developed in terms of practice, but is a particular feature of the LEARNing project as new, second-order cybernetic forms of systems practice are needed which are theoretically grounded (e.g. Winograd and Flores 1987; Open University 2000; Ison and Russell 2000, 2007).

Moving beyond Social Learning research necessitates the co-production of a common set of concepts in regard of action, the agreement on a common language, the definition of a knowing agenda based on share objects, the management of permanent reflexivity and the building of a common vision of the future (which includes in our case a Research Agenda). All these points can be related to an assessment procedure, because any such process needs to be evaluated as it is not only willingness to interact and to build ‘dreams’, but procedures to act in the real world, which relates to the accountability of any participant in regard of his/her speeches and actions, and particularly to the role of the researchers, as agents for change (R. Barre, personal communication).

**Consequences for research-policy relationships:**

**Towards an agenda for social-sciences oriented R&D in industrial-country agricultures**

Science and technology are so involved in the construction of our world that the old distinction between scholarly and lay knowledge is increasingly transgressed in ordinary life as well as in public action and policy making. The boundaries between policy, culture, market, and science become muddled as a result of the co-evolution between research and society, whilst the latter increasingly call for greater accountability on the part of researchers.
Even among researchers and practitioners who share this vision of knowledge as emerging from action, there is a substantial multiplicity of points of view, disciplines, and fields of application. Diversity, however, is essential to a social sciences network interested in the advancement of a knowing-based society. The reason for welcoming such diversity relates to the new societal demands placed on science in a knowledge-based society. In this new context, researchers need to commit to genuinely active and interactive partnerships with other stakeholders. Single-discipline or even inter-disciplinary or multi-disciplinary approaches where inputs from several disciplines overlap appear insufficient and add weight to moves towards a trans-disciplinary approach.

**Less advising and being more committed**

The cases supported the argument that with respect to research, there is a need to evolve (or transform) out of the approach whereby ‘experts’ advise decision makers who take on the entire responsibility in the decision-making process in public action. It requires a change in attitude and an acceptance of interactions with other forms of knowing. This change can come about with the increased involvement of researchers in collective action settings where results are genuinely the product of the interaction process rather than being pre-determined or framed from a disciplinary perspective. Such a shift results in a modification of research objects resulting in different objects that are more compatible with the circumstances and thus more relevant to a wider group of stakeholders and the needs of dealing with the issue(s) of concern (Hubert and Bonnemaire 2000). This shift concerns social scientists in two ways: (i) regarding their own objects of research, (ii) to help biophysical scientists to modify their objects of research so they can become more relevant to society and to practitioners’ and policy makers’ preoccupations. In the latter case timing is critical – little is achieved if social scientists participate at the ‘end of the pipe’ and are used by research managers to enhance the uptake of research that may not be relevant, other than to build institutional capital for the researchers and their organisations.

**Building new ‘objects’ in a research agenda for social sciences**

Six key themes emerged as central to a research agenda for learning in European agricultural and rural contexts, from across the whole LEARNing project. The project researchers identified these themes through an iterative process of analysis and synthesis of questions, issues and themes that emerged in national level work programmes. Priorities for this research at national level vary a great deal across Europe depending on history, local circumstances and stakeholders’ perspectives, but there are some common themes that resonated with all who were involved in the project. Issues associated with each theme however, also varied from country to country. This variation was partly because of the way in which this research agenda
was built, with each country choosing a different focus as a ‘promising configuration’ at the start of a ‘bottom-up’ process (see Blackmore et al. 2012).

The overall context from which these key themes emerged was the changing situations in industrialised country agricultures. Where reference is made to ‘stakeholders’ without specifying what their stake-holdings applied to, we are referring to stakeholders in agricultural, food, environmental and rural policy and practice. Our different ways of knowing (epistemologies) framed our consideration of learning processes.

The themes overlap to some degree e.g. a particular research question may have theoretical, process, evaluation and practice elements some of which are common to others. There are also different ways in which these themes could have been organised e.g. drawing frequently recurring or crosscutting issues such as ‘politics’ or ‘networks’ to the forefront, but these dimensions have instead been included within the other themes listed. The six themes were:

**Theme 1: Learning and knowing as a project, theory or ideology**
This theme concerns the critical use of concepts of learning and knowing, recognising that these concepts are not neutral but value-laden and that there may be both advantages and disadvantages in using them in different situations and in different ways – hence our reference to ideology. The theme is only partly theoretical, considering theory that underpins practice and grounded with examples from a range of situations. The idea of learning and knowing ‘as a project’ refers to having an intention to use learning and knowing as concepts for change rather than to an organisational form of project. Researchers in the LEARNing project were mainly concerned with situated learning in changing environments and capacity building of the stakeholders involved in collective action in such environments. We also mainly understand our engagement as researchers -in-action who thus functioned as learning agents. Developing methods to get more in-depth understanding of our own position and of our way to ground our action on theoretical assumptions was part of the task to be accomplished.

**Boundaries and implications of Theme 1.** What are our assumptions about learning, the theory we are using in practice and how it works as an epistemology or as an ideology? This addresses our professional skills as researchers on collective action in situations of change. This theme relates also to new claims about participation and new social forms of ‘policy-in-the-making’.

**Theme 2: Learning and knowing as a process**
This theme considers the nature of learning and knowing as a process. It emphasises the dynamics of the processes involved and the factors that facilitate or underpin learning and knowing processes. Learning and knowing are considered mainly as social or collective processes rather than as something individual, though with recognition that individual learning and knowing are a part of these social processes. Learning and knowing processes are assumed to be interconnected and inseparable.

**Boundaries and implications of Theme 2.** Learning and knowing can be thought of as a process of inquiry to manage change and complex situations, which leads to new understandings, practices, and behaviours. This conceptualisation of learning
and knowing leads to questions about (i) the conditions required at an overall level for ‘all’ stakeholders to be involved in starting and developing such a process (ii) how to ensure sustainability of learning systems, if it is needed and (iii) how effective such a process of inquiry is for managing change, in comparison with other alternatives.

**Theme 3: Evaluating and assessing processes relevant to learning**

This theme is about how to assess, evaluate and make judgements about processes related to learning and knowing. It addresses the way to assess the relevance of the learning and knowing processes in changing environments in relation to capacity building, sense making, identity building and empowerment issues. It also addresses the need to develop new evaluation processes for researchers for the development of scientific knowledge when this is done through involvement and commitment to collective action in changing environments.

*Boundaries and implications of Theme 3.* If learning is a method and a process of change, it needs to be assessed in relation to the purpose of change (including 2nd order change) and mainly by revealing what is new or problematic for whom. Then methods have to be developed to carry out such assessment. There is a need to develop normative considerations to assess the link between learning and knowing processes and the outputs in terms in knowledge whether actionable or scientific. Assessment has to be reviewed within different spans of time to capture how learning evolves.

**Theme 4: Institutionalising and organising in learning and knowing**

The need to know more about a range of institutional factors emerged from all national level work programmes. This theme considers the importance of different kinds of institutionalisation and organisation in learning and knowing. It tackles the relation between the local and the global, the ways boundaries can be overcome and the ways networks and organising settings become stabilised. It also tackles the emergence of governance procedures and of human agency based on learning statements. It recognises the role of skills and learning agents within organisations.

*Boundaries and implications of Theme 4.* There is a need to understand the institutionalisation of learning and knowing as a process or as an output. Continuity of multi-stakeholder learning in organisations and multi-organisational settings is likely to depend on this institutionalisation. There are different institutional levels of action at which a culture of learning could be valued or fostered. The institutional implications and power issues of valuing a diversity of understandings and engaging in collective action need to be recognised.

**Theme 5: Learning as a social and professional practice**

This theme focuses learning associated with social and professional practice, among stakeholders in agriculture, food, environmental and rural issues across Europe at national and international levels. The role of methodologies and tools in facilitating learning and knowing processes is included. The practices of brokering between communities of practice and mediating are also considered.
Boundaries and implications of Theme 5. A wide-ranging array of issues and processes is included in this theme. It included methodologies, methods and skills to foster learning and knowing processes among stakeholders and for recognising stakeholders and stake-holdings; the role of researchers and processes for recognising stakeholders and stake-holdings and developing and building on social and relational capital; methods of working include reflexivity, creativity and energising and processes of mediation, networking and brokering.

Theme 6: Learning, knowing and futures
This theme is not mutually exclusive from the other five themes as all the themes have a futures dimension. This theme is about the future and its uncertainty and how thinking of the future and predicting it affects learning and knowing. It emerged as a theme in the context of researchers’ perceptions of sustainability.

Boundaries and implications of Theme 6. Learning, knowing and futures as a theme raises issues of sustainability, sense making, politics, interactions and dealing with uncertainty that were not raised in other themes. The focus on futures also encouraged questions around challenging expectations and participation of stakeholders in building futures.

What is the significance of these research themes?

How do our research agenda themes compare with themes generated by other processes in similar contexts? How do they reflect our current times? In 2000 the book “Cow up a Tree – Knowing and Learning for Change in Agriculture: case studies from industrialised countries” was published (see LEARN 2000). Several of the LEARNing project team were involved in that book-writing process. At that time themes generated by editors were (i) valuation; (ii) facilitation; (iii) traditions of inquiry and understanding; (iv) sustainability of what and how? (v) praxis – the relationship of theory to practice and practice to theory building; and (vi) new research questions. The process of generating themes for a research agenda in the LEARNing project has been a very different one this time with the participation of many more stakeholders working with researchers. Europe has moved on since 2000 and issues associated with, say, accession to the EU and subsidies have changed. But some of the themes have similarities – evaluation and sustainability are still in focus for instance, as is the dynamic between theory and practice. However our first theme in this research agenda i.e. Learning as a project, theory or ideology, is a development of a praxis orientation (Fig. 9.7).

Institutional factors remain high on the agenda and organisational factors such as partnerships, networks of networks and communities of practice while not new since 2000 are perhaps increasing in significance. Most of the LEARNing researchers also found an increasing number of people in policy communities taking, or at least sympathetic to, or interested in, a learning or social learning approach in the face of uncertainty in their domains compared with the year 2000.
The domains in which participants were working have also changed with a shift from industrialised country agricultures to multifunctionality and consideration of the wider area of agriculture, food, environment and rural issues in a more integrated way. Changes in stakeholders and stake-holdings in these issues have been observed by researchers, but many questions remain about what and who has changed and what might be done to improve situations from the perspectives of stakeholders. Hence the detail of our research agenda!

Our conclusions will therefore encourage social scientists to focus on social tensions associated with the transformation of the biophysical world and requiring urgent attention. In this respect, social scientists have an important role to play relative to the emergence of new players and the new social demands placed on research and technology. More fundamentally, this means that social sciences need to focus on objects of study from the biophysical world – that often were previously thought of as outside their area of interest – and initiate new partnerships with natural sciences disciplines.

Systemic orientations in research practice are not always easy to take in the light of the increasing globalisation of norms and institutions that reward researchers for what they do (Hirsch Hadorn et al. 2008; Blackmore 2010; Ison 2010). This observation draws attention to a meta-agenda that belongs to the institutional settings of research practice itself. The theoretical framework emerging from our work will constitute the foundation upon which researchers can function more efficiently in the ‘messy situations’ of complexity, contested values, high stakes, and high uncertainty that are bound to occur more frequently in a knowledge-based society.
Acknowledgements  We wish to acknowledge the special group of people who constituted the LEARNing project. Their critical engagement, personal warmth and friendship made all that is written here possible. They included: Christophe Albaladejo, Rémi Barré, Marco Barzmann, Nathalie Couix, Nathalie Girard, Janice Jiggins, So fi e Kobayashi, Alex Koutsouris, Jozsef Kozari, Catherine Mougenot, Mark Paine, Jet Proost, Ewa Rockika, Niels Röling, Pierre Stassart, Severine van Bommel.

References


Chapter 10

Extension systems and change facilitation for agricultural and rural development

Artur Cristóvão, Alex Koutsouris, and Michael Kügler

Abstract The field of extension is quite dynamic and new configurations and alternative extension systems and approaches have been emerging. This chapter explores the recent developments and debates critical questions such as: Is extension still relevant? What are the current trends and challenges in the field of agriculture and rural development and how are they affecting the structure, mission and delivery of extension services? How is extension being considered in the frame of the EU Common Agriculture Policy? We stress the growing involvement of multi-stakeholder networks of different sorts in extension work (with emphasis on private-profit or non-profit-organisations) as well as the adoption of participatory approaches. We also analyse the complex relationships between extension agents and rural actors. The major focus is on the changing roles of extension agents, underlining their current roles as learning-innovation-change facilitators and knowledge brokers. Examples drawn from proceedings of the European IFSA Symposia specifically address European cases, and illustrate the analysis.

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Is extension still relevant?

The cover story of a recent issue of the journal *Progressive Farmer* (March 2011), published in the USA, is symptomatically dedicated to the question: “Is Extension Still Relevant?” (Patrico 2011). Focusing on the American context and the case of the university-based Cooperative Extension Services, the author interviewed farmers, private industry people, and extension coordinators, specialists and agents, in an attempt to “assess the systems’ relevance as it approaches the 100th anniversary”. The general conclusions can be summarized in few sentences: the farming population has been decreasing, is more educated and more autonomous in terms of information seeking; many farmers, especially large ones, are turning less to (public) extension and more to Certified Crop Specialists, management consultants and private industry, in part because there are fewer extension agents and specialists; universities have been under budgetary pressures to reduce the extension field force, and some have even considered eliminating extension altogether; extension specialists have to work hard to obtain grants from government, commodity groups and other private industry sources, in order to develop applied research and extension work. However, the feeling is that “Extension is as relevant today as ever” and has a special value for young and small farmers, and that it can reach broader audiences, provide independent and objective advice and tackle issues of public interest, such as the environmental impacts of farming practices, among many others.

Focusing on the European context, Knickel et al. (2009) stress that, recently, research, extension and education, and, more specifically, the state-owned or state-funded components of the so-called Agricultural Knowledge and Information System (AKIS), “have been strongly restructured following accusations of being inefficient, bureaucratic and not sufficiently responsive to farmers’ needs”. This results in the “privatisation of delivery, an increasing number and diversity in extension organizations, farmers’ participation in the costs, and competitive bids to assign research and extension tasks” (Knickel et al. 2009:137). Moreover, new concerns have emerged, such as “the negative environmental impacts of industrial agriculture, the quality of life of rural population and rural employment, and the positive externalities linked to agricultural production and demanded by society”, leading to new agendas and shifts in rural development approaches and new demands in terms of knowledge development, as underlined in the “Budapest Declaration”, recently issued at the EU Conference on “Transitions towards sustainable food consumption and production in a resource constrained world” (European Commission 2011; EU SCAR 2012).

These two stories, from contrasting realities, have something in common: they show that the provision of extension has changed considerably in the last few decades, and that it is perhaps more relevant today than ever. However, they also show that the conditions (political, economic, social, institutional, environmental) and needs (of farmers and society as a whole) are quite different today, and that new challenges and priorities, asking for close attention, have emerged. In fact, the world has changed rapidly and dramatically (and continues to change), including the globalisation of economy and social life, the role of the State, the power of markets, deregulation and
privatisation of services, the food crisis and the sustainability of production systems and the global food system, the new and complex rural development scene, with the rural renewal movement (linked to multifunctionality and sustainable agriculture) and the paradigm shift from “modernisation” to an integrated model of rural development, combining endogenous and exogenous drivers and involving multi-level, multi-actor and multi-facetted processes (van der Ploeg et al. 2000).

In this context of changes, uncertainty and risks, many recent reflections, studies and policy documents have shown that a new agenda of critical agricultural and rural development issues need to be urgently and appropriately addressed and that extension systems (along with research, education and training) are facing new challenges and demands, and thus new roles, should be reinvented and revitalised, and deserve larger and continued investments (see Laurent et al. 2006; Lemery 2006; Hoffmann et al. 2009; Knickel et al. 2009; European Commission 2011; Pretty et al. 2010; UN 2010; Esnouf et al. 2011; Foresight 2011; Garforth 2011; European Commission SCAR 2012; Table 10.1).

It is an indisputable fact that governments and international organizations throughout the world are concerned with food security and that agriculture and rural development are back in the priority agenda. That implies, as several of the above cited documents recognize and emphasize, a comeback of extension and the AKIS or the Agricultural Innovation System (AIS) in general, something which is also analysed in Chap. 20 by Klerkx et al. (2012, this book).

Towards new extension systems, configurations and approaches

Extension and innovation systems, configurations and approaches have been a permanent subject of debate and research for a long period of time, and various paradigms have been influential in shaping extension development over time (see Table 10.2). Linear models of knowledge or technology transfer and innovation, implicit in extension approaches such as the Training & Visit System and others have been criticised and challenged, and new forms of interaction, coordination and cooperation among farmers, extension agents, scientists and other stakeholders proposed (Cristóvão et al. 2009). As stressed by Hubert et al. (2000:17), “The dominant linear paradigm of agricultural innovation based on delivery to, and diffusion among, farmers of technologies developed by science, has lost utility as an explanation of what happens”, and “There is a search for new models of innovation and new roles for science”. In this context, Klerkx (2008) shows the conceptual evolution from the technology transfer model to network and systems approaches such as the agricultural knowledge and information systems (AKIS) and, more recently, to the agricultural innovation system (AIS) approach that embraces “the totality and interaction of actors involved in innovation” and extends “beyond the creation of knowledge to encompass the factors affecting demand for and use of knowledge in novel and useful ways” (Klerkx 2008:12, citing Hall et al. 2006).
Table 10.1  Critical development trends and tensions, such as climate change or global population growth, among many others, are leading to new agendas and shifts in rural development approaches and new demands in terms of knowledge development

<table>
<thead>
<tr>
<th>Climate, environment and natural resources</th>
<th>Population and livelihood</th>
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<tr>
<td>Climate change</td>
<td>Global population growth; Rural-urban linkages</td>
</tr>
<tr>
<td>Competition for key resources (land, energy, water)</td>
<td>Food production, distribution and access</td>
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<td>Environmental sustainability</td>
<td>Food security and safety</td>
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<td>Ecosystems and natural resource management</td>
<td>Food processing, supply chains, marketing and chain management</td>
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<tr>
<td>Depletion of fossil reserves and scarcity and high prices</td>
<td>Poverty alleviation, employment opportunities and income generation</td>
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<td>of fossil energy</td>
<td>Well-being and quality of life of rural population</td>
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<td>Landscape preservation</td>
<td>Women’s access to education and training</td>
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<td>Coping with HIV/AIDS and other health problems</td>
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<td>Multifunctional agriculture, rural and environmental services and non-food production</td>
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<td>Off-farm activities and links between agriculture and other sectors of the rural economy</td>
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<td>Values, policies and institutions</td>
<td>Knowledge and technology</td>
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<td>Role of governments</td>
<td>Knowledge society</td>
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<td>Market power; Market liberalization</td>
<td>Knowledge intensive agriculture</td>
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<td>Prices for food, feed, fibre and bio-energy</td>
<td>Commodification of knowledge</td>
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<td>Service decentralization and privatization</td>
<td>Information and communication technologies</td>
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<td>Biotechnologies</td>
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<td>Public participation</td>
<td>Digital divide</td>
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<td>Agrarian reform</td>
<td>Distance learning and e-learning</td>
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<td>Public support to multifunctional agriculture</td>
<td>Social networks</td>
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<td>Articulation sectoral-territorial development</td>
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<td>Globalisation-localisation (of agriculture and food systems)</td>
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<tr>
<td>Changes in values and ethical stance of consumers and</td>
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<td>producers</td>
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<td>Human greed and corruption</td>
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Reinventing extension has been on researchers’ and policy makers’ agendas and Leeuwis (2004:11–17) presented a set of practical changes to be implemented, including a focus on collective issues, co-designing rather than disseminating innovations, articulating the technical and social dimensions of innovation, being able to manage complexity, conflict and unpredictability, and helping organisations to learn, that is, to become ‘learning organisations’. Such changes must be accompanied by conceptual ones, particularly the view of extension as communication for innovation, that is “a series of embedded communicative interventions that are
meant, among others, to develop and/or induce innovations which supposedly help to resolve (usually multi-actor) problematic situations” (Leeuwis 2004:27).

Several authors, based on a wide range of theoretical views on learning and change, proposed extension, training and development approaches rooted in systems thinking and social learning perspectives, and analysed concrete situations of work with learning groups and networks in a broad variety of environments and addressing many different environmental, farming and rural problems (See: Morgan 2011; Schad et al. 2011; Knickel et al. 2009; Braun 2006; LEARN Group 2000). Group-based learning, e.g. through learning partnerships (Crawford et al. 2007), group extension (Schad et al. 2011), farmer-field schools (Dzeco et al. 2010; van der Fliert et al. 2007), communities of practice (Morgan 2011), study circles (Cristóvão et al. 2009; Guijt and Proost 2002), farmer networks (Wielinga and Vrolijk 2009; Wielinga et al. 2008), can be powerful means of engaging and empowering people, creating spaces for communication, network building, knowledge exchanges, negotiation, experimentation and development of skills and competencies. As mentioned by Sriskandarajah et al. (2006:27): “The future challenge will be about learning processes in open networks and less so in well defined and

### Table 10.2 Extension thinking and practices have evolved and there are different extension paradigms, representing alternative views, and leading to a variety of models and approaches

<table>
<thead>
<tr>
<th>Extension paradigms</th>
<th>Key features</th>
<th>Related models and approaches</th>
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<tbody>
<tr>
<td>Transfer of technology</td>
<td>Delivering specific recommendations from research using top-down and persuasive methods to increase food production</td>
<td>Conventional Ministry-Based Extension; T&amp;V System</td>
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<tr>
<td>Advisory services</td>
<td>Responding to specific farmer inquiries about particular problems, using problem solving or persuasive methods</td>
<td>Commodity-Based Systems; Market-Driven (or Market-Oriented) Extension Approaches; Agribusiness Extension</td>
</tr>
<tr>
<td>Non formal education</td>
<td>Training farmers and rural people, and helping farmers to organize into self-help learning groups</td>
<td>Farmer-Field Schools; University-Based Extension</td>
</tr>
<tr>
<td>Facilitation</td>
<td>Facilitating horizontal communication, active/collaborative/social learning, co-construction of knowledge, collective action and empowerment processes among farmers and rural people, working with groups to help them address specific issues</td>
<td>Animation Rurale; Participatory Extension; Farming Systems Research and Extension; Farmer First; Participatory Learning and Action; Participatory Technology Development; Farmer-Led Extension; Farmer-Field Schools; Farmer Networks; Study Circles; Facilitation of Local Processes; Local Development; Agroecological Extension</td>
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often familiar groups. Learning among heterogeneous groups of stakeholders, and among different epistemologies has become one of the most central issues today”.

In today’s complex and dynamic context and accepting the idea that extension needs to be re-focused, the principle of “learning to learn”, and the concepts of self-directed, collaborative and action learning are more crucial than ever, namely when working with rural and local development issues, with groups of farmers, community leaders, development agents, adult educators and other professionals. However, moving from a top-down and transfer-of-technology orientation to more complex new collaborative extension systems and platforms requires the adoption of new configurations and organizational structures, open to multiple actors. Desjeux et al. (2009:24) concluded, as a result of their comprehensive literature review, the new institutional arrangements are based, on the one hand, on the decentralization of extension, with rural communities and local public organizations assuming the key roles, and, on the other hand, on privatization measures aiming at the improvement of advice, through the involvement of NGOs, producers’ organizations and private businesses.

The World Bank’s study of extension reform for rural development, including a wide set of case studies from developed and developing countries (Alex and Rivera 2004a, b, c, d, e) is also worth mentioning. These cases provide comprehensive evidence of reforms in different directions, including decentralized systems (transfer of decision-making functions to local levels and encouragement of public participation), privatized systems (development of new partnerships and associated capacities between government agencies and non-governmental and private sector actors), demand-driven approaches (with extension services tailored to the expressed demands of the clients or recipients of the service, involving participatory approaches, farmers’ learning groups, and extension through producers’ organizations), and revitalization of public sector services (implying partnerships with other actors and service providers, changes in extension methods and linkages with local governments).

In general, what we observe today in Europe, as well as in many other parts of the world, is not a unified extension system, but on the contrary, a plurality of configurations, involving a multiplicity of actors which are part of the AKIS (Röling 2007; Klerkx 2008; Dockès et al. 2010) or the AIS (Klerkx 2008). Old and new institutions and organizations participate, from central and regional or local Ministry services, to universities, education and training institutions, farmers’ organizations, inter-professional bodies, local development associations, private firms, etc., often organized in multi-institutional partnerships, networks and platforms that support information exchanges, knowledge construction and innovation development.

It is clear that, in most instances, the role of the State changed considerably in the last decades, in general from service provider to policy making, administrative and regulatory functions, linkage development, integration of different actors into a coordinated system, monitoring and evaluation, project funding, and service delivery in disadvantaged segments of the territory or the rural population (Klerkx et al. 2006; Rivera and Alex 2006; Alex and Rivera 2004a). As stressed by Alex and Rivera (2004a:xvi):
Governments are the final arbiters of the policy reform. They carry the responsibility of ensuring institutional implementation and generally for creating the environment in which networks of extension providers can flourish and thereby assist the nation to respond effectively to current agricultural and rural development challenges.

Authors like Birner et al. (2006:2) emphasize the benefits of pluralistic extension, particularly “their ability to overcome constraints, such as shortages in funding, staffing, and expertise, and to provide the necessary flexibility to tailor services to the needs of specific subsectors or regions”. However, the plurality of Extension Systems configurations also raises a variety of questions, debates and tensions in different domains, such as: system coordination vs. fragmentation; increased financial and administrative complexity; Extension-Research linkages; articulation between supply and demand; system quality control; monitoring and evaluation of programmes and staff; served and not-served territories and people; capacity building; and system financial sustainability (Alex and Rivera 2004d; Rivera 2008; Desjeux et al. 2009). The role of public services and the question of privatized extension are critical and deserve further debate.

The question of privatisation

For a long time the public sector has been the key provider of extension services worldwide. This has been justified on the basis of broad national policy issues, the understanding that the information relevant to technological innovation is a public good, the risks involved in agricultural production, the limited access to information of highly scattered and heterogeneous farming populations, regional imbalances and the need to control both production inputs and the quantity and quality of agriculture’s output.

Nevertheless, since the 1980s such a role has been challenged; an extensive debate about the role of the public sector in the provision of agricultural extension services thus emerged (see: Rivera 1990, 2000; Cary 1993; Phelan 1995; Haug 1999; Kidd et al. 2000; van den Ban 2000; Garforth et al. 2003; Rivera and Alex 2004; Klerkx et al. 2006; Swanson and Rajalahti 2010). Public agricultural extension has been found to suffer from shortcomings such as incurring high and unsustainable costs (e.g. the Training & Visit System), poor coverage and performance, lack of flexibility and responsiveness (and accountability) to the variation of farmers’ needs and changing contexts, the inefficient use of new communication tools, poor human resource development and methodologies as well as extension’s usually narrow (agricultural) mandate vis-à-vis the pragmatic need for (sustainable) rural development. Moreover, political reforms inspired by international institutions such as the World Bank and the International Monetary Fund, following a neoliberal agenda and policies, have put considerable pressure upon public sector extension services (Rivera 1997, 2008; Caporal 2002; Anderson 2007). Rivera and Zijp (2002:xxiv) put it quite clearly when stressing that:

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1 This section expands and updates the analysis of Alexoupoulos et al. (2009), particularly the section about the ‘International Scene’, pp. 179–181.
“The World’s ideology has changed”, showing a power shift from public to private, and adding that “The transition to this new ideology has been taking place from 1985 to the present and can be described as a period of downsizing public universities and research and extension services, as well as privatizing parastatals, and encouraging overseas private investments and new public-private partnerships”.

Therefore, many countries started implementing and experimenting with different processes (decentralisation; contracting/outsourcing; public-private partnerships; privatisation; cost recovery, etc.) in the provision of extension services (Alex and Rivera 2004a, b, c, d, e), the core rhetoric being that the private sector can more efficiently provide specialized technical assistance and that farmers should obtain the information they need from those best suited to give it. The common grounds of such processes are the changing conceptualisation of farmers (beneficiaries to users to clients), a change of the public sector’s role (from provider to stimulator of a private market of advisory services) and the (partial or full) financing of the service provider by the client (Fig. 10.1).

The reform processes, according to Kidd (2004), are “inherently political and depend on power relations and interests among the various stakeholders”. They tend to be market-oriented, have a broader view of extension, in terms of the types of
services demanded and the range of actors that need advice, are led by producers or aim at their involvement (with varying degrees of success), and show an increased involvement of the private sector in the delivery of services (with public subsidy or donor funding). In the EU countries the legitimacy of public and para-public extension and advisory services has been contested by those with neoliberal perspectives who propose a market regulation to adjust the supply of extension to the demand of farmers, and, as a consequence, more or less radical reforms took place (Laurent et al. 2006:112).

In developed countries reforms focus on economic efficiency, cost recovery and demand-driven supply via privatization or commercialisation. These reforms are based on the premises of the dominance of commercial production systems and the decline of the farming population. Commercialisation implies a public service concurrently with the application of user charges for some services (whilst other services may remain public). Privatisation however, implies the full transfer of ownership from government to a private entity. In both cases, farmers are supposed to be able and willing to pay for services and goods – which thus have private good characteristics. At the same time, issues such as ‘who should pay’, ‘which services’ and ‘how much’ arise and become extremely important. In general, small farmers are likely to have less incentive to pay. Buyers are generally market-oriented, profit-making medium and large farmers (see, for example, Dimter et al. 2008). Thus, for Rivera (1997, 2008), such reforms imply either a shortage of poor, small farmers or a decision not to serve them. Additionally, underinvestment by research and extension in the ‘public good’ topics emerges as a major issue of concern, along with questions of exclusion of smallholders and growing social differentiation. As Klerkx et al. (2006) and Laurent et al. (2006) underline, these privatized extension systems may have negative impacts and face a variety of risks, which are summarised in Box 10.1.

### Box 10.1: Risks of privatized extension systems

- A decrease in the information openly exchanged on a free-of-charge basis among various actors within the (national) agricultural knowledge system
- An increase in discontinuity and a lack of concerted action by the various interested players in the knowledge system as a result of short-term contracts and competition;
- Domination by wealthier farmers or commissioners (e.g. government or agri-industry) in determining extension services
- The system may become accountable to large commissioners of contracts rather than end-users
- Little room to manoeuvre or space for learning with rigid output-oriented contracts
- High transaction costs for realizing desirable interventions and services
- An increase in the opportunities for corruption and patronage
- Information may be biased in favour of certain agricultural inputs

(continued)
Nowadays, as also seen in the previous section, there is an emerging view of extension which is no longer that of a unified service, but one of ‘pluralistic’ services (Birner et al. 2006; Anderson 2007; Christopolos 2010; Swanson and Rajalahti 2010); the increasingly complex market, social and environmental demands within an increasingly diversified agricultural sector lead towards a more sophisticated and differentiated set of services. Mainstream extension services thus give way to a variety of hybrid extension solutions in an attempt to find the appropriate mix of public and private funding as well as delivery mechanisms to serve diverse target populations. Cost-sharing, voucher and cost-recovery programmes are seen as appropriate in making extension services more demand and client-oriented. Within such a context, the State, on the one hand, has to promote the public interest and assure social welfare by ensuring the delivery of specific services (i.e. basic occupational education and training, pilot programmes regarding societal issues, such as the conservation of the natural resources, assignments in remote areas, unattractive subjects and work with the most disadvantaged groups etc.). On the other hand, it has to define and implement a coherent policy vis-à-vis a pluralistic system and its financing, and put in place ‘safeguarding instruments’ in order to control the nature and quality of private extension.

Again, topics such as who is served and whose needs or demands are most clearly articulated, determining a fee for extension delivery as well as choosing direct or indirect (via the user) financing of extension providers are central and difficult to solve. Furthermore, farmers have to know their rights and be organised to defend them; otherwise such systems may well be open to take-over and manipulation by private providers and powerful farmers and once more become ineffective. Moreover, private providers may well function within a top-down, linear model, which, in the face of new approaches to innovation and extension, is considered out-dated and obsolete.

**New roles for extension in a knowledge society**

The aforementioned issues pertaining to changes in rural development and innovation theory and practice, and thus in extension paradigms, models and approaches, illustrate the current, challenging scene for agricultural/rural extension
Extension systems and change facilitation
(and) education. This, in turn, implies that agriculture increasingly resembles non-agricultural sectors in terms of knowledge and technology acquisition.

In the non-agricultural literature, approaches such as Knowledge Management (KM), “encompassing any processes and practices concerned with the creation, acquisition, capture, sharing and use of knowledge, skills and expertise” (Swan et al. 1999:264; see also Hinton 2002) and Knowledge Transfer and Exchange (KTE), i.e. the “interactive interchange of knowledge between research users and researcher producers”, in order to “increase the likelihood that research evidence will be used in policy and practice decisions and to enable researchers to identify practice and policy-relevant research questions” (Mitton et al. 2007:729), are gaining in importance.

These approaches are built on networks, as social processes encouraging the sharing of knowledge (i.e. interrelating and sense making), and notably as preconditions for innovation. Therefore, they focus on processes (instead of the emphasis on structures), with knowledge conceived as being constructed through social interaction – i.e. not un-problematically transferred, but instead continuously created and recreated. Particular attention is given to (social) co-ordination and networking. Moreover, to avoid or overcome gaps (cognitive, informational, managerial or system) are resulting in network and institutional failures (see Klerkx et al. 2012, this volume), growing attention is given to various types of (process) ‘facilitators’. For example, Haga (2009) argues for the need to orchestrate networking enablers and for ‘mediators’ or ‘brokers’ as ‘independent players’ in networks aiming at: (a) acting as points of passage to external actors outside the network, bringing in experience and expertise; and, (b) building internal network resources and network structure – upon which network governance and processes depend (see also Dhanaraj and Parkhe 2006). Such ‘systemic intermediaries’ are increasingly found, particularly in industrial literature, as third parties, (knowledge/technology) brokers, bridging organizations, intermediaries, boundary organizations and so on (Howells 2006).

However, extensive reviews on the topic of various types of ‘intermediaries’ show that the field is still theoretically fragmented, not well grounded and largely practice oriented. Therefore, Howells (2006:720) prefers to employ the broad term ‘innovation intermediary’ according to the following working definition:

An organization or body that acts as an agent or broker in any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations.

It is therefore quite clear that such ‘intermediaries’ are involved, taking an independent systemic role, in process facilitation rather than in the production (i.e., source) or dissemination (i.e. carrier) of innovation. Or, according to Haga (2005), they are involved in ‘indirect’ innovation processes (i.e. in enabling individuals and enterprises) rather than in direct ones (i.e. on actual innovation projects). Furthermore, Howells (2006) distinguishes between intermediaries as organizations and intermediaries as processes. He identifies the following functions of intermediaries: foresight and diagnostics; scanning and information processing; knowledge processing and combination/recombination; gatekeeping and brokering; testing and validation;
accreditation; validation and regulation; protecting the results; commercialization; evaluation of outcomes. Howells (2006) also states that such functions are dependent on the context, the development stage and the composition of the innovation network, and the aggregate levels of the innovation system.

**Facilitators of change and knowledge brokers**

In general, due to the aforementioned lack of conceptual groundedness, definitions of various types of ‘intermediaries’, on the one hand, have not yet been widely agreed and, on the other hand, are used interchangeably. In the case of ‘facilitation’, Auvine et al. (2002:54) note that facilitation “is designed to help make groups perform more effectively” and that “a facilitator’s job is to focus on how well people work together”; although a facilitator “can fulfil different kinds of needs in working with a group” his/her actual role depends on “the group’s purpose for coming together and by what is expected … of the facilitator”. Savage and Hilton (2001) distinguish between facilitation, mediation and persuasion, and note that a facilitator affects the orientation of a group and its relationships, adding that a facilitator’s intervention affects both internal (direct and indirect) and external (inward and outward) group processes.

Thompson et al. (2006), in their comparison between Opinion leaders, Facilitators, Champions, Linking agents and Change agents, point out that facilitators’ overall role is “to assist (individuals or groups) through the process of implementing a change in practice” (Fig. 10.2); their distinctive role relates to the use of “the dynamics of a group and their skills to assist persons to move towards change” (2006:694). For Murray and Blackman (2006:239), facilitation aims at “supporting the work of different types of teams in solving mostly complex problems and in developing decision solutions … The point is that facilitation enablers allow learners to be confronted with different kinds of participation.” Finally, Leeuwis (2004) summarises the facilitator’s tasks as (a) to facilitate the group process, (b) to teach, and (c) to be an expert on technical aspects of farming. Such approaches to facilitation relate to
Habermas’ (1984) perspective, in the sense that “a facilitator tries to create an ideal speech situation and through the appropriate intervention strategies helps the participants to engage in a communicative dialogue that results in consensual decision-making” (Savage and Hilton 2001:48).

The case of brokers is, in the first place, similar to that of ‘facilitators’. ‘Knowledge brokers’ have emerged as a part of ‘Knowledge Management’, as well as in ‘Knowledge Translation’ literature, as an ‘emerging human resource’ with the aim to facilitate and improve knowledge sharing between stakeholders, facilitate learning and build local capacity (Dobbins et al. 2009; Jones et al. 2009; Kitson 2009; Melkas and Harmaakorpi 2008). When attention shifts to innovation however, an ‘innovation broker’ is defined as “a type of boundary organization that specializes in brokering or facilitating innovation processes involving several other parties, but does not itself engage in the innovation process” (Devaux et al. 2010:10), i.e. as a ‘facilitator of innovation’.

Innovation brokers are, in general, seen as beneficial to the innovation process by closing system gaps and acting as animators or catalysts. Klerkx and Leeuwis (2008a, b, 2009), through their literature review, identify three major functions of an innovation broker: (a) demand articulation, (b) network formation, and (c) innovation process management (for a more elaborated account see Kilelu et al. 2011; see also Juho and Mainela 2009; Klerkx et al. 2012, this book).

Facilitation of participatory processes

Agricultural literature is rather familiar with the topic of ‘intermediaries’, in the sense of publicly funded bodies aiming at bridging the gap between agronomy-science and farming practice (i.e. ‘conventional’ extension). Such an approach has to do with ‘exploitation’ rather than with ‘exploration’, i.e. with the capturing, transfer and deployment of knowledge in other similar situations rather than with the sharing and synthesizing, thus with the creation of new knowledge (Levinthal and March 1993; Murray and Blackman 2006). ‘Conventional’ extension therefore belongs to the old type of the so-called KIBS (knowledge intensive business services) identified with the linear model of innovation. On the contrary, the topic of the new KIBS operating on the systems perspective and aiming at enhancing the interaction between a variety of actors is a rather new one and has not been extensively dealt with (Klerkx and Leeuwis 2008a). A major role of the new KIBS, increasingly recognised as playing a significant role in the wider innovation system, is that of the facilitator or broker.

Nonetheless, ‘networks’ and ‘facilitation’ have long been discussed in agricultural and natural resources management literature, especially since turning away from the expert syndrome (top-down approach) towards facilitation and group (bottom-up) processes and the empowerment of participants (i.e. ‘passing the stick’ to participants). Important in this respect has been – within the Farming Systems Research – the turn from Rapid Rural Appraisal (RRA) to Participatory Rural Appraisal (PRA) (Chambers 1992; Table 10.3), which “tends to favour facilitation of a non-interventionist variety” (Robinson 2002:48).
A suite of participatory approaches and methods has thus been developed relating to agricultural and rural development (Pretty 1995). This turn has signalled the radical change of the approach towards local populations, from ‘objects’, implying manipulation and dominance by the external ‘experts’ (researchers and extensionists), to ‘subjects’, implying animation and facilitation (Chambers 1995; Fals-Borda and Rahman 1991). Consequently, the need for interaction and dialogue between different actors and networks (the interpenetration of actors’ life-worlds and projects; Long 1992) forcefully emerged (Chambers 1993; Scoones and Thompson 1994), based on the realisation that flows of communication and exchange between different actors are extremely important for existing knowledge to be either reinforced or somehow transformed or deconstructed, thus leading to the emergence of new forms and a “fusion of horizons” (Leeuwis et al. 1990).

Such changes imply that extension has to be transformed to a co-learning facilitator aiming at the development of shared meaning and language between dialogue partners in order to stimulate change and develop solutions and innovation. The engagement of stakeholders in dialogue, despite its difficulties and its time-consuming nature (since (social) learning and change are gradual), is necessary so that critical self-inquiry and collaboration will be achieved. Furthermore, it does not necessarily imply consensus, but rather underlines the need to work together while recognising differences (Meppem 2000).

Such considerations have been further enhanced in agricultural literature and practice owing to the wide dissemination and (although highly contested) acceptance of the Sustainable Development rhetoric, including multi-stakeholder processes (MSPs) thinking (see Dalal-Clayton and Bass 2002; Hemmati 2002), and its adoption/adaptation within various forms of sustainable agriculture. This is based on the understanding that, in addition to the ecologically, agronomically and socio-economically complex nature of farming systems, sustainable agricultural practices in particular are complex, knowledge intensive and non-prescriptive. Thus, for Somers (1998), collaborative problem-solving methods with extensionists fostering discovery learning are required. Extension for sustainable agriculture therefore implies a (social) mechanism for facilitating social learning (Allahyari et al. 2009) with the latter being defined as an approach focusing on participatory processes of social change, that is, shared learning, collaboration, and the development of consensus about the action to be taken (Woodhill and Röling 1998:53). Therefore, a new extension approach aiming at participatory, group learning and networking

<table>
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<tr>
<th>Table 10.3 Between Rapid Rural Appraisal and Participatory Rural Appraisal</th>
<th>Nature of process</th>
<th>RRA</th>
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<tr>
<td>Mode</td>
<td>Extractive-elicitive</td>
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<td>Outsider’s role</td>
<td>Investigator</td>
<td>Facilitator</td>
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<tr>
<td>Information owned, analysed and used by</td>
<td>Outsiders</td>
<td>Local people</td>
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<td>Methods used</td>
<td>RRA</td>
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<td>Based on Chambers (1992)</td>
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A. Cristóvão, A. Koutsouris, and M. Kügler
with extension agents acting as facilitators is required (Röling 1994; see also Garforth and Lawrence 1997) (Fig. 10.3).

**Box 10.2: The ecological knowledge system**

- **Epistemology:** reality is socially constructed, acceptance of multiple perspectives;
- **Ecology:** people are part of the bio-physical environment. They can amplify the human biotope by knowledgeable use of natural processes and cycles;
- **Practices:** applying general principles to the low-input management of locality specific, diverse and variable eco-systems;
- **Learning:** farmer is expert on his/her own farm and takes decisions based on knowledgeable inference from observation and analysis, and relies on his/her ability to anticipate;
- **Facilitation:** creating conditions for discovery learning (through agro-ecosystem analysis, resource flow mapping, etc.), training in observation, experimentation and collective decision making;
- **Institutions:** decentralised self-learning network of farmers and facilitators with access to scientific knowledge;
- **Policies:** financial support for facilitation, network activities, such as farmer meetings, the development of curricula for discovery learning, etc. Regulation of environmental pollution, poisoning and destroying biodiversity and thus making it harder to externalise environmental costs.

(Source: Röling and Jiggins 1996)

Moreover, Röling and Jiggins argue that the move towards sustainable agriculture or, more generally, towards an ‘ecological knowledge system’ (Röling and Jiggins 1996) means the need to move from a praxeology (i.e., theory informing practice, and practices feeding new theory) of ‘transfer of knowledge’ to a ‘facilitating knowledge’ one (Box 10.2). The latter one focuses “on enhancing the farmers’ capacity to observe, experiment, discuss, evaluate and plan ahead” (Deugd et al. 1998:269). It therefore calls for an alternative extension pedagogy entailing stakeholders’ participation in experiential learning and knowledge exchange (Cullen et al. 2008; Woodhill and Röling 1998). Such an alternative framework is guided by systems thinking, experimentation and communicative rationality (Maarleveld and Dangbegnon 1999).

**Facilitation experiences in extension practice**

Within the European Farming Systems community, the issue of ‘facilitation’ has been given attention particularly since 2000, both implicitly (in papers concerning:
systemic and participatory approaches; multi-stakeholder and interactive processes; sustainable (particularly organic) farming; education for sustainability; inter- and transdisciplinarity) and more explicitly in papers particularly within Workshops (WS) devoted to learning (see Appendix I, and also Brossier et al. 2012, this book; Gibbon 2012, this book). Furthermore, a Workshop specifically devoted to ‘Facilitation’ appeared in the 2010 Symposium. Following, based on the review of the proceedings of the European IFSA Symposia, the position of ‘facilitation’, and relevant experiences in the European context are explored.2

In the first place, the need for facilitation of group events and/or networking and coordinated learning and action is stressed in papers discussing projects such as GRANO (research for the environment) (Aenis and Nagel 2000; Nagel et al. 2002) and Regionen Aktiv (regional action) (Knickel and Peter 2004) in Germany, sustainable dairy production in the Netherlands (Bos et al. 2008), the saffron groups in Italy (Santucci 2010) as well as the role of the Chambers of Agriculture in France (Compagnone et al. 2008). The need to manage and fund facilitation along with skills building activities is also highlighted in these papers.

Additionally, examples on how to facilitate learning are presented in a number of papers. For instance, Blackmore (2004) provides processes designed to facilitate learning for managing complexity and change through encouraging reflective praxis.

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2 The papers referred to in this section are not listed in the references and can be seen and downloaded from: www.ifsa-europe.org
Langeveld and Proost (2004), based on their experience with the ‘Farming with a Future’ project in The Netherlands, provide a number of recommendations about how to facilitate learning by focussing on project organisation and learning conditions. Holster et al. (2008) present the activities of the Dutch Dairy Farming Academy, which based on the slogan “Farmers learn from farmers”, acts as a network broker and facilitator of knowledge exchange. Šūmane (2010) also provides examples of how networking activities facilitate innovation and knowledge for the development of organic farming in Latvia. On the other hand, Karner and Chioncel (2010), based on their experiences gained through the FAAN project, discuss the importance and in particular the difficulties of the role of the process facilitator. Cristóvão et al. (2008) in their examination of a number of collaborative learning communities in Portugal, show the importance of agents/facilitators for rural development as well as the challenges they face, while also pointing to the fact that in the case of discontinuance of project support to external facilitators relevant activities did not continue.

The facilitator’s profile is drafted by Ljung and Emmelin (2000) in the context of the Swedish ‘Farmers’ Dialogue’ project. A more detailed reference to facilitation is found in Ljung (2002), sketching a practical theory for collaborative learning and decision making in natural resource management. Further, Wielinga and Vrolijk (2008), based on the Dutch ‘Networks in Animal Husbandry’ experimental programme, developed the Free Actor in Networks (FAN) approach, according to which innovative networks require a free actor, i.e. someone who can create and maintain necessary connections, or facilitator; additionally, the work of free actors requires a different set of tools from that which is usual in project management. The approach is further developed in Wielinga et al. (2010), where the need for knowledge brokers, i.e. for people with the specific task to create knowledge arrangements, is highlighted. Beers et al. (2010), through a systematic analysis of collaborative learning processes, also provide hints for the design of facilitation-support tools.

The topic of facilitation is also discussed in papers addressing the conversion to organic farming and sustainable farming practices in general. On the one hand, the positive roles of advisors as facilitators (and their characteristics), as for example in Wales (Mills et al. 2010; Morgan 2010), are demonstrated. On the other hand, other papers focus on advisors’ inability/constraints to act as facilitators of participative learning processes, as for example in Denmark (Kaltoft 2000; Lisborg 2002), France (Chiffoleau and Dreyfus 2004) and The Netherlands (Klerkx and Jansen 2010). These cases make it clear that the application of facilitation methods is problematic since the ToT model is still dominant owing, for example, to the lack of understanding what participatory learning processes entail, or the fact that extensionists have been trained and brought up in a professional tradition built on the ToT model (Fig. 10.4). One solution might be the provision of external support/facilitation so as to establish a dialogue between different forms of knowledge, which will allow for the identification of bottlenecks, synergies in achieving a common goal as well as the transformation, through collective action, of actors’ skills and activity per se (Cerf et al. 2002).

The inconsistency between extensionists’ beliefs (in collaborative projects and social learning) and practice (i.e. lack of collaborative efforts) is discussed by Christensen and Sriskandarajah (2008) in their examination of rural development extension in Denmark. This may, according to the authors, be attributed to a number
of inter-related constraining conditions related to the organisation of extension service, which reinforces traditional agricultural thinking, is not open to other rural actors and topics except farmers and agriculture, and does not have a clear view on the benefits of collaborative projects in extension.

Similarly, Girard et al. (2004), in one of the most systematic pieces of work on the topic, maintain that, in their involvement with interactive knowledge networks, ‘rural development agents’ are no longer able to rely on their initial training alone, and need to have additional (facilitation) skills. Facilitation is thus one of such agents’ skills and functions, the development of which implies, however, a significant change in their role and professional identity. The difficulties related to the training as well as to the withdrawal of the agent (from a given project) are also pointed out.

A more holistic approach (Cerf et al. 2010) indicates that the problems emerging in various situations where advisers support farmers in developing sustainable farming systems are derived from the advisors’ own professional model or their historically-and culturally-built identities. The latter defines, more or less, the agent’s mandate and role, the mode of interaction with farmers as well as the resources and the way they are mobilized to reach a fairly specific goal. Moreover, the coherence of the model implies that it might be difficult to reconsider it. Nevertheless, the authors highlight the need for ‘innovation brokers’ and discuss entry-points enabling advisors to change their professional model.

Last but not least, recent papers from The Netherlands address the need for independent innovation brokers based on the exploration of ‘brokers’ or ‘boundary organisations/spanners’ and the role(s) of a facilitator/mediator held by key persons in such organisations (Klerkx and Leeuwis 2008a, b; Klerkx et al. 2010).
On the basis of this review, it may be argued that, in the European context, the farming systems community does not seem to have been substantially built on facilitation (in either theoretical or practical terms). The European community has not, for example, seriously embraced prominent facilitation advocating cases such as *Landcare* (Lockie and Vanclay 1997) and *Farmer Field Schools* (Van den Berg and Jiggins 2007), to which the Participatory Extension Approach (PEA), incorporating facilitation for change (Ngwenya and Hagmann 2007), may also be added. The very few exceptions, as for example the implementation of Participatory Learning and Action by the Swiss Center for Agricultural extension (LBL) and, on a pilot basis, in Germany (Stöber 2004) and of FFS in Denmark (Vaarst et al. 2010), eventually work toward the reinforcement of the insufficiency argument.

Overall, despite the general agreement on the shift from a ‘transfer of knowledge’ to a ‘facilitating knowledge’ praxeology, the work on facilitation is rather restricted. Such a gap may be attributed to the fact that despite the development and application of interactive concepts and methods in other regional contexts, western agriculture has for long been dominated by and managed on the basis of linear models (Hubert et al. 2000). Consequently, ‘facilitation’ is largely underdeveloped, especially on the part of European extension organisations. There is a need to open the ‘black box’ of expert knowledge of the extensionist (Kaltoft 2000) in order to move towards a facilitated model of behavioural change. This can be local and contextualised (Ison 2002) in order to develop a theory about platforms and facilitation (Röling 2002), or to define and develop system skills (Blackmore 2004) or to advance research on the role of organisations who facilitate innovation (Knickel et al. 2008). In this respect, Cristóvão et al. (2008) underline the difficulties involved in the transition from the conceptual model to successful practices, while Hubert et al. (2000:20) underscore that “the application of uniform recipes or solutions devised by others for other or even equivalent situations is not acceptable”.

**Looking ahead**

*Extension systems* changed considerably in the last decades and will continue to change, but there is little or no doubt about their present and future relevance. On the contrary, the magnitude and speed of technological, societal and environmental changes all over the world make it even more relevant and necessary than ever before. Agriculture will play a crucial role, as it will have to feed a growing population in a sustainable manner in a scenario of resource scarcity. At the same time, climate change will remain as a fact and a social and political concern, and many other challenges will have to be faced, such as the alleviation of poverty, the well-being and quality of life of the rural population, and the tension between rural depopulation and growing urban areas.

If it is true that, in the last years, public interest and investment in extension tended to decrease, recent documents, such as the 3rd EU Standing Committee on Agriculture Research (SCAR) Foresight Exercise Report (European Commission...
A. Cristóvão, A. Koutsouris, and M. Kügler (2011:181), stress the role of the knowledge and innovation system and specifically underline that “Agricultural extension services are a vital component of a strategy to ensure that science developments and innovative practices are appropriately developed and targeted”. In the same direction goes the reflection and proposals of the SCAR Collaborative Working Group AKIS (EU SCAR 2012).

In the EU, in recent years, the so-called Farm Advisory System has been one of the major initiatives and its results clearly show the diversity of approaches used in the different EU-Member States. The evaluations demonstrate that the results, even though difficult to quantify, are positive, but also a rather low use of FAS’ tools and the need to improve its management, ensuring that knowledge is shared between actors and that synergies between various instruments (advice, training, information, extension and research) are enhanced (ADE 2009; European Commission 2010).

Currently, the EU-Commission as well as various actors involved in/concerned with extension/advisory services are reflecting and engaged in a dialogue aiming at the improvement of the state and efficiency of extension services in view of the new CAP (2014–2020) Pillar II policies. With reference to the definition of the ‘advisory system’, the following three aspects are debated: (a) advisory content and methods, i.e. which are the questions/topics to be addressed, for which farmer groups, with which requirements and needs, and how should they be satisfied; (b) the organisation of advisory services, i.e. ownership, influence/steering, staff qualifications, and (c) the financing of advisory activities, i.e. who pays for what legal setting.

The European Chambers of Agriculture Network, taking an AKIS/AIS approach, proposes that the new CAP Pillar II should include an innovation-partnership measure dedicated to the development and dissemination of innovations in farming systems and rural territories, in order to address future challenges for agriculture and rural development.

The extension agenda, given the speed of changes and the multiple and diverse agricultural and rural development processes, will certainly be multifaceted and dynamic; it will encompass a broad and complex set of issues, such as the sustainable transformation of food production systems, food security and safety, the provision of environmental services, employment creation, territorial cohesion and development (see Table 10.1).

The configurations of the AKIS/AIS in general, and of extension in particular, will be shaped and re-shaped through the continued interplay of different political and social forces (inside and outside the system). The goals, the approaches, the functions and roles of extension agents and other stakeholders, and the types of organizations will certainly differ from country to country and place to place, but a set of global traits can be envisaged, as a result of the review and reflection developed in this chapter.

3 Chambers of Agriculture are established in 14 European countries with about 15,000 employees providing extension and advisory services for more than five million farmers, as well as local authorities, applied research agencies and rural enterprises. They also manage numerous experimental stations, test areas and research laboratories for applied life science. See: www.landwirtschaftskammern.de or http://www.chambres-agriculture.fr/ and http://www.pklwk.at/
Such a complexity, and perplexity, of the present as well as of the foreseen context, along with the well-grounded criticisms of the linear models of knowledge or technology transfer, require the transition to extension paradigms based on systems thinking and focused on process facilitation, social learning and networking, in other words, a shift from a reductionist pedagogical (teaching, knowledge transfer) paradigm to one of co-construction of solutions, recognizing the value of farmers’ (as well as other actors’) cognitive autonomy and praxis (Lemery 2006:250).

Such a paradigm implies organizational changes as well. Thus, Extension systems will tend to become mediating or boundary organizations, assuming hybrid configurations, like multi-stakeholder participatory platforms and consortia, operating with both public and private funds. In these systems, different actors will negotiate the development of their activities, exchanging knowledge, learning and co-building innovations. At the same time, public policies will remain essential in taking care of system funding, coherence, coordination, evaluation, as well as social and territorial equity.

Appendix I. Learning workshops in IFSA symposia

2000 – Workshop 3: Learning and processes in research and extension
2002 – Workshop 5: Learning processes in research and extension
2004 – Workshop 4: Knowing and learning: Labour and skills at stake for a multidimensional agriculture
2006 – Workshop 1: Learning as process
2008 – Workshop 1: Learning, collective action and empowerment for rural reorganisation.
2010 – Theme 1: Knowledge systems, learning and collective action
  WS 1.1 – Innovation and change facilitation for rural development
  WS 1.2 – Care farming: Challenges and innovations in agriculture and social care
  WS 1.3 – Reaching the unreached
  WS 1.4 – Design methods, system approaches and co-innovation
  WS 1.5 – Transdisciplinarity as a framework for integrating science and stakeholders
  WS 1.6 – Learning from and with local experts
  WS 1.7 – Virtual realities and the future of distance learning in rural areas
  WS 1.8 – Knowledge systems, innovations and social learning in organic farming

The full-text proceedings of these workshops can be accessed at: www.ifsa-europe.org.

Note: The first appearance of a WS devoted to ‘learning’ was the joint workshop at the 1998 Symposium ‘Learning processes in developed countries’ out of which the LEARN Group (2000) book titled “Cow up a tree: Learning and Knowing Processes for Change in Agriculture in Industrialised Countries” and the LEARNing
The first workshop specifically devoted to ‘Facilitation’ appeared in the 2010 Symposium (convenors: A. Cristóvão and A. Koutsouris).

References


LEARN Group. (2000). *Cow up a tree, knowing and learning for change in agriculture – Case studies from industrialised countries*. Paris: INRA.


A. Cristóvão, A. Koutsouris, and M. Kügler


Chapter 11
Agri-Food systems and territorial development: innovations, new dynamics and changing governance mechanisms

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Abstract  The chapter explores the linkages between farming systems and agri-food chains in a territorial development context. Lock-in effects within the current agri-food system are analysed through a socio-historical analysis. Then the experiences of emergent, still relatively small-scale, alternative food networks are assessed in terms of their transformative potential to enable sustainable food systems at a larger scale. Finally, the analysis focuses on the transition processes of agri-food systems at the territorial scale and considers the changes needed in governance modes. The chapter underlines the interdependencies and possible complementarities between the various actors of agri-food systems from production to consumption, including intermediaries as well as public policies and civil society. It emphasizes the transition and governance aspects involved.
Introduction and conceptual framework

In the last decades important changes have taken place in approaches to the development of agri-food systems, both in terms of the models and paradigms considered appropriate to guide their transition towards social, economic and environmental sustainability and of concrete practices associated with these. Roughly speaking, two different paradigms and associated agri-food geographies can be distinguished (Wiskerke 2010): the agro-industrial paradigm, and the integrated territorial paradigm (Fig. 11.1).

The agro-industrial paradigm is anchored in the principles of the agricultural modernization project which has guided the development of European agri-food systems in the last 30–40 years (Marsden 2003; van der Ploeg 2004), and can be characterized by three mutually reinforcing processes:

• The modernization and industrialization of food provisioning systems (production, processing, distribution, sales);
• The standardization of food production and processing practices and procedures; and
• The globalization of food markets (Murdoch et al. 2000).

The renewed agro-industrial paradigm for sustainable agri-food systems, which is currently appearing, does not question the agri-food modernization process of past decades, but rather envisages its acceleration and deepening. Advocates share a firm belief in technological solutions for the problems of contemporary food systems, and claim that these may also contribute to an ‘ecological modernization’ of food

Fig. 11.1  Two different paradigms can be distinguished: the agro-industrial paradigm (left) which is based on modernized agriculture and standardized food production; and the integrated territorial paradigm (right) in which distinctive food qualities and territorial linkages are emphasized
production processes; for example through labour-saving technologies to reduce cost prices or zero-emission agro-industrial parks. The hypermodern food geography associated with this paradigm is increasingly becoming footloose or placeless (Holl 2004), and is projected on the urban environment e.g. by means of ‘vertical farming’ techniques.

The integrated territorial paradigm, which emerged in its contemporary version in recent decades, but has profound historical roots and backgrounds, supposes a rupture with the principles and policies of the modernization project. Against the idea of a generalised model with universally claimed validity (Renting et al. 2008), it aims to reinforce the capacity of agri-food systems to valorise specific territorial resources and social relations of proximity. In many respects territorial embeddedness is a common denominator for the emerging practices of the alternative, local food geography (Watts et al. 2005), i.e. agri-food systems are increasingly embedded in and based upon the distinctive features of the territory, and integrated with other activities such as nature and landscape conservation, tourism, care and education (Renting et al. 2008; van der Ploeg and Marsden 2008). In line with this, the integrated territorial paradigm is built around highly differentiated food quality definitions – reflecting differences in farming systems, networks, cultural traditions, consumer preferences, etc. (although this does not necessarily replace formal quality signs). This territorial perspective is in strong contrast to the standardized and ‘placeless’ quality characteristic of the agro-industrial approach (Renting et al. 2003; Sonnino and Marsden 2006). While several empirical case studies suggest that territorially-based supply-chain initiatives are characterized by good sustainability performances,1 an important limitation for this model to play a leading role in transitions to sustainable food systems is that existing initiatives remain relatively small and localized and that viable dissemination models (either by up-scaling or ‘multiplication’) are not sufficiently clear. Another bottleneck is that the role for different (public, private, civic) support strategies in the further unfolding of an alternative local food geography is still largely unexplored. Existing initiatives have frequently developed outside, or even in opposition to existing policy frameworks, but also often require support mechanisms that are at odds with existing governance conceptions.

Under the integrated territorial paradigm, the specific experience of alternative food networks which may be defined as localised initiatives aimed at re-connecting production and consumption on the basis of shared goals of environmental and social sustainability, has added new perspectives. It has revitalized the public and scientific debate on agri-food systems and has attracted the attention of policy makers who are increasingly aware of their innovative potential and in some countries and regions have become more strongly involved in their development. For about a decade, alternative food networks have been analysed by emphasizing their potentials and limits, including their transformative role, and have also been critically

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1 Examples are case-studies in European research projects such as IMPACT (www.rural-impact.net), SUS-CHAIN (www.sus-chain.org) and COFAMI (www.cofami.org).
assessed with respect to their degree of ‘alternativeness’ (Allen et al. 2003; Watts et al. 2005; Holloway et al. 2007). As far as the ability to develop innovation pathways is concerned, some scholars have analysed this transformative role by drawing on transition theories, for their capacity to provide a useful conceptual framework and analytical tools to explain the contribution of alternative food networks to wider societal changes (Wiskerke and van der Ploeg 2004; Seyfang and Smith 2006; Brunori et al. 2009). In this paper, we will also apply this theoretical framework to Italian Solidarity-based Purchase Groups (GAS) to study in detail the changes alternative food networks might convey. However we will also show that a territorial viewpoint open to the diversity of actors and initiatives, their interactions and complementarities, is useful in order to study the processes and conditions of transition towards sustainable agri-food systems.

As areas of experimentation and fine-tuning of alternative socio-technical practices, alternative food networks appear as early expressions of the process of food re-territorialisation and re-socialisation and of the integrated territorial paradigm. Parallel to their growth and in part also as a result of the stimulus to change that they have introduced, other experiences of re-organization of food production-distribution-consumption have developed at the crossroads of alternative and dominant food systems (therefore characterized as ‘hybrid’ initiatives). Indeed, the two paradigms and associated food geographies we have presented above are to be considered oppositional Weberian ideal types, and although expressions of both paradigms can be found in practice, a significant part of contemporary food systems are best understood as a hybrid food geography, combining elements of both paradigms and part of on going, incomplete transition processes (Whatmore 2002; Sonnino and Marsden 2006). Beyond the classical dichotomies of territorialized forms of food quality (artisanal products, protected origin denominations like PDO/PGI, etc.) versus de-territorialized forms (mass production in industrialised farms, for anonymous markets), short food chains versus long food chains, organic versus conventional farming practices, it appears that the transitions towards sustainable farming systems can also combine different types of agri-food chains (of different lengths), and even of modes of agriculture. Studies focusing at the territorial scale suggest that the combination of mixed forms (short + long food chains, territorialized + mass production, or even organic + conventional) might be a promising pathway towards sustainability for territorial agri-food systems (Lamine et al. 2012). In this paper, we will stress the need to analyse the coexistence and interrelations (but also contradictions) between these different initiatives, adopting a territorial viewpoint. We consider that this perspective and its implications in terms of governance are most helpful to better understand the transition pathways towards more sustainable agri-food systems.

Our main argument is that the development of innovative pathways for agri-food systems at territorial level relies on the existence of a diversity of initiatives and actors, and therefore on the structuration of networks of relations between them, but also on appropriate governance mechanisms. Here we will define and analyse the agri-food system as a socio-technical system encompassing the ensemble of interrelated social and economic actors and institutions involved in food production, processing, distribution and consumption. Alternative food networks – of which
consumer buying groups like GAS\textsuperscript{2} in Italy and AMAP\textsuperscript{3} in France, Community Supported Agriculture (CSA) initiatives, and Farmer’s Markets are all examples – represent experiences of construction and experimentation of alternative pathways within the agri-food system, necessarily embedded in the territory at local and regional scale. Their relative success is also triggering broader processes of change, which give rise to hybrid forms, new experimentations, involving new actors (e.g. public institutions and conventional market parties) and gradually reorganize old forms of coordination (e.g. cooperatives, brokerage). These alternative and hybrid experiences, seen and studied as a whole at the scale of a ‘territorial agri-food system’, are creating new contexts of opportunities for a transition process. At the same time, they also pose new challenges in terms of modes of governance. We will show that we fundamentally need to rethink the role of governance mechanisms in the development and functioning of agri-food systems.

In line with this overall perspective the paper is structured as follows. In the first section we will address, based on a socio-historical analysis, the past and current lock-in effects within the dominant agri-food system and describe the agri-food governance mechanisms corresponding to the agro-industrial paradigm.

In the second section, based on the case of Italian GAS Solidarity Purchase Groups (see footnote 2), following the transition theories perspective, we will analyse the transition pathways suggested by this specific type of alternative food networks. We will describe the way they change production and consumption practices thanks to a shared process of reshaping the socio-technical system, in its practical and immaterial components, and the push they thereby give to the other agri-food system actors, the institutions and the civil society.

In the third section, we will adopt a broader perspective to analyse the diverse food-related initiatives developing at territorial level (among which some very alternative, some less) in two regions where a significant overall transition towards organic farming can be observed and the way these initiatives involve local food chain actors through specific modes of coordination and governance. We will explore the changes in governance modes that currently emerge in line with the integrated, territorial agri-food paradigm, and that may potentially enable a more fundamental transition towards sustainable food systems.

**Lock-in effects within the current agri-food system**

Based on a socio-historical analysis, we will first demonstrate how the current agri-food system has embraced the agricultural modernization project and the related agro-industrial paradigm, by following a convergence of specific innovations and of associated actor strategies over a longer period of time. The changes and *lock-in*
effects within different components of the current mainstream agri-food system resulting from this are then illustrated with insights from recent studies. Finally, we will indicate how the dominance of the agricultural modernization project throughout the last decades has also been reflected in the role and relative weight of state, market and civil society as key agri-food governance mechanisms.

The process of intensification in wheat cultivation: a socio-historical analysis of the agro-industrial paradigm

The path dependency theory, developed within evolutionary economics, suggests that an innovation trajectory may become dominant and strengthened by the feedback of its implementation, despite the existence of alternative innovations which could have offered a better sustainability in the long run (Dosi 1982). Possas et al. (1996) have adapted it to the case of agriculture and shown how the convergence of the main external providers of innovation (suppliers, public institutions, agro-industry, collective organisations, etc.) has led to the reinforcement of the productivist regime anchored in the agro-industrial paradigm. Despite its recent questioning, strong uncertainties about future technologies and paradigms hamper the transition towards a new socio-technical regime.

In line with these approaches, we draw on the case of winter wheat cultivation in France and demonstrate through a socio-historical analysis the coherence of the socio-technical system and the irreversible effects created by the specific and interdependent trajectories of different components of the agri-food system. From the 1960s onwards, this socio-technical system has stabilised itself around a productivist ‘intensification paradigm’, which has progressively created lock-in effects and path dependencies (Cowan and Gunby 1996; Vanloqueren and Baret 2009) due to the convergence of innovations (for example homologation of new pesticides, selection of cultivars, changes in farming practices such as fertilisation methods, sowing techniques) and associated actor strategies. This has led to a change from a curative to a more systematic use of pesticides. Pesticide use became even preventive in various respects as was shown by the analysis of technical arguments prevalent at that time, appearing in a special issue of the main French arable crop growers’ journal (Effland 1981). It is also linked to the development of early fertilisation, early sowing dates and higher sowing densities in a productive model with yield maximization as main objective (Fig. 11.2).

The professional identity was centred on these criteria: a professional network created around 1980 was called ‘Club des 100 quintaux’ (‘100 quintals club’, i.e. 10 t/ha club), a level of production that some farmers began to reach. Research in genetics and the seed industry were organised around this demand of high yields, and developed high yielding varieties that were nevertheless also sensitive to pests and diseases (Fig. 11.3). The seed inscription process and criteria also prevented the development of resistant varieties as was demonstrated in a recent socio-historical study (Bonneuil and Hochereau 2008). Several official events and dissemination
Fig. 11.2 Time line of the progressive evolution towards intensification: a convergence of innovations and strategies (regarding pesticides homologation, plant breeding, farming practices, research and advice etc.) from the 1960s to the present, with a shift around 1980.

Fig. 11.3 During the modernization period, agrochemicals were increasingly used by farmers and cropping practices were introduced that depend on the use of treated seeds, fertilizer, herbicides and pesticides. This created a path dependency, i.e. a self-perpetuating dependence which is difficult to break away from.
strategies spread out this model especially in the advisory sector, in which at the same time input suppliers became increasingly involved.

The high coherence of these developments and their consequences in terms of ‘lock-in’ effects become clear when we look more precisely at the different system levels: cropping systems, farming systems, advisory systems, plant breeding and seed market (Meynard and Girardin 1991) and processing and distribution:

- At the level of cropping systems, there is a strong coherence between practices, i.e. varieties choice, sowing, fertilisation and the use of chemicals.
- At the level of the farming system, there is a strong coherence between intensive crop management, work organisation and equipment.
- At the level of advisory systems, there is a strong coherence between the dominance of intensive cropping systems, the origin of technical advice and the content of information.
- At the level of plant breeding and seed industries, there is a strong coherence between intensive, high-input management strategies and the prevalence of plant and disease sensitive varieties on the seed market.

While these processes of technological change have been studied mainly at farm and agricultural sector level, there is also a clear relation with changes at the level of the processing and distribution sector (the milling, bread and bakery industry). For example, the development of technological criteria linked to industrial processes such as the protein content, which is directly linked to fertilization levels, has been unfavourable for an evolution towards low-input practices (Wiskerke 2003; Lamine et al. 2010)

There have been minor deviations in this general development which highlight the conditions for a global transition towards more sustainable crop protection strategies. From 1993 until 2006, cereal prices were decreasing, while environmental problems were increasing. This led some producers to change their practices, mainly to reduce their costs, but also for environmental and ethical reasons. Some chose to convert to organic farming, others reduced their use of inputs. Those transitions were sometimes strengthened by the existence of public subsidies such as the agri-environmental schemes from 1992 onwards. In the same period, several scientific studies assessed the technical and economic feasibility of more extensive farming practices (Meynard and Girardin 1991; Rolland et al. 2003). However, these results were not really displayed by public advisory services, and for long references were hardly found in scientific and technical publications. More generally, these trends have remained relatively isolated and occurred mainly in social and geographical contexts where collective dynamics could develop and where good support could be offered to producers.

One of the difficulties hampering the development of these trends is the need to articulate organic or integrated cultivation practices with new forms of processing and commercialization, which often need to be built from the ground up. Some interesting initiatives were developed regarding regional breads (Wiskerke 2003), which once again underline the interdependencies within the wider agri-food system and the need for collective dynamics involving different relevant actors.
Current lock-in effects: empirical studies of actor strategies and interdependencies in crop production systems

In recent studies\(^4\) current *lock-in effects* within the agri-food system and their role in hampering transitions towards more sustainable plant protection practices such as Integrated Pest Management (IPM) and organic production were analysed. The analysis focused on the cases of wheat and fruit production and on four components representing main sources of both lock-in effects and changes within the agri-food system and allowing to address the interdependencies within this system\(^5\):

- Evolutions in grower’s practices: conditions of change go far beyond the farm level, collective dynamics and learning processes among farmers are of utmost importance;
- Advisory systems and governance of research and extension: these actors focus on the improvement of techniques rather than on radically alternative socio-technical systems;
- Retailers guidelines: quality criteria, most often defined by market regulations, appear as a major bottleneck for increasing the sustainability of farming practices, retailers guidelines are generally poor in terms of environmental aspects and focus mostly on record keeping of practices (Haynes et al. 2010);
- Involvement of civil society: environmental NGOs have highly influenced changes in the European pesticide risk regulation, but think in terms of zero pesticide rather than low-input practices, except at local scale in interactions with farmers and their reality (Cardona 2012).

Due to the complexity of interdependencies within the whole agri-food system, changes in agricultural practices have to involve different levels of the system. The different components presented above define the main conditions for significant evolutions towards more sustainable food and farming systems: collective dynamics among farmers, translation of changes in farming practices into marketing strategies, implication of research and extension, and the involvement of the civil society. They also show the importance of public policies and governance mechanisms.

In the case of Switzerland for example, it was demonstrated that a major change towards IPM could be progressively achieved precisely because these different conditions were present and inserted in a global movement involving extension services, education, research, IPM groups of growers and retailers’ strategies. Eventually, IPM was translated into public policies once the civil society confirmed with the 1996 constitutional vote, that it was prepared to support the Swiss agriculture on the condition that it would be ‘in tune with nature’ and multifunctional.

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\(^5\) The results are based on 188 qualitative interviews with a variety of stakeholders by sociologists in France, Switzerland, the Netherlands, the UK, Denmark, Italy, Poland and Hungary within ENDURE.
The innovation process from the first voluntary groups of growers in the early 1960s to the generalisation of IPM as compulsory method in the late 1990s has been progressive and well-managed, for example by mixing old and new members in groups of growers or by integrating IPM as part of the teaching programs of agricultural schools (de Sainte Marie 2010).

Changes in agri-food governance mechanisms: the agricultural modernization era and the successive CAP reforms

The dominance of the agricultural modernization project throughout the last decades did not only result in a specific convergence of socio-technical practices and inter-relations between the main components of the current agri-food systems. It is also reflected in the shaping of main agri-food governance mechanisms in this period, their evolution over time, and the particular role and weight that is addressed in these to public policy, private actors, citizens and their organizations.

To describe the changes in agri-food governance mechanisms, we apply the basic ‘governance triangle’ composed of the state, market and civil society (Fig. 11.4) which is used in social sciences to distinguish key institutional mechanisms that may give ‘structure’ to collective human behaviour within society (Rhodes 1997; Renting 2008; Wiskerke 2010). While the state mainly corresponds to public regulation in order to structure collective action, the civil society’s governance mechanisms refer for example to active citizen’s participation and democratic control. The market, on the other hand, mainly makes use of market regulation mechanisms such as prices and rules for market liberalization or privatization as means to govern market partners’ actions.

Debates on agri-food governance in recent decades have mainly focused on relations between market and state intervention in agriculture, while much less attention was given to other axes of the triangle, i.e. to the role of civil society in structuring agri-food systems. On the one hand, this bias reflects that agriculture and food production for long were mainly considered as an economic activity and food as a tradable commodity, not that different from other products and economic sectors, for which (perhaps with the exception of emergencies and acute shortages) price mechanisms played a central role in the structuring of markets. On the other hand, agriculture and rural development have figured among the first policy fields for which state intervention was relatively early an accepted phenomenon, if not with respect to markets then certainly for improving farm structures, technical efficiency or food safety control. International public regulation of agriculture has a long tradition, keeping in mind that agricultural market structuring was a key reason for founding the European Union (then Community) in 1957 and since then the Common Agricultural Policy (CAP) has remained a main policy area of the EU.

While market and public regulation were thus considered as key governance mechanisms, this was not the case for civil society. Indirect control by general representative democratic institutions was considered a sufficient level of citizens’
involvement and only for professional organizations and interest groups (farmers’ unions, and exceptionally, consumer groups) a stronger involvement in policy making was foreseen. As for involvement in markets, civil society’s role was reduced to that of (individual) passive end-user of food products.

In the past decades, important changes occurred in the role and importance of different governance mechanisms and their interrelations. The governance triangle enables us to analyse these changes within their historical context and to understand their driving forces and implications (Renting 2008; Wiskerke 2010). Figure 11.4 visualizes the role and importance of different governance mechanisms at the heydays of the agri-food modernization project (ca. 1960–1985) as well as changes that occurred in these in successive CAP reforms (ca. 1990–2000).

In the agricultural modernization era the original CAP design was put into practice to guarantee basic food self-sufficiency in response to post-war shortages. Indirectly it aimed to enable a diversification of the economy by providing cheap food for growing urban populations working in industries and services. The CAP was therefore principally intended as a food policy, albeit with a focus on boosting and restructuring farm-level production and a stronger role for agro-industries. The resulting policy approach combined market and price policies, on the one hand, and structural development policies on the other, both with the aim to modernize EU agriculture and increase farm productivity. In terms of governance mechanisms, in the modernization era public regulation played a dominant role. The state not only attempted to shape infrastructural conditions and improve farm structures or management practices, but also intervened in commodity markets by providing subsidies and setting...
price levels to make specific crops attractive to farmers. However, beyond securing minimum safety standards the state hardly intervened in food quality issues.

Looking back, the original CAP has been very successful in meeting its objectives of raising productivity and realizing EU food self-sufficiency. However, by the late 1980s increasingly negative side-effects of the agro-industrial model it had promoted became apparent, including detrimental effects on the environment, budgetary pressures due to overproduction, unequal distribution of policy benefits between regions, and growing international pressure to reduce policy support to agriculture. This multi-dimensional crisis made the initial CAP layout unsustainable and triggered a reorientation of public policies, resulting in a redefinition of the role of different key agri-food governance mechanisms (see Fig. 11.4).

The successive CAP reforms from ca. 1990 onwards, first of all established a new balance between public and market regulation. Market intervention and price support were gradually abolished and partially compensated by direct income support to comply with requirements to avoid trade distortion established in international policy arenas such as the World Trade Organization (WTO). However, the CAP reforms were more than a gradual withdrawal of the state as principal actor within overall agri-food governance mechanisms. They also implied a redefinition of the role of public policy in agri-food governance in response to the dramatically deteriorated public image of mainstream agriculture due to the environmental crisis and reinforced by food-related health scares and animal disease outbreaks like BSE and Foot and Mouth Disease in the 1990s. The CAP reforms tried to counteract societal discontent by introducing several complementary measures principally aimed at improving environmental performance and food quality. Examples include agri-environment schemes, support for conversion to organic farming, and the protection of origin-labelled food products introduced with the 1992 CAP reform and afterwards integrated in the rural development pillar of the CAP. In response to food scares, additional food safety measures and health and consumer protection policies gained importance within over-all agri-food governance throughout the 1990s. With these measures state agencies attempted to reinstall the confidence of wider population sections in mainstream agri-food systems, generally however without explicitly and directly involving civil society groups (e.g. environmental and consumer NGOs) in public policy development and effectuation.

We will see later on that there are important indications to suggest that the contours of a new agri-food governance mode is currently emerging, which corresponds to the integrated, territorial paradigm outlined in the introduction.

**Innovation in production and consumption: alternative food networks as triggers for wider changes**

Drawing on transition theories, in the following paragraphs we will analyse the processes of innovation promoted in recent years by alternative food networks, seen as niches of experimentation of new attitudes to and practices with food. Then, we
will focus on the experience of the *Gruppi di Acquisto Solidale* (Solidarity-based Purchase Groups) (GAS) in Italy. Despite their relatively small size, their widespread diffusion across the country and the capacity to stimulate public opinion and political-institutional contexts make these initiatives significant from the perspective of transition to more sustainable food systems.

**An application of transition theory: alternative food networks as niches of experimentation**

Transition theories have provided a useful conceptual framework to better explain the contribution of alternative food networks to wider socio-technical changes (Wiskerke and van der Ploeg 2004; Seyfang and Smith 2006). Based on studies of technological transitions and system innovations, the transition theories have developed a multi-level perspective which understands transitions as outcomes of changes at three main levels which are socio-technical regimes, landscape and niche innovations (Smith et al. 2005; Geels and Schot 2007). The notion of socio-technical regime refers to the set of rules, knowledge and technologies with respect to a given sector, i.e. food production, processing, distribution and consumption in our case. Changes at the landscape level, i.e. the exogenous environment (macro-economics, cultural patterns and macro-politics), create pressure on the socio-technical regime and its destabilisation in turn creates windows of opportunity for niche innovations. These innovation paths may then contribute to a change of the dominant socio-technical system through integration or even replacement. The size of niches is small enough to guarantee a protected space of operations, and despite their modest impact in terms of volume, they may be very effective, as they suggest different ways of looking at things and different rules and norms. This concept of ‘niche’ is useful in order to understand the development of alternative food networks and their transformative role (Brunori et al. 2011).

The carrying out of alternative provision-consumption practices as developed within the framework of alternative food networks indeed looks like a *radical innovation* process, involving deep changes into knowledge and value systems, techniques and infrastructures, rules, codes and organisational patterns. This process firstly entails, within specific actor networks, the socialization of new meanings attached to food and secondly, the removal of social and material constraints (of a technical, regulatory, organisational, social or knowledge-related nature). By doing so, it moves towards a real re-configuration of the dominant socio-technical system. The creation of concrete alternatives to the conventional ways of producing, selling and consuming, generates tensions with the context in which they operate, and triggers processes of change at a higher level. For example, they express demand for new technological solutions, which may stimulate innovative research programs; they push to adapt existing regulations on the basis of their exigencies; and challenge dominant values and behavioural norms with regard to consumption and production. In other words, alternative food networks appear as drivers for system innovation.
The interrelations between niches and regime represent a crucial issue in transition theories (Shove 2003, 2007). To what extent may niches have a relevant impact on regime change, how can this happen and how will the regime manage the transition? Empirical evidence shows that quantitative growth of alternative food networks is not necessarily an indicator of success, as scaling up may end up in deviations from innovative trajectories and absorption into existing regimes. The debate on ‘conventionalization’ has explored this problem with reference to organic farming (Guthman 2002, 2004; Seyfang 2006) and fair-trade (Renard 2005; Jaffee 2007). Other studies have pointed at the processes of ‘appropriation’ of values and meanings in relation to other kinds of quality products (Allen et al. 2003; Kirwan 2004). Focusing on the appropriation of the meanings related to the ‘local’ attribute, considerable debate has grown on the strategies of co-optation carried out by corporate agri-business companies (Novak 2008). All of these experiences have stimulated a fruitful debate on the trade-offs between growth, integration with existing agri-food systems and coherence to constitutive values (Goodman and Goodman 2007; Jaffee and Howard 2010). Movements like Community Supported Agriculture (CSA) in northern America (Cone and Myhre 2000), AMAP in France (Lamine 2005), GAS in Italy and certain types of Farmers’ Markets (Kirwan 2004; Govindasamy et al. 2002) build upon points of weakness of previous experiences of innovation (organic, fair-trade, territorial), and draw upon a strong political commitment to re-articulate ethical values, technical norms, commercial patterns and organizational rules.

The case of GAS (solidarity-based purchase groups) in Italy

Pushed by the members’ need for quality food, but also by a deep sense of dissatisfaction and distrust of the conventional production and distribution system, Italian GAS have given rise to innovative food provision systems (see Box 11.1 for a detailed description). By a variety of mechanisms such as creating partnership with farmers, bypassing middlemen, employing voluntary work, creating alternative logistics based on private/social tools and spaces, avoiding unnecessary operations and materials, and by substituting official certification with other forms of control and guarantee, these systems facilitate access to good food and create win-win situation for farmers and consumers (Brunori et al. 2007, 2011, 2012).

From the transition theories perspective, GAS express the willingness of involved actors to reshape food conceptions and practices by entirely re-building the socio-technical system, intentionally founding it on shared ethical principles. The adhesion to this particular kind of direct relationship between production and consumption entails significant changes in consumers and farmers cognitive and normative frames, as well as practical and organisational assets. With the adhesion to GAS,

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6This analysis draws on research for the European IN-SIGHT project (Brunori et al. 2007; Dockès et al. 2008) and for a regional project that has monitored this reality since 2006.
Box 11.1: Gruppi di Acquisto Solidale (Solidarity-Based Purchase Groups)

GAS are groups of consumers who collectively manage direct purchasing and distribution – of food and non-food products, sometimes of services – according to shared ethical principles of solidarity, sustainability and equity. They are self-organised and based on members’ voluntary work. The first GAS was formed in 1994, but they spread strongly from 2000 onwards. In September 2011 about 800 GAS groups were registered, but their number is likely much higher (about 2,000, according to their national coordination).

Farmers are selected on the basis of their adherence to sustainable consumption and production principles. The agreements established with them are different from group to group, ranging from ‘simple’ arrangements for recurring orders (establishing quality of products, prices, organisational aspects, etc.) to more sophisticated agreements based on a stronger commitment by the GAS to supporting the farmers (e.g. through various forms of financial support, mid-term contracts).

There is an intense communication within the networks, which allows for the circulation of organizational information, but also exchange of opinions (ranging from sustainable consumption and production to broader political issues). These practices are significant to the process of defining shared norms and rules, building common knowledge infrastructures, as well as for the organization of other initiatives and interaction with the outside.

Each GAS is autonomous in selecting farmers and in organizing ordering and distribution. There are also regional and national levels of coordination, which have a more political character.

consumers change their attitude and adapt their purchasing and consumption routines; this both with regard to their attitude towards food and the related organization of space-time habits (Brunori et al. 2012). As in other alternative food networks, in this process of adaptation they try to resolve and balance several significant dilemmas: e.g. price vs. quality, convenience vs. health, freedom of choice vs. ethics, taste for artificial additives vs. taste for natural goods. Consumers involved in these processes are encouraged to re-define their conception of food, (re-)learn the way to handle it, (re-)position it in their scale of priorities and in some cases to get motivated to adjust their lifestyles and to (re-)socialize their food practices. All these adjustments at the individual and household level create ‘learning spaces’. Yet, GAS consumers live this experience collectively and, thus, learning becomes ‘social learning’ in the sense that innovation is shared and becomes part of a common frame of understanding and action.

Farmers also face significant adjustments in order to cope with GAS needs. They need to adapt key aspects of their practices and organisation such as: crop planning, moving from specialization to diversification; methods of production,
converting from conventional to organic farming (an essential condition for the GAS movement); their conception of management, within a new partnership with their ‘customers’ (Lamine 2005); their organisation and human resources; the relations with other farmers involved in direct marketing, in order to find forms of co-operation; their communication practices, which require developing relational abilities. Farmers often have to change their entrepreneurial model and acquire new knowledge and skills as well as develop awareness of the many opportunities linked to a partnership with reflexive consumers (Brunori et al. 2011), a process that cannot be taken for granted except maybe for the specific category of ‘neo-peasants’ (Willis and Campbell 2004).

However, GAS activity is not limited to the relations between consumers and farmers and is open to the interaction with wider networks. The ongoing experiences show the importance of interactions with local farmers’ markets, associations of small farmers, other local actors involved in alternative food networks or more generally engaged in sustainable production and consumption or territorial development (local administrations, technicians, NGOs, political groups). All these interactions constitute social structures in which communication, negotiation and learning processes on different perceptions and concerns take place (Brunori et al. 2007; Kerton and Sinclair 2010) and thereby new cognitive, normative and regulative institutions are developed.

Within these networks, the processes of building collective identity and of sharing common sets of meaning attached to food production-consumption underpin the consumers’ and producers’ turn towards new, responsible practices (Kneafsey et al. 2008). Reflexive consumers discuss their way of purchasing and consuming, thus gaining awareness and getting stimulus to behave coherently. Likewise, farmers discuss their status, their way of producing and managing their activity and their expectations towards the direct relationship with consumers (Lamine 2005; Chiffoleau 2009).

New systems of knowledge and skills, strongly based on peer-to-peer interactions and on the sharing of expertise, lead to new rules and organizational patterns. They affect the production processes and hence the ‘quality’ of products, the practices involved in food distribution and consumption, as well as the relations between the two parts (Fig. 11.5). This concerns not only constraints that belong to the farmers’ and consumers’ world, but also to the other spheres of the regime (e.g. hygienic, fiscal and seeds regulations, technology, consumption norms).

In a context of increased awareness and criticism towards the unsustainability of the current agri-food system, this concrete implementation of an alternative approach to food production and consumption marks a turning point. It is no longer only the expression of the reflexive choices of consumers (and producers) within a given supply of partial options (Shove 2005), often grounded on a trade-off between different principles like the willingness to save the environment, cultural heritage, health or localised (far away or close by) economies. It rather represents a conscious and intentional effort to build ‘another’ system, in which a shared, coherent set of meanings, principles and goals is translated into new, concrete social practices.
Looking at the transformative role of alternative food networks

This innovation process goes beyond the direct operation of a new food provisioning system. As a result of this grassroots mobilization, a different discourse about food is developed, which incorporates ethics and equity issues as well as various other aspects linked to food practices. A demand for new policies is arising, both at territorial and at a broader scale.

At local level, empirical evidence shows how the GAS experiences can work as a revitalising factor within local communities. In an increasing number of cases, GAS have proven to be able to give rise to fruitful experiences of social learning, involving different actors. These new organizational patterns created around food are proving to act as catalysts of new forms of social mobilization within the territory and, together with other alternative food networks, are stimulating other local actors (public administrators, farmers’ organizations, cultural and environmental associations, social movements, and training agencies) to develop new approaches and initiatives. More generally, they have posed new questions and challenges in the public arena, including demands for quality of food products, rural and urban land management, biodiversity conservation, etc.

At a broader scale, the GAS experiences are fostering a process of increased public awareness and ultimately the development of a new discourse and the demand for new politics and policies about food-related issues. The emphasis that these direct systems of food provisioning are receiving from the media, opinion leaders, cultural
associations (e.g. Slow Food) as a possible alternative to face the uncertainty created by food scandals and to answer to the growing criticism on the mainstream system, has favoured the growth of interest outside the ‘alternative arena’ of committed citizen-consumers or activists. It has also favoured the growing recognition of the legitimacy and the social value of these initiatives by public institutions, even though these continue to mainly focus on traditional top-down and sectorial approaches instead of a more fundamental reframing of policies.

Like other alternative food networks, the GAS experience was born as a grassroots initiative aimed at implementing a radical change in the ways of conceiving, producing and consuming food. As expression of a different system organised around different attitudes, values and demands, it is reflecting the growing demand of citizens for ‘food democracy’. As a niche of experimentation of new attitudes and practices however, its innovative potential is also represented by its capacity to challenge the dominant food regime, and in some ways put the finger on some of the critical areas to be dealt with in the transition towards sustainable food systems. Widespread changes in food practices demand significant changes in important areas such as food culture, knowledge and technological systems, regulatory and institutional frameworks, territorial planning, etc. Clearly this is a complex process with many implications in terms of policy. The possibility to capture the innovative potential of these initiatives is strongly linked to the presence of a favourable institutional environment, open to experimentation and valorisation of the diversity of transition pathways following an integrated approach.

Towards an integrative, territorial mode of agri-food governance

Redefining agri-food systems at the territorial scale: two case studies from southern France

At the territorial scale, i.e. for a small region with up to one million inhabitants depending on the population density, it is possible to identify the main actors of the agri-food system both within ‘alternative’ and more dominant ‘conventional’ structures and initiatives with the aim to consider possible complementarities of different food chains. The aim is not to oppose alternative networks and actors to more conventional ones, but rather to consider the whole range of initiatives in a given territorial agri-food system and the changes and interactions within and between them. Following this approach, since 2009 ethnographic comparative fieldwork was realized in two Southern French rural regions in the Rhône Alpes: the Drôme valley and Southern Ardèche.

Both regions are diversified in terms of natural conditions and productions, with cereals in the plains, extensive livestock in the mountains, and wine and fruit production on the hillsides. However, apart from areas close to the Rhône valley, most of the regions are too remote to be competitive in mainstream fruit or cereal production.
In recent years both regions have undergone similar changes: an economic crisis in traditionally the most viable sectors (e.g. fruit production), a strong growth of organic farming (about 10–20% of arable land) especially in niche productions (aromatic and medicinal plants in the Drôme valley, chestnut and kiwi in Southern Ardèche), and a historically strong attraction for neo-rural inhabitants wanting to go ‘back-to-the-land’. More general tendencies such as distrust in ‘industrial’ food and farming techniques and increased willingness to access local food are also present.

In both territories the transition of vegetable and fruit growing to organic production was studied focusing on a series of initiatives launched by producers, consumers and local actors or alliances between them, together composing a gradient of degrees of ‘alternativeness’. While in the previous section we focussed on specific alternative food systems directly linking consumers and farmers, here we consider a larger range of initiatives (alternative, hybrid or more conventional) involving other local food chain actors (e.g. cooperatives and wholesalers), local authorities and civil society as well as a larger range of farm types (including large and specialised ones).

Regarding changes in farming systems, interesting ongoing and potential transitions to organics were found for both small and large, formerly specialised farms. These transitions appeared to rely on diverse, complementary objectives: developing ‘school food procurement schemes’ (Fig. 11.6); extending organic supply to local and more distant consumers; improving economic and social viability for example by diversifying production on conventional farms who were in lasting economic difficulties, etc. These farming systems transitions could be characterised, according to the initial situation, by dynamics of either diversification or specialization of production and a related evolution of marketing strategies (Lamine et al. 2012).
In the case of Southern Ardèche transitions to organic farming were shown to depend on three main conditions:

- Complementarity between different kinds of market outlets: short food supply chains (AMAPs, box schemes, open air markets, on-farm sales) and longer food supply chains (school food procurement, organic wholesalers, local fruits cooperative).
- The integration of farmers in various networks: organic professional networks, an informal local producers’ group (collecting and marketing products to wholesalers and school food schemes), civil society organizations (AMAPs and consumer organizations).
- The role of local public policies: support to organic farming and school food procurement. However, local policy support is still relatively weak compared to the Drôme Valley or other regions which embraced the ‘quality’ or ‘organic’ turn earlier and succeeded in mobilizing regional, national and European funds (e.g. LEADER).

In a complementary study for both territories relevant initiatives were identified, which may be distinguished in three main categories following our introductory discussion of agri-food systems paradigms:

- Alternative food networks: producers’ collective shops (run by producers, some organic, who have to be present a few hours a week), AMAPs (reciprocal commitments between producers – generally organic – and consumers).
- Conventional initiatives, responding to the demand for local and organic foods: an organic vegetable product line developed by a local producers’ cooperative for a large organic wholesaler with technical support of the local Chamber of Agriculture, and a producers’ shop run by the same cooperative.
- Hybrid initiatives, which do not involve direct producer-consumer relationships, but build modes of coordination and commitment in between alternative and conventional ones: informal organic producers’ group which organise collective expeditions and sales to organic wholesalers, a school food procurement network (organic and local products), and a network providing a local cooperative organic shop.

Each of these initiatives were studied with respect to their emergence (starting date, initiators), trajectories (enlargement), links to other networks, and modes of coordination with various involved actors and institutions, were studied. A comparison of these initiatives shows their diversity and helps understanding their modes of coordination and commitment:

- In conventional initiatives, marketing rules are based on classical quality criteria, there are no lasting contracts and part of the production may be refused when the market is saturated;
- In alternative initiatives on the other hand, we observed reciprocal producer/consumer commitments (written long term contracts, weekly encounters) in AMAPs or at least a direct access to consumers’ expectations through producers’ presence in their shops as well as a relative autonomy from classical quality...
criteria. Producers also coordinate together through collective planning of vegetable crops.

• Hybrid initiatives allow some adjustments of quality criteria (for school procurement or local consumer cooperative) as well as collective planning of crops involving producers and schools or consumer cooperative’s staff.

These hybrid initiatives are promising in two main aspects. First, they allow these adjustments of classical quality criteria which in turn might allow for a reduction or suppression of chemical impacts and/or diverse tasks such as grading the products. Second, they rely on collective crop planning which allows producers to be more efficient in their work, enhance complementarities with nearby producers and reduce risks in terms of sales. The case of the local organic consumer cooperative is particularly interesting, because a recent change in governance mode (involving not only consumers, but also producers, other local operators and local authorities) allows the cooperative to play a coordinating role in local food projects (e.g. school food procurement and processing facilities) within the territory. The network strongly involves local civil society as well as local authorities and economic actors, thereby allowing these actors to build a shared vision for the territory (Lamine 2011).

This case study more generally points at the importance of coordination and the need to establish adequate governance modes for innovative territorial experiences, an issue which has also been addressed concerning the case of local food platforms and ‘food hubs’ (Morley et al. 2008). Finally, it underlines the need for diversity of initiatives and for complementarity between more alternative and more hybrid ones in a perspective of transition towards sustainable territorial agri-food systems.

**Redefining the role of the state, market and civil society:**
the contours of a new integrated mode of agri-food governance

The case studies presented in the previous sections suggest that gradually the contours of a new mode of agri-food governance is emerging, which increasingly corresponds to the integrated, territorial paradigm outlined in the introductory section. While it is too early to fully define this new mode of agri-food governance it is increasingly becoming clear, that in several important ways it is different from the previous governance modes that were described earlier.

First, it appears that no longer any of the main governance mechanisms are dominant, there is rather a search for an effective balance between mechanisms in different spheres and a redefinition of the roles of state agencies, market parties and civil society groups. Public-private partnerships, territorial bottom-up approaches and active citizen’s involvement play an important role in the emerging model, and new governance forms may as well find their roots in policy developments as in market-driven trends or civil society initiatives.

Secondly, the integrated, territorial governance mode is characterized by a growing diversity of involved institutional and societal partners. As for public institutions,
policies are no longer principally driven by EU and national state agencies, rather regional and local governments increasingly claim a role in the development and implementation of new agri-food policies. Moreover, involved policy actors are no longer limited to state agencies traditionally dominating agri-food policies (e.g. departments of agriculture, rural development, or economic development). Increasingly also representatives from policy fields with a less strong producer-focus (e.g. public health, climate change, education, sustainable development) and with a non-rural background (cities, metropolitan regions) take up an active role in agri-food policies. Examples are ‘urban food strategies’ and ‘food charters’ to enhance the availability of healthy and sustainable foods established by territorial authorities like London, Amsterdam, Vancouver and New York (Vermeulen 2007; Reynolds 2010) or the ‘Food & Climate’ initiative of the city of Malmö to reduce food-related greenhouse gas emissions with 40% by promoting organic foods and changes in food habits. A similar diversification of involved actors can be noted for involved civil society partners. This growing heterogeneity of actors has contributed to the development of new, innovative approaches, but also results in specific new governance challenges.

The growing diversity of involved institutional and societal actors is a reflection of the changing nature of contemporary agri-food related problems. In response to multi-dimensional food-related health and sustainability concerns in recent years, a range of initiatives from civil society organisations, (local and regional) governments and sometimes also market partners has emerged. Together these new food practices compose a new alternative and local food geography which is grounded in a different logic and incorporates different values. Driven as it is by new concerns about food quality and safety, nutrition, food security and climate change, the emerging new food geography is developing along three interrelated and mutually reinforcing societal axes (Renting 2008; Wiskerke 2010) (see Fig. 11.7):

- Alternative food networks – new relations between citizen-consumers and food provisioning systems (the civil society-market axis).
- Re-valuing public food procurement – new relations between the public sector (as food buyer and consumer) and food provisioning systems (the market-state axis).
- Urban and territorial food strategies – the rise of local authorities as food policy makers, pointing to new relations between public institutions and citizens (the state-civil society axis).

The development of short food supply chains and alternative food networks, is generally considered to be the first sign of the emerging new food geography. The next ingredient of the new food geography is the rising awareness of the role the (semi-)public sector can play in enhancing sustainable food systems by changing its food procurement strategies. By re-localizing, greening and moralizing public sector food the government and (semi-)public bodies such as hospitals, schools and prisons have the capacity to deliver health and sustainability objectives in addition to enhancing regional employment in the food sector (Morgan and Sonnino 2008).
The third ingredient of the new food geography regards urban and territorial food strategies, i.e. the active role of local (often urban) authorities as food policy makers, which principally aims to re-establish linkages between the state and civil society around food issues at local and regional level. Although territorial food strategies differ from place to place, the common denominator is the intention to connect and create synergies between different public domains that are somehow related to food, including the construction of markets for sustainable, local and/or organic foods, public food procurement, educational activities, reinforcing (peri-) urban agriculture, etc. (Wiskerke 2010). Facilitating civil society initiatives is often an essential part of urban and territorial food strategies.

**Conclusion**

Three main themes emerge from this combined approach, which are the role of alternative and hybrid initiatives within transitional food strategies, the fruitfulness of territorial approaches to study these transitions, and the changes of the agri-food governance mechanisms involved.

First, it appears that transitions to more sustainable agri-food systems will not only rely on alternative food systems, even though these niche initiatives are precisely
those which trigger broader processes of change in the agri-food systems as the case of GAS showed. Our argument is that it is necessary to consider the diversity of actors and modes of coordination involved in the wider agri-food system, and the complementarities between more alternative and more hybrid initiatives.

On the farm scale, it is necessary to take into account the diversity in which farmers combine different modes of production, market outlets and networks, and to overcome some classical opposing views such as ‘organic farming + short circuits + high diversity’ versus ‘conventional farming + long circuits + specialization’. We have illustrated that the territorial scale is often the most appropriate for describing and analysing the transitions within the agri-food system, as it allows a representation of the new geography of food linked to the integrated paradigm and to consider the changes in governance modes which facilitate transitions towards environmentally and socially sustainable agri-food systems.

This broader perspective allows us to see beyond ‘alternative’ and ‘non-alternative’ initiatives and to adopt an integrated vision, focusing on the relations which can develop among all the relevant actors of the new food geography. The emerging integrated and territorial food geography points to a shift in agri-food governance, both vertically and horizontally (Van Kersbergen and Van Waarden 2004). Policy aims and legal frameworks for European agriculture, food and rural development are largely formulated in Brussels. However, the actual implementation and specification of these EU aims and frameworks is increasingly delegated to the regions. Although the emergence of urban and more generally territorial food policies is not a result of decentralized food policies, it does show the growing importance of lower administrative levels in policymaking and implementation.

Besides this vertical shift in management tasks and responsibilities, we also observe a horizontal shift. For instance, food quality and safety is increasingly seen as a joint responsibility of government and private enterprises (Kirwan et al. 2012). The role of civil society, to a certain extent organized through social movements, seems to be crucial and centres on notions such as food democracy and food sovereignty (Hassanein 2008). The rise of integrated and territorial food geography requires a reconsideration of the role of the state and of public policies in food policy (Lang et al. 2009) as well as a strong articulation of agricultural and food issues. Food policy is no longer synonymous with agricultural and rural policy and food issues have become an item on diverse policy agendas such as public health (e.g. obesity, food poverty), environment (e.g. climate change) and food quality and safety (e.g. local and authentic food). These policy fields cross the boundaries of ‘traditional’ agricultural and rural policies and institutions in charge of these and have resulted in the involvement of a range of new public government institutions and civil society organisations in food policy issues. A sustainable food economy requires the active role of public authorities to fully exploit the potential of re-localizing public food procurement (Morgan 2008) and to guarantee some principles of social equity between concerned social groups.
References


Chapter 12
The Territory Agronomy Approach in research, education and training

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Abstract Landscape and territory agronomy analyses the two-way relationship between farming practices and land patterns. It takes into account both agro-environmental and socio-economic processes. A conceptual framework is presented to facilitate understanding of the complex interactions between the disciplines that contribute to this new field of research. We discuss the organisational issues that arise at various spatial and temporal scales during the development of territory-based case studies and research projects. The territory agronomy approach is a participatory action science. Building on our experiences, we propose a conceptual research-education-action platform for land management and territorial development. It demonstrates that the Territory Agronomy Approach is an iterative process where researchers, teachers, trainers and stakeholders develop new questions and methods through participation. These characteristics make the territory agronomy approach adapted to promote the territorial dimension in research, education and training activities on farming systems.

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Introduction: from farms to landscape and territory

The experiences and knowledge that matured in Farming Systems Research (FSR) since the first European Symposium in the late 1990s have resulted in a significant contribution to the development of sustainable family farms and farming systems in general (Darnhofer et al. 2012, this book). However, farmed land constitutes only part of the landscape and the sustainable management of farmed land by itself is not enough to create sustainable European landscapes. In our view, emphasizing the landscape and territorial dimension in Farming Systems Research would contribute to move from sustainable farming systems to sustainable farming landscapes.

In fact this process has slowly started to take place within various research and education units in Europe. In the last two decades, researchers from various disciplines have increasingly focused on large-scale studies concerning agricultural related issues (Marraccini 2010). The spatial scale of the agronomic research tends to move from the field to the cropping system and then to the farming or the agricultural systems. There are two main reasons for this shift in attention. On one side, the production of knowledge at the small experimental sites has to take into account processes occurring at different spatial and temporal levels (Pelosi et al. 2010), on the other side, society asks researchers to support land management decisions (Nassauer and Opdam 2008). Following the often misleading or controversial use of the words landscape and territory (Caron 2005; Rapey et al. 2008) it is difficult to extract the substantial scientific production that exists regarding these themes from international databases. A bibliometric research combining ‘landscape’ in relation to various disciplines (Fig. 12.1), and ‘landscape’ with key words related to farming activities (Fig. 12.2), clearly shows how territorial issues have gained interest in the last 20 years.

![Bibliometric analysis of landscape scale research concerning agricultural related issues](image-url)
This trend has not involved disciplines in the same way (Marraccini 2010). While in ecology and planning this increasing trend has started around 1995, it proceeds more slowly for agronomy. The first agronomical studies which started to take into account larger spatial scales were mostly based on the analysis of the interaction among the ecological and agronomic components and regarded the whole environmental system (Burel and Baudry 1995; Borin et al. 1997). At the same time, however, some research pointed out that the structure of the landscape is generated by all the farming practices as a whole, and that the agricultural production system is one of the main drivers in the spatial organization of the territory (Deffontaines et al. 1995; Giupponi et al. 1999). More recent studies have focused on the structure of the landscape trying to link land use systems to the services they provide to the society (Willemen et al. 2008).

Looking at research concerning the systems at various landscape scales (cropping, farming, agricultural systems), the same increasing trend as for disciplines is highlighted, which started in 1995. Agricultural systems research shows a stronger link to these landscape studies probably because of the larger spatial scale researchers take an interest in when studying agricultural systems. It is also interesting to notice that peaks in landscape system related research occurred in relation with important European policy steps, as was the case of Common Agricultural Policy and Rural development reforms in 1999, 2003 and 2006.

In recent years various attempts have been made to conceptualize this under the general term ‘landscape agronomy’ and ‘territory agronomy’. Landscape agronomy focuses mainly on agro-environmental issues at a landscape scale involving farmers as main stakeholders (Rapey et al. 2008; Lazrak et al. 2010; Moonen et al. 2010).
while Territory Agronomy focuses on issues which involve the interactions between farmers and other stakeholders with an interest in non-agricultural activities such as industrial, recreational, cultural, nature conservation or living, and their implications for the allocation of all socio-economic activities and land uses within agricultural landscapes (Boiffin 2004; Caron 2005).

The opening in the Territory Agronomy Approach (TAA) towards stakeholders and issues not directly involved in farming obtains extreme importance seen the great variety of semi-agricultural areas in Europe, such as peri-urban areas, High Nature Value Farmland, environmentally sensitive areas. The importance of taking into account different stakes in agricultural landscapes becomes clear when looking at the division of land use types in Europe, where agriculture represents 41% of the total surface (European Union 2010) and is homogeneously distributed over Europe (EEA 2010). Of this area, mixed land use types (sum of all areas where land use is a mixture between agriculture and forest, semi-natural and urban) resulted in a high diversity of European landscapes for a large part of Europe (Eurostat 2009).

The introduction of the term ‘territory agronomy’ and the widening of the context this brought along finds its origin in south European countries who, in their original language, differentiate strongly between ‘landscape’ (French: ‘paysage’; Italian: ‘paesaggio’; Portuguese: ‘paisagem’) which is used in a more ecological context and refers mainly to the processes taking place, and ‘territory’ (French: ‘territoire’; Italian: ‘territorio’; Portuguese: ‘território’) which refers to land governance units and is thus more related to the geographical and social spheres. The Anglo-Saxon meaning of the word ‘territory’ on the other hand, has its origins in classical ecology, i.e. the area occupied by a living organism for fulfilling all its needs for survival and reproduction.

‘Territory’ in the Territory Agronomy Approach goes one step further and unites both ‘landscape’ and ‘territory’ concepts. This is very similar to what Caron (2005) described as ‘integrative agronomy’ (Fig. 12.3). This type of agronomy sits at the crux of biophysical processes, technical procedures and social dynamics. Territory Agronomy should therefore not be confused with the study of the land managed by one farmer, indicated by some agronomists as the farm territory (Thenail and Baudry 2004) where the territory can be spatially discontinuous.

In this chapter we will present existing tools and methods of the Territory Agronomy Approach which we think can be useful in Farming Systems Research as well. The objectives of this chapter are to show how the Territory Agronomy Approach allows shedding light on the territorial dimension of farming, and thus captures important aspects for Farming Systems Research. We will do this by analysing the Territory Agronomy Approach in research and illustrate this with two examples showing how important it is to involve stakeholders in the process of problem definition regarding territorial issues. We will then show how the Territory Agronomy Approach can be implemented in education and training curricula to enrich existing agronomic curricula and ensure that agronomists are ready to face the complexity of needs of today’s stakeholders in agricultural landscapes. Lastly, we will discuss how we think Territory Agronomy Approach can contribute to enrich Farming Systems Research for sustainable agricultural landscape management and
make those aspects of the existing Territory Agronomy Approach explicit which have to be further developed in order to match up to the needs of research and education.

**Territory Agronomy in research**

**The Territory Agronomy Approach**

As explained above, Territory Agronomy (TA) can be seen as an enlargement of the concept of Landscape Agronomy (LA) (Moonen et al. 2010) and in Fig. 12.4 this has been visualised graphically. Landscape Agronomy focuses mainly on agro-environmental issues related to farming practices and effects on and of agricultural land use patterns in relation to agro-environmental issues (Benoît et al. *under review*). Consequently it limits its interactions to strictly agronomic stakeholders (dark grey area in Fig. 12.4). Territory Agronomy includes a wider range of land use issues in areas where agriculture is concerned but might not be the major or only activity (light grey area in Fig. 12.4). A logical consequence of this widening of the system boundaries is that non-agricultural activities, governing bodies and the socio-economic context of the study area gain an important place in the research.

However, widening of the system boundaries does not necessarily mean that the spatial scale of the study is larger. One can perfectly well approach a landscape agronomical issue (livestock farming systems effect on groundwater pollution) at national level or a Territory Agronomy issue (causes of land abandonment) at local level. So, the approach is not related to a specific spatial scale and can be applied at different levels.
Central research themes of the Territory Agronomy Approach are expressed in the three poles of Fig. 12.4 (Moonen et al. 2010; Benoît et al. 2012). The poles represent the original disciplinary backgrounds Agronomy, Ecology and Geography, which, when combined and placed in a spatio-temporal and social context, create the synergies and innovations of Landscape and Territory Agronomy: farming practices and systems (Landscape Agronomy) as part of broader land management practices and systems (Territory Agronomy), agro-environmental processes (Landscape Agronomy) as part of broader environmental and socio-economic processes (Territory Agronomy), and agricultural land use patterns (Landscape Agronomy) as part of broader land use patterns (Territory Agronomy). The interactions between the poles represent the type of research questions or management
and planning issues that constitute the study objects of the Territory Agronomy Approach. The nature of these interactions can be read and interpreted at different temporal, spatial and social levels (e.g. season/year/generation time spans, field/farm/landscape scales, farmers/land-users associations/local authorities’ organization levels) and this will influence the interpretation of the studied phenomena. Therefore research following the Territory Agronomy Approach needs to explicitly refer to the spatial, temporal and social dimensions at which the study will be carried out.

**Concepts and tools of the Territory Agronomy Approach**

Research questions falling within the scope of the Territory Agronomy Approach are characterised by the following key-words: agriculture, interdisciplinary, spatial scale, dynamics, complexity, multi-functional land use and stakeholder oriented. It follows that mere disciplinary-based research and analysis concepts and tools are not sufficient to tackle these projects efficiently.

Disciplines which have contributed to the development of the Territory Agronomy Approach are geography, ecology, agronomy, land planning and management, and especially in southern Europe, landscape architecture. In the past, interdisciplinary fields of research have been conceived from bilateral interactions between these core disciplines, such as landscape ecology, agro-ecology and geo-agronomy.

The first concepts gathered within the Territory Agronomy Approach by the various disciplinary contributions were for example related to farm territory and landscape description and analysis, farm territory and landscape management, agricultural land use and farming practices, multifunctional agriculture, agro-biodiversity, cropping systems, farming systems, agricultural systems, dynamics of systems and processes and spatial land use patterns. We can roughly say that concepts related to production and farming practices were brought in by agronomists and these themes are treated at a small spatial scale involving mainly farmers as stakeholders. Themes related to landscape, farm territories and land use patterns are brought in by geographers or ‘geo-agronomists’ (Deffontaines 1998; Prévost 2005), and themes related to dynamics of agro-ecological processes and land use changes by ecologists, landscape ecologists and agro-ecologists. Management issues at larger spatial scale involving other land use types than agriculture were represented by landscape architects.

Each type of research has its own set of tools although some overlap already existed. Main tools in the Territory Agronomy Approach toolbox are farmers/stakeholders interviews, farm mapping, aerial photo interpretation, landscape areas mapping, landscape element identification; graphical modelling (“chorèmes” see Brunet 1986), local knowledge mapping, land use typology, agro-environmental indicators development. Research themes which may benefit from a Territory Agronomy Approach are for example: ‘How do agricultural systems contribute to conservation of surface water quality?’, ‘Do farmland dynamics co-evolute with land use changes?
Examples of research projects

In general PhD projects are good test cases for innovative research because they have the advantage that (i) they are not always strictly connected to financed projects which need to produce predefined knowledge outputs, and (ii) because innovation is the first requirement for these projects. Box 12.1 describes two PhD theses that contributed to the development of Landscape Agronomy or Territory Agronomy. The description is based on six concepts which are characteristic of territorial studies: the type of farming system analysed, the study object(s) involved, the used land patterns, the groups of stakeholders involved, the spatial and temporal scale, and the main discipline involved in the project. The considered PhD theses are particularly interesting because they are at the interface between Landscape Agronomy and Territory Agronomy.

Box 12.1: Two PhD theses addressing landscape/territory issues

_Agriculture dynamics and soil conservation issues in Mediterranean rural landscapes_ (Debolini 2010). The research project analyses environmental degradation processes to evaluate how agro-environmental functions have been affected by land use change in the past years, and which kind of agricultural practices and landscape management can reduce the risk of function loss. The study aimed to apply a multi-scale approach, passing from the regional scale, to a more detailed watershed scale. The study allowed to identify similar areas where we could propose new development models for agricultural systems. The research question of the project contained the main key-words indicated as concepts in Territory Agronomy Approach: agriculture, interdisciplinary, spatial scale and multi-functional land use. In term of involved disciplines, agronomy and geography are included in the methodological approaches used and in the theoretical framework, and the final aim dealt with land planning and management in rural landscape. In fact, among the applied tools we can identify farmers interviews, aerial photo interpretation and land use change mapping, as well as some tools from geomorphology, hydrology and physical geography (i.e. erosion modelling). Accordingly, the main land patterns involved in the study are land use, soil typology and agricultural practices, besides the hydrological information needed for modelling (e.g. water networks and rainfall). According to the final aim of the project about new management and planning strategies in rural areas, the (continued)
Both PhD projects (Debolini 2010; Marraccini 2010) are characterized by a multi-scale approach, going at least from the landscape to the farming system scale. Local production systems are especially relevant when research involves land management and territorial development. Land use is the main landscape pattern, but it is not sufficient to define the landscape functions in the study area. It has to be integrated with the main anthropic and natural elements of the analysed landscape. Intermediate production structures (e.g. agricultural cooperative, environmental associations, farmers associations, extension services) play a relevant role as

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**Box 12.1:** (continued)

Project was characterized by a spatial multi-scale approach, going from the landscape to the farming system scale, and a multi-temporal approach, considering the land use change analysis.

**Agro-environmental functions: a landscape agronomy approach** (Marraccini 2010). This PhD thesis dealt with an innovative methodology to characterise the fulfilment of agro-environmental functions (AEFs) defined in a territory by policy objectives and testing whenever land use patterns can be used as indicators of functions fulfilment. In a context where European agro-environmental policies target several environmental resources used for farming, difficulties in considering multiple agro-environmental functions and farming activities, along with lack of databases, hinder the implementation of such policies at regional scale. Starting from the relationships among farming systems, agro-environmental processes and land use patterns, a link was hypothesised between land use patterns and agro-environmental function fulfilment obtained from geographical conditions influencing such processes. Furthermore, characteristics of the developed method were (a) multiple functions oriented, because of the current agro-environmental policies; at multiple levels (from NUTS 3 to the landscape level), because of the complex relationships between our research subjects; spatially-explicit, reproducible for different time spans; empirical, because partially based on assumed relationships between descriptors of agro-environmental function fulfilment. We have tested the method in: Puy-de-Dôme (France) and Grosseto Province (Italy), presenting similar agro-environmental heterogeneity (e.g. varying from arable crops plains to extensive livestock mountains) and different conditions (e.g. soil quality, land use, climate). In the research, the stakeholders’ point of view were considered at all the stages: stated objectives in policy document, expert knowledge on farming regions, farmers knowledge on its farm and farming practices. All the stages of the research needed different methods and tools, which were taken from geography, landscape ecology, sociology. However the classical agronomic point of view was taken into account, for example by making hypotheses on the choice of the indicators, on the production systems and using the description of the farming practices as the main basis for agro-environmental function assessment.
stakeholders involved in these research projects, and in some cases they represent a preferential speaker to point out the territorial issues associated to the landscape planning and territorial management, because they easily and actively participated in these projects and therefore provided most relevant information to the researcher.

Both studies followed a systemic approach: interdisciplinarity was developed, particularly between agronomy, environmental sciences and human science; stakeholder participation was large even though co-construction of the research was rare; territorial issues were considered with different spatial and temporal levels of organization; projects were developed based on the diversity that was presented by the case studies. The Landscape and Territory Agronomy framework (Fig. 12.4) is a helpful tool in analysing research projects, both our own work and work from others (Benoît et al. under review), indicating the issues and interactions which received most attention during the research, and the ones which we touched upon only from a distance. In such interdisciplinary projects it is almost impossible to pay similar attention to all issues and dimensions (spatio-temporal and social/organisational), but it is important to make these choices in a conscious way and make this explicit.

**Linking Farming System Research to the Territory Agronomy Approach**

From the maturing phase of Territory Agronomy five key concepts and attitudes emerged as crucial: spatio-temporal relationships, reflexivity, co-construction, connection to the field and context-dependence adaptation. The concepts related to spatio-temporal relationships are fundamental for a correct analysis and interpretation of the study object in the sense that they determine the observed patterns and processes. The social dimension which is equally important in the Territory Agronomy Approach is present in the following attitudes.

First of all we mention the importance of ‘reflexivity’ (Ison 2012, this book) which regards both an attitude of the researchers as of the stakeholders involved. It is the researcher’s role in the analysis process to stimulate this attitude in all participants. Co-construction and connection-to-the-fields are guarantees for involvement of all territorial stakeholders (Carmona-Torres et al. 2011), and from this it follows that no two studies can be performed by a similar itinerary (context-dependence). Each project will find its basis in a real-world case study (connection to the field) and determines its itinerary together with the involved stakeholders (co-construction) (Poudel et al. 2000; Martin et al. 2011; Breton et al. 2011). The continuous evaluation and interactions between stakeholders and researchers leads automatically to adaptation of the itinerary during the project. This process goes one step further than mere inter-disciplinarity and we can therefore state that the Territory Agronomy Approach is a trans-disciplinary activity (Gibbon 2012, this book).

The Territory Agronomy Approach is strongly rooted in Farming System Research. Research question formulated within the Territory Agronomy context touch upon farming systems in as far farming systems are among the main drivers of agricultural landscapes. However, with increasing diversification of the landscapes, the impact of other land use types and land management systems on landscape
Farming systems and territorial issues

patternning, spatial organisation and processes increases (Tasser et al. 2009; Zhang et al. 2008). It is especially in these multifunctional landscapes that the Territory Agronomy Approach gains importance. For example, issues related to agricultural activities located in areas which are or will be designated as high nature conservation value will benefit from a Territory Agronomy Approach because there are strong links between the agricultural and non-agricultural land uses and land users (Halada et al. 2011). At the same time, these areas have gained interest of policy makers at all levels (from EU to regional), and they have different objectives which they try to stimulate through new rules and regulations (Visser et al. 2007). In such complex situations we will have to pass beyond the study of single farming systems and look at the territorial dimension in all its complexity.

Other complex Farming Systems Research themes which can benefit from the Territory Agronomy Approach are for example: social issues in rural development because the farmer’s development cannot be seen isolated from the social context (Egoz et al. 2001), water quality and quantity issues because what happens on farm originates from and impacts on an entire watershed (Dodd et al. 2008), erosion problems because also in this case the farm is part of a larger system (Poudel et al. 2000), and conflicts between farming and non-agricultural land uses because land is a limited resource which has to be shared by multiple stakeholders and multiple objectives (Styger et al. 2007).

Territory Agronomy Approach in education and training

In this section, we describe the benefits for PhD students if the Territory Agronomy Approach is included in curricula of higher education. We then illustrate two experiences with training courses for territorial stakeholders (farmers, local authorities, land managers, etc.) confirming the previous issues and opening to new perspectives for Territory Agronomy research. The first one is a participatory training course for technicians and representatives of local authorities on agricultural landscape management in Tuscany (Italy) held in 2009 and 2010. The second one is a participatory and prospective territorial diagnosis training course for newly employed administrators of French local authorities which has been conducted for 10 years now.

Education

Current situation

The authors of this chapter – together with a wider group of colleagues from all over the world who expressed interest in the territorial approach to agronomy – are convinced that there is a great need to educate young agronomists in the complex and problem-solving aspects of land management. Inclusion of territorial issues in their curricula would better prepare them for the important role they can have in land management and
planning issues where so far agronomist are only very little involved, despite the fact that most land management issues are located in agricultural landscapes.

Currently agronomist follow rather classical courses and the only innovative aspects they may come across in their courses are related to the impact agriculture has on the environment and how to develop more sustainable agricultural systems. Wider themes related to agricultural landscapes, such as the contributions agriculture gives to landscape preservation, nature conservation, rural development and urbanization, tourism and recreation are mostly left to ecologists, geographers, landscape architects, and landscape planners (Tress et al. 2005). Occasionally agronomists become interested in these cross-cutting themes but they have great difficulty in widening their education and gaining a respected place when applying for jobs. Our experience teaches us that students generally have the impression that their basic education failed to prepare them for these innovative approaches and they all attributed great value to the courses in Landscape Agronomy and Territory Agronomy organised by individual researchers that have taken an interest in territorial issues, organized, as part of more classical PhD programmes.

**International experiences**

This aspect clearly emerged from two workshops held on ‘Education in Landscape and Territory Agronomy’ at the 2008 and 2012 European IFSA Symposia.¹ During these sessions participants from several countries (France, Italy, Portugal and Germany) presented and analysed their experiences with the organisation of courses which dealt with changes in agriculture, related to landscape and territory dynamics and environmental demands (Benoit et al. 2008; Benoît and Lardon 2010; Dosso and Soulard 2008; Etienne et al. 2008; Martin 2008; Michelin et al. 2008; Paradis et al. 2010; Pinto-Correira et al. 2010; Therond et al. 2010).

Study objects represented farming systems, land use systems and agricultural systems and involved both planning and management activities. The most frequent disciplines involved besides agronomy were technical sciences, life sciences, geography, social and economic sciences, planning, landscape architecture. These experiences show that the territorial issues include the systemic and interdisciplinary concepts of the Farming Systems Research. By including a territorial dimension in education, the importance of interdisciplinary approaches increases and innovative tools and learning methods are more likely to be developed to transmit these complex concepts to the students. Besides classical lectures which are needed to give all students the same level of basic knowledge needed to participate to the course, use can be made of various observation methods, computer simulations and prospective vision approaches.

Almost all education experiences showed that the collective implementation of a case-study with territorial stakeholders was a successful way to stimulate the learning.

¹ Full papers available at: http://ifsa.boku.ac.at/cms/index.php?id=62
Full papers available at: http://ifsa.boku.ac.at/cms/index.php?id=112#c290
Both students and lecturers evaluated this approach extremely useful and important because it emphasized the necessity of a close connection to the field and increased awareness of the complexity of issues. By studying problems at a farm scale, awareness of interaction with the surroundings are not always clear. The territorial approach urges students, teachers and participating stakeholders to open their minds to the impact of their action on other components of the system (e.g. environment, other land users), and with that, to re-evaluate the appropriateness of their handling on a smaller scale (e.g. farm management). At the end of such experiences the students are more prepared to cope with complex situations in real-life situations they may encounter during their professional life, and will be more inclined to involve local stakeholders in their research projects.

Therefore learning by doing is a good practice and is a very effective tool to increase awareness of the complexity of situations. The Territory Agronomy Approach makes the territorial dimension explicit by considering landscape as the result of farming activities, a medium to interact with stakeholders and an object of planning activities in which agronomy could play a key role. Territory Agronomy Approach can contribute to sustainable farming systems by increasing awareness of how development at farm level relates to development taking place at landscape level. Farm development opportunities depend to a large extent on the surrounding environmental conditions, and the local and regional socio-economic characteristics. Both environmental and socio-economic conditions can be a constraint of or a catalyst for certain development strategies and it would be important that farming systems researchers have tools in hand to adequately analyse these interactions. This will allow them to re-evaluate farm-scale decision making. The diversity of the study cases that could benefit from a Territory Agronomy Approach underlines the need to reply on approaches with a great adaptive capacity. Our aim is therefore to enrich the students’ toolbox with tools that can be applied to the great variety of territorial issues that they may encounter in the future.

Future developments in education

For the development of future education courses which include the territorial dimension it would be important to focus on the following aspects. First of all it would be important to have PhD courses which actually express the focus on territorial issues in their name. This would give more visibility and easy recognition of the PhD title on the job market. From our experiences we conclude that there is a wide enough basis for such a formalisation of territorial issues in higher education. This would stimulate reflection on educational methods in Territory Agronomy, and could give a boost to new approaches both for research and for education. We think there is ample space for innovation regarding some key issues of the Territory Agronomy Approach.

For example, the reflexive attitude of students should be developed. They need to be stimulated to analyse their own approach to research and to learn from such an auto-analysis. This is part of the iterative process of problem analysis in the Territory
Agronomy Approach but is useful in other work situations as well (Fig. 12.5). Another innovative potential of the Territory Agronomy Approach is related to tools for combining scientific concepts with stakeholders’ knowledge. This is exemplified by for example theoretical contributions to practical work or by using a participatory approach for the development and implementation of innovative solutions for specific situations. Future agricultural land managers and planners would greatly benefit from innovative courses which make them experiment the importance of combining these types of knowledge and giving them tools in hand to optimize the process of combining knowledge from different sources. These different types of knowledge should not be seen as contrasting, but as components which can create synergies and new visions.

To facilitate knowledge uptake by students in such complex and interdisciplinary fields of research the development of conceptual frameworks which position theoretical concepts and methodological foundations in relation to key issues would be extremely helpful. This asks a major effort of teachers to conceptualise the arguments of their teaching programme and would therefore be instructive also for the teachers involved in these courses. Courses illustrating the territorial issues in agronomy, or more specifically in Farming Systems Research, will most likely be give by a team of teachers, each having his or her specific contribution. The complexity and the interdisciplinary characteristics of the course argument will inevitable require inputs from a variety of teachers, from different disciplinary background or specialised in different spatial or temporal scale related problems.
Training

In the previous part we have already given some evidence of the crucial role stakeholders play in the Territory Agronomy Approach and also of the necessity to ensure that agronomists are ready to face the complexity of needs of today’s stakeholders in agricultural management. These aspects will be exemplified in the two examples we describe below. Among the different management issues, the agricultural landscape transformation is illustrative because it involves different kinds of stakeholder on a societal topic. A 10 years long training experience on this issue has highlighted an emerging role of Territory Agronomy in designing training projects and in facilitating the training activities. The contribution of the Territory Agronomy Approach is in fact crucial because it urges the trainers to take into consideration the complexity of the topic and to facilitate the use of common grounds. In general an added value is offered by Territory Agronomy Approach by considering the agricultural landscape also as an expression of different local farming systems, a perspective not common among the stakeholders. For example stakeholders representing local authorities involved in urban planning tend to consider agricultural landscapes as simple open spaces, whereas those involved in conservation policies interpret agricultural landscapes as spaces with a high cultural or natural value. These stakeholders rarely considered farming systems as the main driving forces of agricultural landscapes. For our experience in training design and facilitation, this general knowledge on the relationships between the farming systems and the agricultural landscape in terms of transformations was fundamental, but also the interaction with other issues such as those socio-institutional, environmental and productive ones.

Facilitating training in agricultural management issues

A recent 2 years training experience in Tuscany (Italy) aimed to combine ‘training’ and ‘assessing of new training demands’ (contents and methods) with stakeholders of local authorities (technicians and representatives). Stimulated by facilitation, some important proposals emerged from these training sessions with stakeholders regarding the definition of new training strategies in terms of contents to be dealt with and methods to be applied. These proposals may be synthesized by the following four questions.

Which processes were considered more critical in terms of rural landscape transformation (so more interesting in terms of training content)? With reference to rural territories the more critical landscape transformations were the changing role of farming activities (for example solar photovoltaic installations in farms or swimming pools for agri-tourist services), abandonment of farming areas, the change of rural buildings, land use changes (for example the construction of residential, industrial or sporting areas – i.e. golf clubs, adventure camps etc.) and the increase of infrastructures for transportation.

Which are the more important governance tools to manage rural landscape transformation? Planning tools provide more instruments to manage landscape transfor-
mation, but their effectiveness has to be considered in relation to other kinds of governance tools, mainly economic and environmental ones. All together they contribute to sustainable development. It is not possible to manage landscape transformation without pursuing goals of sustainable development of the rural territory.

**Which are the main skills/expertise to enforce by training for a more effective rural landscape governance?** With reference to the role of local authorities, important skills/expertise concern: the visual assessment of landscape change by 3D rendering modelling and animation, remote sensing, geographic information system, etc.; the evaluation and the monitoring of the economic capacity of farming activities to contrast abandonment and land use change; the management of land tenure questions including innovative tools such as those for the management of abandoned land or for public services on private properties.

**Which role for the stakeholders of the local authorities?** Some training actions may benefit from the participation of stakeholders of local authorities such as the training sessions based on (a) the exchange of good practices and of innovative experiences in landscape governance and more generally in sustainable development of rural territories, (b) the involvement of all levels of authorities (local, provincial and regional) to share the goals in rural landscape conservation and management and (c) a permanent coordination among authorities, universities and professionals associations to systematize a project of continuing training of adults (involved in landscape governance) (Fig. 12.6).

![Multi-functional landscapes involve stakeholders from different backgrounds, each with their own knowledge and viewpoints regarding territorial development requirements. Individual objectives may not be compatible or do harm to others. However, this picture can only appear if all pieces are put together. Therefore, the interaction of different stakeholders maximizes the positive synergies on agricultural landscape management](image-url)
Territory Agronomy Approach is a part of an interdisciplinary and multi-skills perspective in research and training. For this complexity the facilitation, or in other words the presence of ‘sharing environments’, it is essential to maximize the positive synergies, as happened in participatory training on agricultural landscape management. It follows that the participatory process was conceived as ‘a connection to the field’ in an adaptive way that may be synthesized ‘from territory to territory’ thanks to the active role of the stakeholders. The confrontation with the stakeholders put in evidence the opportunity to consider a territorial approach as an emerging and cross feature for the research and training applied to issues relevant for development and governance.

The ‘territory game’ as a training governance tool

The complexity of territories and their management at different level of organizations with different stakeholders increased the need to have facilitating methods and tools to help the conception of territorial projects. For more than 10 years, we have been experimenting with a participatory and prospective method of territorial diagnosis with the AgroParisTech engineers, future actors of the territorial management. The aim of this course is to prepare them to deal with complex reality and multi-partners work. A multidisciplinary approach is then promoted, based on spatial representations of the territory and their issues.

For that, we have developed a ‘territory game’, wherein the actors express and debate their positions to build a shared vision of the territory, thereby facilitating collaborative decision-making and joint action (Debarbieux and Lardon 2003). This local project leadership tool can be employed as a governance tool, since it creates a feeling of community between actors and enables the emergence of a shared vision of the territory (Angeon and Lardon 2008). The ‘territory game’ seeks to build a forward-looking diagnosis via a series of spatial modelling-based steps (Angeon and Lardon 2008; Lardon et al. 2010a, b). The usefulness of this process hinges on creating interplays between different information processing methods while pro-actively involving the actors to generate a shared strategic vision of a given territory (Fig. 12.7).

The main questions improved along more than 10 years experimentation are:

What does it mean to share visions with all the actors concerned? What tools are needed? We used theoretical and methodological foundations of the prospective diagnosis based on spatio-temporal representations (Lardon 2006; Lardon et al. 2007). We assessed that it was a good tool, as the local actors who participate shared effectively a common vision and imagine innovation collective actions to improve a

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2See: http://www.agroparistech.fr/Masteres-Specialises-Advanced.html
How to conceive the partnership? The application on the management plan of a territory in Quebec (Lardon et al. 2010a) shows it was operational to build with local actors a shared vision of their territory and express new characteristics of their territory. It was also successful for the appropriation of the approach by the territorial managers because they appreciate the methodology and test it again without the researchers help to share vision of their territory. But, they were not able to use this approach in their next strategic management plan, because they were not able to adapt this methodology in their own governance process. So, we have to improve a conceptual framework which makes sense for all the partners.
How to formalize a conceptual framework for research and action? What methodological itinerary? We experiment continuously with stakeholders and design appropriated ‘how to’ and ‘how to be’ ways. From a research point of view, we go on the formalization of conceptual framework by reflexive practices of research that bring us to try to have a mediator position to translate between two worlds (the one of the research, and the one of the action). We give tools to adapt the approach to each situation, by formalizing methodological itinerary and the means to adapt it in ‘real-world’ situations. From a pedagogical point of view, it represents the new competences that we have to give to our students. They have not only to be able to analyse (diagnosis), but also to intervene with stakeholders (companion modelling) by animation capacities but also by facilitation (resolution of conflicts, of gaps between the different points of view). We have to give them the methodological itinerary but also a reflexive capacity to improve it (Lardon 2009). For the action point of view, the stakeholders are actors in the approach from the beginning to the end, each of them at their own place and relatively to their own competences. So we have to recognize the competences of each actor and the synergy given by the collective project. Reflexivity and adaptation have to be at stake.

Discussion

In this chapter we have analysed the state-of-the-art of research, education and stakeholder training sessions which take into account the territorial dimension of Farming Systems Research. The relevance of the Territory Agronomy Approach concepts and tools for Farming Systems Research was identified through a systematic and retroactive analysis of the research, education and training examples we presented.

It appears that Farming Systems Research can be enriched with the territorial dimension and are then able to answer to territorial agronomy issues. This process is appreciated both by students and by stakeholders involved in territorial management and stimulates researchers to develop new approaches and research methods. The importance of a systemic understanding of the studied system is a parallel concept to what we called ‘reflexivity’ in Territory Agronomy. To analyse complex interactions and contrasting stakeholder needs in agricultural landscapes the researcher has to deepen his insight in the problematic to obtain detailed information and increase understanding of the various aspects (main socio-economic activities, key agro-environmental processes, dynamics of local land use patterns), and subsequently to study this micro-cosmos from a distance to come up with analyses and generate new insights which can be used also to increase stakeholder awareness. Furthermore, in the Territory Agronomy Approach the concept of ‘reflexivity’ has to be part of the research process and should be transmitted to students and stakeholders as well. Only in this way can the research become fully participatory.

The reliance on interdisciplinary research is made explicit by the three poles in the ‘landscape and territory agronomy tripod’ (Fig. 12.4), which combines a great variety of disciplinary knowledge and through the interactions, generates new synergies
and trans-disciplinary research questions. The need to ‘co-construct’ research follows almost naturally from the Territory Agronomy Approach. Projects and studies trying to tackle the territorial dimension of agronomy need to be set up in an interdisciplinary team of researchers in collaboration with local stakeholders. Different disciplines are combined and each discipline is able to understand a part of the complex study object. Interaction between them through trans-disciplinarity is necessary to guarantee the links between the diverse elements and preserve the whole entity. The participatory approach can be seen as a key concept in Territory Agronomy Approach, especially in those cases where the objective of the project is to mediate between stakeholders to help decision making regarding territory development. Involvement of stakeholders through co-construction is crucial in the Territory Agronomy Approach. Thus, participatory research may be a valid solution to be in ‘connection to the field’.

By applying a Territory Agronomy Approach to territorial issues in Farming Systems Research researchers can guarantee the coherence between research and action objects. This is extremely useful in training sessions with local stakeholders because local actors are used to translate what they learn practically in their daily work. Another aspect that is normally greatly appreciated by local actors is that when applying the Territory Agronomy Approach, we analyse interactions and tend not to give blunt recommendations. This is an important condition to facilitate actors’ participation.

Up- and down-scaling through the ‘spatio-temporal relationships’ and various organization levels involved in the territorial management has to be part of the approach. At the same time, this is probably the most difficult aspect of the Territory Agronomy Approach. Studying a phenomenon at different scales requires different methods. Using classical interpretation techniques it is often not possible to compare results obtained from analyses which were performed at different spatial, temporal of administrative scales. There are ample opportunities within the Territory Agronomy Approach to develop new methods to allow such comparisons and therefore to increase understanding of the real territorial dimensions of the studied questions.

Because of the wide variety of issues which would benefit from a territorial analysis approach, the Territory Agronomy Approach toolbox needs to develop, besides case-specific tools, some generic tools valuable in this great variety of situations. This means that the ‘adaptation’ capacity of the tools and methods is extremely important.

Therefore, the Territory Agronomy Approach will continue to develop, to grow and to mature for as long as there are researcher which take up case studies and try to apply its principles and enrich its toolbox. We therefore promote the development of a research-education-action platform for land management and territorial development to formalise this development and give a clear identity to territorial issues in Farming Systems Research. A better visibility will facilitate the uptake of the Territory Agronomy Approach by researchers, teachers and trainers, and through this the development of Territory Agronomy Approach will be stimulated giving rise to a positive feedback loop.
Conclusions

From the various research, education and training experiences of the authors, it appears that there is a growing interest in including the territorial dimension in Farming Systems Research. The presented examples showed that since the Territory Agronomy Approach searches for high adaptability of research methods and tools and co-construction of research questions, a co-evolution of research-education-action takes place where experiences in all three fields contribute to developments in the other fields as well as in the Territory Agronomy Approach. Synergies between research, education and action in territorial issues stimulate new research questions in an iterative process, contribute to the definition of new competences to apply in education and training and this is in turn linked to action research. Participatory research, education and training increases the capacity to modify research questions and roles of all participants in these processes, again increasing adaptive capacities of the Territory Agronomy Approach which is needed to respond to the issues of land management and territorial development. There is ample space for new developments within the Research-Education-Action platform for land management and territorial development, especially regarding multi-scale spatio-temporal and social analysis tools and research methods.

Acknowledgments We want to clarify that the development of the Territory Agronomy Approach is an ongoing process which results from various interaction the authors have in their research projects and education and training experiences. We are therefore grateful to all colleagues, students and stakeholders we have interacted with in the past years, and all participants to the 2008 and 2010 IFSA sessions on ‘Education in Landscape and Territory Agronomy’. We want to express special thanks to the following people for their significant contribution to the development of the Territory Agronomy Approach: Enrico Bonari, Paolo Bàrberi, Marc Benoit, Patrick Caron, Claudine Thenail, Hélène Rapey, Teresa Pinto-Correia and Davide Rizzo. Thanks again to Davide for preparing the Fig. 12.4, the Landscape and Territory Agronomy framework.

References


Chapter 13
Simulation models in Farming Systems Research: potential and challenges

Giuseppe Feola, Claudia Sattler, and Ali Kerem Saysel

Abstract Integrated simulation models can be useful tools in farming system research. This chapter reviews three commonly used approaches, i.e. linear programming, system dynamics, and agent-based models. Applications of each approach are presented and strengths and drawbacks discussed. We argue that, despite some challenges, mainly related to the integration of different approaches, model validation and the representation of human agents, integrated simulation models contribute important insights to the analysis of farming systems. They help unravelling the complex and dynamic interactions and feedbacks among bio-physical, socio-economic, and institutional components across scales and levels in farming systems. In addition, they can provide a platform for integrative research, and can support transdisciplinary research by functioning as learning platforms in participatory processes.

Introduction

Simulation models have been used in farming system research for a long time. The last decades have seen the development of a specific family of simulation models, i.e. integrated, bio-economic, or socio-ecological models (e.g. Oriade and Dillon 1997;...
These models allow not only modelling a specific environmental compartment (e.g. soil) or bio-physical process (e.g. fate of pollutants such as pesticides in the systems, or crop growth). They also allow representing several processes, system components and sub-systems of interest, including the social component (i.e. economic, institutional, social networks), within a given agricultural system. The increase in computational capacity and the development of user-friendly programming software both played important roles in making the diffusion of simulation models in farming system research possible. More important however, was the progress in the conceptualization of agricultural and farming systems (e.g. Bawden 1995; Schiere et al. 1999; Doppler 2000; Darnhofer et al. 2012, this book), including the understanding of farmers as key actors in these systems (e.g. Darnhofer et al. 2010; Feola and Binder 2010). In this respect, simulation models are an important support in farming system research in that they help unravelling the complex and dynamic interactions and feedbacks among bio-physical, socio-economic, and institutional components across scales and levels (Dent et al. 1995; Janssen and Van Ittersum 2007; Rossing et al. 2007; see also Milestad et al. 2012, this book; Schiere et al. 2012, this book).

Simulation models may be developed with different, but often overlapping goals, such as farm optimization, sustainability assessment, or policy evaluation (Fig. 13.1). With social learning recognized as a key factor in the transition towards sustainable agriculture (see Gibbon 2012, this book; Blackmore et al. 2012, this book; Hubert et al. 2012, this book), simulation models are increasingly developed and/or used within some sort of participatory and transdisciplinary process involving actors such as farmers and policy makers (e.g. Etienne 2011; van de Fliert et al. 2011).

Different approaches and techniques exist to build simulation models of agricultural systems. Among them the most common are linear programming (LP), system dynamics (SD) and agent-based modelling (ABM). Increasingly, simulation models combine several approaches either to combine the modelling expertise built by single
disciplines (i.e. social sciences and physical sciences), or to take advantage of the specific strengths of each approach used to model specific socio-economic, biophysical, or socio-ecological processes. Some earlier bio-economic models, as well as trade-off models, for example, combined econometric and physical models (Oriade and Dillon 1997; Stoorvogel 2004). In other cases, the integration of different approaches does not overlap with traditional disciplinary boundaries, but exploits the functionality of a given approach to model a specific type of process. In yet other cases, both socio-economic and bio-physical components of agricultural systems are modelled adopting one single approach.

Combining different modelling approaches, each with their different assumptions, techniques and procedures, is often challenging. Other acknowledged challenges for simulation models are the establishment of a solid theoretical base, especially with reference to social agents and institutions, model calibration and validation, the involvement of stakeholders or users in model building, and the communication and transfer of results into the policy process (e.g. Bousquet and Le Page 2004; Rossing et al. 2007; Feola and Binder 2010). These, among others, are open issues that must be considered when evaluating the role of simulation models in farming system research.

This chapter gives an overview of three simulation modelling approaches, i.e. linear programming, system dynamics and agent-based modelling, each briefly described in its fundamental characteristics. The strengths and drawbacks of each approach are then presented through a few application examples. Finally, we conclude by summarizing the potential and challenges of simulation modelling in Farming Systems Research.

**Linear programming**

**Characteristics**

Linear programming (LP) is a mathematical method of determining a way to achieve an objective, such as maximum profit or lowest possible costs, with a given or limited set of resources, such as available productive land, labour force or capital. The expression to be maximized (e.g. profit) or minimized (e.g. costs) is called the objective function. The optimization of the objective function is subject to linear equality and inequality constraints. These constraints specify over which conditions the objective function is to be optimized.

In the context of farm modelling, a LP model generally holds four basic elements: (i) the objective function, (ii) the farming activities, (iii) the constraints, and (iv) the technological coefficients.

The objective function (i) is usually set for maximizing the total gross margin of the farm. The farming activities (ii) define all production activities that relate either to crop farming (e.g. production of wheat, sugar beets, etc.) or livestock farming (e.g. production of dairy, beef, pork, poultry, etc.). The constraints (iii) are set by the available resources, e.g. farm land, labour, water for irrigation, fertilizer for nutrient...
provision, and so forth. Finally, the technological input-output coefficients relate activities to the constraints, i.e. land, labour, water, fertilizer, etc. needed to perform activity \( x_1, x_2, x_3, \) etc. (Danzig and Thapa 1997).

To make the approach less elusive, the following paragraph exemplifies LP for a very simple farming problem. Let us suppose that a farmer has a piece of farmland (6 ha), to be planted with either wheat (activity \( x_1 \)) or potatoes (activity \( x_2 \)) or a combination of the two. To prevent pest calamities, constraints are set with respect to the maximum share of the total area each crop can occupy. For wheat the maximum share is 4 ha, for potatoes it is 3 ha. The (purely fictional) market prices are calculated with 200 €/ha for wheat and 500 €/ha for potatoes.

LP is now used to compute the optimal levels (in terms of ha) of activity \( x_1 \) and \( x_2 \) to maximize the financial return. The problem can also be expressed graphically. In Fig. 13.2, the x-axis depicts activity \( x_1 \) and the y-axis depicts activity \( x_2 \) (activity level is measured in ha). The three thin black lines set the limits according to the defined constraints: one line refers to the total available area of 6 ha while the other two refer to the maximum levels of both activities (4 and 3 ha, respectively) to prevent pest calamities. The grey area in the graph then shows the solution space. The dotted line depicts the price ratio between the two activities. Finally, the dashed line depicts the isocostline.

The isocostline shows all combinations of the activities which cost the same. The slope of the isocostline equals the ratio of unit costs of the two activities. To find the optimal solution (employing the simplex algorithm, see more details below) the isocostline is moved from vertex to vertex along the edges of the

![Graphical representation of the LP problem](image)

**Fig. 13.2** Graphical representation of the LP problem. LP is used to compute the optimal levels of activities \( x_1 \) and \( x_2 \) (e.g. crop or livestock farming) to maximize the objective function (e.g. financial return) given the existing constraints (e.g. set by the available resources)
polytope that defines the solution space (grey area). In this example, the maximum financial return is achieved when the isocostline cuts the x- and the y-axis at 3 ha for both activities. This determines the optimal levels of the two activities while respecting the existing constraints, yielding a maximum financial return of 2,100 € for the farmer (200·3 + 500·3 = 2,100).

In general, the computing power required to solve a problem by LP is high, as testing of all permutations to select the best assignment is vast. Thereby, two types of LP problems can be differentiated: integer linear programming (ILP) and mixed integer programming (MIP) problems. In the first case all unknown variables are required to be integers, while in the second case only some of the unknown variables are required to be integers. Generally, ILP problems are harder to solve than MIP problems. Farm modelling relates to MIP problems, where some variables need to be integers, e.g. number of cattle heads raised (as it makes no practical sense to raise 0.5 cattle), while others can be real, e.g. number of hectares wheat grown, etc. However, different algorithms can be applied which help to drastically reduce the number of possible optimal solutions that must be checked for optimization. The most prominent algorithm is the simplex algorithm (Danzig and Thapa 1997). In practice, the simplex algorithm is quite efficient and can be guaranteed to find the global optimum. Other algorithms include several interior-point algorithms. In contrast to the simplex algorithm, which finds an optimal solution by moving from vertex to vertex along the edges of the polytope of the solution space, interior-point algorithms move through the interior of the feasible region (Kojima et al. 2008).

Applications

LP can be applied to various fields of study. It has proved useful in modelling diverse types of problems in planning, routing, scheduling, assignment, and design. Farm modelling is just one example where LP is successfully employed.

Historically, LP has been widely employed in agricultural economics (e.g. Heady 1954; Day 1963). Basically, it is used to describe the behaviour of farmers as decision makers, assuming their choices are based on economic rationality and driven by the frame conditions included in the model. Modelled agricultural land use based on the decision behaviour then mirrors the expected reaction of the farmers in response to e.g. policy change, technology change (technical progress, new production methods) or global environmental change including climate change. If combined with a component for environmental impact assessment, LP models can also be used to model environmental implications of agricultural land use along with the economic consequences to generate economic-environmental trade-offs. Sometimes there is also a social component included in LP models (e.g. food security, risk issues, etc.). Rarely, economic, ecological and social components are combined to allow for a sustainability impact assessment.

LP is employed to study different types of farming systems such as dairy, crop, beef, or forestry (e.g. Leigh et al. 1974; Fokkens and Puylaert 1981; Bertomeu et al. 2006; Bartolini et al. 2007; Zimmermann 2008), the transition from conventional to
organic farming (e.g. Kerselaers et al. 2007), and trade-off analysis (Sattler et al. 2006). LP is also widely used in impact assessment of policies such as market prices, policy reforms and agri-environmental programs (e.g. Ramsden et al. 1999; Topp and Mitchell 2003), in environmental impact assessment, whereby aspects as diverse as inputs, soil erosion, biodiversity, greenhouse gas emissions, waste allocation are studied (e.g. De Cara et al. 2005; John et al. 2005; Chardon et al. 2008; Jatoe et al. 2008; Schuler and Sattler 2010; Osgathorpe et al. 2011), in social impact assessment (e.g. Pannell and Nordblom 1998; Stott et al. 2003; Valeeva et al. 2007; Amede and Delve 2008), sustainability impact assessment (e.g. Dogliotti et al. 2005; van Calker et al. 2008), and in new technologies (e.g. energy, machinery) assessment (e.g. Camarena et al. 2004; Sherrington and Moran 2010).

LP modelling approaches can also be combined with other approaches. For instance, the AgriPolIS model which basically is an agent-based modelling system also has a LP component which makes it a hybrid of both approaches (Happe et al. 2006).

**Box 13.1** Multi-objective decision support system for agro-ecosystem management (MODAM)

The bio-economic LP modelling system MODAM (e.g. Zander and Kächele 1999; Zander 2003) mimics farmers’ decision making in crop and livestock farming assuming that farmers’ decisions are based on economic rationality and that farmers know about the specific characteristics of their production activities, farm resources and available political incentive programs and regulations. MODAM also takes into account environmental impacts on natural resources (e.g. soil, water, habitat and biodiversity). These impacts are determined by the interaction of the production activities’ characteristics in terms of input (e.g. fertilizers, pesticides), timing of field operations, type of machinery used and the characteristics of the natural resources (i.e. sensitivity, resilience) related to the specific site conditions of the plots. MODAM can either model individual farms in a given region or it combines all farms into a so-called regional farm. The latter approach is less specific, but helps to significantly decrease overall running-time and computing power.

The case study region ‘Prenzlau-West’ is located in north-eastern Germany and covers roughly 200 km². About 60% of the region is arable land and 11% are grasslands. Soil erosion by water is a wide spread problem. Erosion events on farmland are caused by insufficient soil coverage and inappropriate agricultural practices, especially on farmland susceptible to erosion. The objective of the modelling exercise is to compare different policy options relating to the latest reform of the EU’s Common Agricultural Policy (CAP) with respect to their environmental effectiveness (measured in the reduction of the potential soil loss in t/ha) and their cost-efficiency (measured in costs per unit of reduction). The modelling problem was defined opting for a regional farm
model under four different policy scenarios: (i) status quo (used for model calibration and validation) (STA), (ii) CAP reform implementation (BAS), (iii) CAP reform implementation with extra restrictions (obligatory command and control measures) (RES), (iv) CAP reform implementation with extra premiums (voluntary financial incentive measures) (PRE). Complete description of the modelling procedure for the case study in Sattler (2008) and Schuler (2008).

To allow for a cost comparison of the RES and PRE scenarios, the same level of erosion reduction of about minus 30% compared to the BAS scenario was aimed at. The premium height in the PRE scenario was set to 68 €, as a lower premium did not effectuate the desired reduction of the erosion level below 30%. The share of the farmland labelled as ‘susceptible to water erosion’ was based on the calculated potential soil loss applying the universal soil loss equation (see Sattler 2008; Schuler 2008).

The simulated outcomes of the MODAM model runs allow for a comparison of changes in land use under different scenarios and consequent potential soil loss. The latter is achieved in the RES and PRE scenarios through different production practices (e.g. reallocation of row crops). Finally, TGM, on-farm and budget costs are also simulated, whereby in terms of cost-efficiency, the RES scenario performs better than the PRE scenario.

This case study example outlines how LP farm modelling can be applied to investigate and evaluate different policy instruments. Limitations of the presented modelling approach include: that (i) the regional farm model approach (compared to an individual farm model approach) generally overestimates the farm’s capacity to spatially optimize the land use by reallocating production practices away from the susceptible sites to insusceptible ones and therefore underestimates the loss in total gross margin, and that (ii) restrictions, although here identified as the more cost-efficient policy option, can encounter severe resistance from the farmers’ side, as they have to bear all related costs.

**Strengths and drawbacks**

LP models are often used because they are less data demanding compared to econometric models. LP models can be applied to a vast number of problems and have proved their practical use in over 50 years of application (Paris 1991). A broad variety of possible activities in agricultural production can be defined and, based on the given constraints, the best possible combinations of them can be chosen in the optimization process. This allows finding the optimal utilization of the available farm resources in a given context. LP models can be used to structure and formulate highly complex problems and model outcomes are appreciated for informing
decisions in the context of problem exploration, forecasting and ex-ante assessment of policies, technologies, or any other future trend scenario assessment (e.g. Heckelei 2002). LP models can be applied on a highly detailed scale at the single farm level or on a less detailed scale at the regional (or even national) level.

However, the maintenance requirements in keeping the databases up to date are high, especially with respect to the technological coefficients and the farming activities (e.g. Pannell 1997). Standard LP models can also have a tendency to skip between extreme solutions after only small changes (e.g. in- or output prices) in the model parameters resulting in over-specialization. Over-specialization can be avoided by increasing the number of available activities the model can choose from in the optimization process (Schuler 2008). Potentially, there is also the risk of misuse of the result if not carefully interpreted and taking into consideration the data quality and calibration results (Pannell 1997). One last aspect relates to the main objective function, which, for reasons of simplicity, is often set to pure profit maximization, although farmers quite obviously also have other objectives. These might include avoiding risks, sparing time for their families, or protecting the environment. A workaround solution can be to introduce additional objectives by defining further restrictions in the model (Box 13.1).

**System dynamics**

**Characteristics**

*System dynamics* (SD) modelling and simulation aim at improving our understanding of the root causes (structure) and trajectories (behaviour) of dynamically complex problems. Early applications start with the work of the system dynamics group in the MIT Sloan Management School (e.g. Forrester 1971), that inspired the influential dynamic global sustainability assessment ‘Limits to Growth’ and its recent updates (Meadows et al. 2004). SD is built on the foundations of modern systems thinking and control feedback theory. The method is outlined through the steps of dynamic problem identification, closed loop hypothesis generation, model (structure) identification, validation, and scenario and policy analysis with computer simulation (Sterman 2000; Barlas 2002; Ford 2010).

Being a systems discipline, SD is a holistic and interdisciplinary approach to dynamically complex real-life problems. According to the philosophy of SD, for example, understanding the structural causes of water use in a canal irrigation system requires knowledge of such fields as hydraulic engineering, hydrology, soil science, crop production, economics, anthropology and behavioural sciences. The analyst facing this problem must select and synthesize all relevant information from these individual fields at an appropriate level of detail and aggregation.

SD research cycle starts with *closed-loop* dynamic problem identification. Closed loop dynamic problems are characterized by change over time which cannot be trivially explained by exogenous driving factors. For example, human induced
salinisation on irrigated farmlands can be addressed as a closed-loop dynamic problem caused by an internal structure operating and creating the dynamic patterns of salt accumulation over time. Human induced salinisation is a problem influenced by factors of irrigation volume and fresh water salinity through the processes of run-off, infiltration, percolation, groundwater salinisation, elevation and intrusion to the plant root-zone (Saysel and Barlas 2001). These physical processes interact over time with managerial policies aiming to control the accumulation and flushing of salt in the root-zone to create (or to alleviate) salinisation. Typically, the control and management of a closed-loop dynamic feedback problem requires a manager embedded in the system (Barlas 2002). Thus, the farmer-manager observes and perceives the root zone salinity (the dynamic problem), decides on water application amounts and drainage alternatives and in turn influences the root zone salinity.

The second step in SD modelling is the creation of a dynamic hypothesis aiming to identify the feedback complexity of the internal structure which can potentially explain the causes of the observed or anticipated dynamic problem. A dynamic hypothesis (a conceptual model) is typically represented by causal loop diagrams comprising the relevant variables integrated in feedback. Because SD is design oriented rather than forecast oriented, it is essential that the underlying model structure is an adequate, but simplified representation of the so-called real system structure. Therefore, it is a must that the variables identified at this phase of research should have real empirical and/or theoretical meaning. That is, arbitrary, dummy concepts and variables interfere with model validity. Moreover, the relationships identified among the variables should be based on assessment of causality, rather than mere observations on correlation in past behaviour. Unidirectional causality strictly distinguishes the cause and the effect. On the other hand, closed-loop problems are caused through processes identified with feedback causalities where the causes become the effects of other factors and variables in time. Thus, a dynamic hypothesis is a working feedback theory of the underlying causes of the dynamic problem (Fig. 13.3).

The third step in SD modelling is to create the formal computer simulation model. Formal simulation model is typically a high-order (multi-state, multi-loop) non-linear system of differential equations. Because of their non-linearity, these systems are hard, if not impossible, to solve analytically, i.e. they cannot be broken down into determined parts whose behaviour sums up to the system behaviour (i.e. the system is more than the sum of its parts). The solutions are therefore generated by numeric simulation. The model structure is built on the foundation of the dynamic hypothesis and developed by identifying the stocks (accumulating, slow changing variables), flows (change in stocks), delays (the time lag between cause and effect) and nonlinearities (un-proportional, nonlinear influence of stocks on flows). Model initialisation, parameter estimation and equation writing are the tasks fulfilled in model development stage.

The model structure represents the physical and institutional environment of a system as well as the decision processes of the agents acting within that structure. In SD models, particular decisions are the stream of actions produced by decision rules. Decision rules are model structures formulated with the fundamental building
blocks of the dynamic system, namely the stocks and flows. In decision rules, flows represent particular decisions per unit time while stocks represent accumulating, slow changing elements like perceptions, beliefs, expectations, knowledge or some persistent non-living physical attribute of that system. Decision rules are integrated to the physical, non-living structure of the system in feedback and constitute a structural element of the model.

Fig. 13.3 Causal loops diagrams represent a dynamic hypothesis, i.e. a working feedback theory of the underlying causes of the dynamic problem. Here a causal loop diagram of the salinisation process. A “(+)” sign indicates a reinforcing loop, while a “(−)” sign indicates a balancing loop. Causal connections constituting the feedback loops are identified by bold arrows (Source: Saysel and Barlas (2001). Reprinted with permission from Elsevier)
SD models are descriptive as opposed to prescriptive. They do not prescribe how the decisions should be to attain optimum or equilibrium results as in mathematical programming and in various optimization models (e.g., linear programming). Rather, they describe the sources and channels of information and adopted heuristics of actual decision makers living in the real system. Thus, the bounded rationality (Simon 1982) and behavioural decision theory provide some guidelines for modelling decision making in SD (Sterman 2000; Feola et al. 2012).

Model validity is assessed through structural and behavioural tests. Because the model structure in SD has a strong claim of causality, structural validity is crucial and precedes the procedures for behavioural validity assessment (Barlas 1996). Structural validity is assessed by direct semi-formal observations on model structure and through indirect tests involving simulation. Direct assessment of model structural validity involves tests that evaluate the meaning of constants and variables, unit consistency in equation writing and assessment of equations under extreme parameter conditions. Indirect tests involve simulation experiments under extreme and alternative parameter conditions and modified structures. Structural validation is followed by behaviour pattern validation. Formal procedures involve tests that compare the behaviour patterns generated by the model with real-life data by visual comparison and in terms of means, trends, periods, phase lags and amplitudes (Barlas 2007). The ultimate purpose of model validation is to build confidence in model structure as an adequate representation of the real system with respect to the particular purpose of the analysis.

After building sufficient confidence through the validation process, the model can be used for policy design. Selected policies are alternative decision rules that yield desirable results under various scenarios. Indeed, the ultimate purpose of SD research is to help decision makers learn about the dynamic complexities of the system that they manage, and to assist them implement better decisions that would yield improved results.

SD encourages theoretical and empirical research in model building for policy design and strategic analysis. Nevertheless, with respect to the pedagogic, standard description of the method outlined above, the model is necessarily also a reflection of the modeller’s own mental model of the problem. Moreover, even relatively small dynamically complex models are hard to understand, communicate and analyse (Saysel and Barlas 2006). Validation is a prolonged, semiformal process, where the criteria for sufficiency are not definite but dialogical. Implementation of derived solutions require the commitment of the client groups, the managers and decision makers in the field, which in turn entails a group learning process starting with the identification of the commonly agreed problem and continuing through the steps of model conceptualization, model building, validation and analysis. In order to overcome the above impediments to group learning, legitimacy and implementation of useful results, concepts and scripts for participatory processes of model building and analysis are created (Vennix 1996; Andersen and Richardson 1997). While many group model building activities are performed within corporate and business contexts, there are applications in public domain, particularly on environmental problems. Applications cover environmental management in watersheds, coastal zones, national parks and rangelands (Stave 2002; van den Belt 2004).
Dynamic complexity of living and non-living systems is characterized by the existence of stocks and flows, delays, feedbacks and nonlinearities in the system’s structure. Even a very simple model structure with a minimum of these elements can have the potential to communicate important insights about the systemic causes of dynamic problems. On the other hand, dynamic system models have uses for integrated policy analysis and for pattern prediction that may require larger model boundaries and more detailed model structures. The tension between detail and simplicity is resolved throughout the iterative process of model building and analysis where the criteria for sufficiency depend on the purpose of the analysis.

Spatially dynamic models and models with agent complexity arise from the need for increased detail in representation of space and agents in a dynamic problem. Ford (2010) describes practicalities of spatial dynamic modelling on common simulation platforms. Population dynamics, transport and diffusion problems are the typical categories which may necessitate spatial approaches.

Agent (individual) based and causal-descriptive (system dynamics) approaches to complexity stem from different philosophical standpoints. Agent based approach aims to understand and identify emerging complexity in the behaviour of dynamic systems caused by well defined, simple, sometimes heterogeneous behaviour rules of individual agents interacting over time. A causal-descriptive approach tries to understand and identify dynamic complexity as the physical, institutional and decision structure of a dynamic system characterized by feedbacks, delays and nonlinearities which may yield non-trivial, counterintuitive behaviour (see Scholl (2001) for a comparison of the two approaches.) However, agent complexity (the interaction of multiple agents with heterogeneous decision rules) is relevant to SD approach. Recent studies on agent complexity in SD investigate so called hybrid approach to modelling where disaggregated decision rules, multiple information channels, heuristics and interactions are modelled within the framework of a nonlinear feedback structure (e.g. Borschev and Filippov 2004; Demirel 2006).

Applications

SD modelling and simulation is applied to farm systems research at global, national and regional levels. Rather than focusing on individual farm based problems, most research adopt sector based holistic analyses. Particular applications include problems of crop growth and management (e.g. Bala et al. 1988; Yin and Struik 2010), soil degradation (e.g. Saysel and Barlas 2001), rural energy systems (e.g. Alam et al. 1997; Bala 1997), livestock farming and animal disease control (Rich 2008), pastures and sheep farming (e.g. Mashayekhi 1990; Davidsen and Asheim 1993), development of environmentally friendly farm systems (e.g. Belcher et al. 2004; Shi and Gill 2005), irrigation systems design and management (e.g. Saysel et al. 2002; Fernandez and Selma 2004), food supply and security (e.g. Bach and Saeed 1992; Georgiadiis et al. 2005), aquaculture farming (e.g. Bala and Satter 1989; Arquitt and Honggang 2005), agricultural development policy (e.g. Bontkes 1993; Weber and Schwaninger 2002) and forestry management (e.g. Jones et al. 2002; Dudley 2004) (Box 13.2).
Box 13.2 System dynamics in action: sustainability problems in GAP

On fertile lands in semi-arid regions, large-scale surface irrigation facilitated by dam building has been a prominent regional and national development policy. Expected benefits are higher crop yields, increased crop varieties, improved rural welfare and development. Adverse social and environmental impacts include shortfall in irrigation and power production targets, several forms of land degradation, and nonpoint environmental pollution. SD is applied to create a systemic long term environmental analysis of GAP (South-eastern Development Project) in Turkey that fits into the general typology of large scale irrigation development projects (Saysel et al. 2002). GAP is located at the Syrian and Iraqi borders of Turkey on the border crossing water basins of the two rivers, Euphrates and Tigris. It targets irrigating 1.8 million hectares of agricultural fields (20% realised as of 2010) and producing 27,000 GWh/year of electricity. Total cost of the project is estimated around 35 billion US dollars. Model simulation horizon is 40 years where the first 10 years calibrate the model generated behaviour to real life data and the next 30 years creates foresight into the future.

The original model with over a 100 stock variables and 13 model components (GAPSIM) is simplified to a structure with 17 stock variables and 4 model components (GAPSIMPLE, see Fig. 13.4) representing farmlands transformation, water resources development, salinisation and pesticides application (Saysel and Barlas 2006).

Model reference behaviour highlights the potential problems of irrigation systems performance and agricultural environment. Energy production (in GWh/year) and irrigated lands (in ha) fall short of targets because water consumption on farmlands is above the prior estimates used in project master plans. Very high amounts of water are diverted from streams to the farmlands (of about 50% of annual hydraulic flow). Yields are slightly reduced due to water scarcity (of about 5%).
As irrigated lands develop, rain-fed farmlands are transformed to irrigated lands (all in ha). However, lands adopting monocultures increase to levels significantly above those adopting mixed crop systems to the disadvantage of water availability, salinisation and pest abundance. First of all, cotton monocultures demand and use higher water amounts compared to its alternatives and this therefore reduces the irrigation development rates. Secondly, because they use higher amounts of water they stimulate irrigation induced salinisation (in mg/l). Thirdly, they stimulate pest growth and consequently, pesticide application (kg/ha).

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GAPSIMPLE provides an experiential learning platform for the policy-makers to investigate the systemic relationships between water development (for hydropower and irrigation), crop selection, and agricultural environment. The model is useful for long term strategic management of large scale water development schemes rather than creating support for short term, day to day operational decisions.

**Agent-based modelling**

**Characteristics**

Agent-based models (AMB) are computational models representing a population of interacting agents situated on a virtual landscape or environment (Bousquet and Le Page 2004; Freeman et al. 2009). Each agent is endowed with the capacity to relate
Table 13.1  Elements of agent-based models, and examples

<table>
<thead>
<tr>
<th>ABM characteristic</th>
<th>Examples</th>
</tr>
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<tbody>
<tr>
<td>Agents</td>
<td>Farmer; Farm household</td>
</tr>
<tr>
<td>Environment</td>
<td>Agricultural unit; River catchment</td>
</tr>
<tr>
<td>Relationships</td>
<td>Observe; Exchange information</td>
</tr>
<tr>
<td>Rules</td>
<td>Imitate; Calculate</td>
</tr>
<tr>
<td>Operations</td>
<td>Cultivate/Fallow; Rotate crop/ Same crop; Cultivate crop X/crop Y</td>
</tr>
<tr>
<td>Properties</td>
<td>Risk aversion; Educational level; Location in the environment</td>
</tr>
<tr>
<td>Emerging system behaviour</td>
<td>Land use pattern; Diffusion of innovative technology</td>
</tr>
</tbody>
</table>

to other agents and the environment, to assess the situation, and to make decisions or enact selected operations on the basis of a set of rules (Bonabeau 2002; Bousquet and Le Page 2004) (Table 13.1).

The relationships, rules and operations are typically common across agents, but unique in parameters for each individual agent (Freeman et al. 2009). For example, while a common rule of farmer-agents behaviour can be the imitation of other farmers, the strength or the probability of imitation may vary for different farmer-agent types (Feola et al. 2012). Moreover, the relationships and the actions may be constrained by properties of the individual agent or of its particular location in the environment (Table 13.1). For instance, farmer-agents may not be able to interact with all other agents due to their specific spatial location in the environment. Agents interact repetitively among each other and their environment during the simulation time. Feedbacks exist and variables influencing the agent’s action are determined co-temporally (Freeman et al. 2009). Consequently the system has to be studied as a whole and cannot be broken down into determined parts whose behaviour sums up to the system behaviour. This typically makes it impossible to solve the system of underlying equations analytically (i.e. the system is more than the sum of its parts), and motivates the use of computer models (Bonabeau 2002). In addition, due to this feature, even simple ABMs can exhibit complex behaviour patterns. A distinctive characteristic of ABM is that of modelling such patterns from the bottom up, i.e. by representing the underlying disaggregated basic rules from which the system behaviour or dynamic emerges. Finally, sophisticated ABMs allow for agents to evolve and show unanticipated behaviour, i.e. to learn through the simulation time (Bonabeau 2002).

Applications

ABMs are flexible and currently applied to a wide spectrum of topics relevant for farming system research. Significant fields of application for ABM are the ex-ante assessment of policy impacts (e.g. Happe et al. 2006; Barnaud et al. 2008; Lobianco and Esposti 2010), the adoption of agri-environmental measures or technological
innovation (e.g. Deffuant 2001; Berger et al. 2006; Freeman et al. 2009; Schreinemachers and Berger 2011), and land use patterns (Parker et al. 2001), in some cases in form of scenario analysis (e.g. Etienne et al. 2003). ABMs are also applied to the ex-ante exploration of options for sustainable agricultural intensification (e.g. Vayssières et al. 2011), change in nutrient management (Matthews 2006), the environmental effects of farmer decision-making and agricultural practices (Mathevet 2003), or forest (e.g. Simon and Etienne 2010) and watershed management (Souchère et al. 2010). Finally, ABMs have also been used to study the interaction of agriculture and rural development in local systems characterized by persistent poverty and vulnerability (e.g. Saqalli et al. 2010).

Current applications of ABM do not only differ with regard to the research problem addressed, but also with respect to several additional features. One of such features is that of agent definition, i.e. both in terms of social and environmental agents. Typically, the social agent modelled corresponds to a single farmer or, more often, to a household or farm. The choice of what constitute the social agent is partly linked with that of the level of analysis, i.e. farm, local community or region, and specific issue at stake, e.g. water management in a basin or nutrient management in soil. Thus, for models at community or regional level, farm households are the most common social agent. However, it is also important to note that a model often contains different types of agents at the same time, e.g. individual farmers, farm households, or institutions. The environment can be modelled as single agent with which the social agents may interact, although in other cases different environmental compartments or units (e.g. plots) might correspond to a respective number of single agents. Clearly, the latter approach allows for achieving a higher degree of spatial detail, but it might dramatically increase the need for data and computational power. The interaction among social and environmental agents is usually direct, i.e. actions cause change in environmental conditions which are then perceived or affect actions at a later stage. While the environment is often modelled as a *per se* static agent, i.e. one which is modified only through the actions of social agents, in some interesting cases the environment is instead modelled in such a way that internal dynamics independent from social agents are rendered (e.g. Matthews 2006). Interactions among social agents might occur directly, e.g. by exchange of information or imitation of agricultural strategies (e.g. Deffuant 2001), or indirectly, e.g. by competing in factor and product markets (e.g. Happe et al. 2006).

One important feature of ABM is whether the modelled social and environmental agents aim to reproduce key characteristics of farms observed in reality. While this is often the case, examples of ‘synthetic farms’ also exist, i.e. farm agents which represent more generalized farms with realistic characteristics but no direct relation to a specific case study (e.g. Happe et al. 2006, see also Le Page et al. 2011 on singular/generic models). The former case might require a higher effort in terms of model parameterisation, since more data and information on the observed case study is needed to build the farm agents. Parameterisation can also vary significantly among applications of ABM. In general terms, there seems to be a tendency towards the integration of different data sources such as from surveys, qualitative interviews, focus groups, existing scientific and grey literature,
key informants interviews, role-playing games, and field measurements (e.g. Janssen and Ostrom 2006; Voinov and Bousquet 2010; Feola et al. 2012). Participation of farmers and other relevant actors in the model building process is also an approach often followed to contribute to model parameterisation, e.g. to define behavioural rules for the social agents (e.g. Souchère et al. 2010; Etienne 2011). While combining different data sources is often seen as a way of giving a solid ground for the modelling exercise, relying on incompatible data can also be a drawback for model validation (see below).

Another feature making a difference among ABM applications is their spatially explicit development. Many ABMs are developed in a spatially explicit way, whereby the spatial dimension of social or social-ecological interaction, as well as the heterogeneous distribution in space of social agents and environmental properties is considered fundamental to understand the dynamics characterizing the research problem (e.g. Matthews 2006; Lobianco and Esposti 2010). Furthermore, spatially explicit representations of results are also powerful tools of communication. Nevertheless, in cases where the costs of implementing a spatial component are high, or the spatial distribution of agents and environmental properties is not considered essential, agent-based models are not spatially explicit (e.g. Barnaud et al. 2008).

**Strengths and limitations**

The major strength of ABM is arguably the possibility of modelling complex socio-ecological behaviour in agricultural systems, i.e. one that is characterized by non-equilibrium, non-linearity, discontinuities, feedbacks among levels, bounded rationality, uncertainty, threshold effects, and individual and environmental heterogeneity (Bonabeau 2002; Nolan et al. 2009). This relative advantage of ABM over other modelling approaches is related to three major features (Schreinemachers and Berger 2011): agent and landscape heterogeneity, heterogeneous interactions, and spatially explicit interactions.

ABM might be the preferred choice to model a heterogeneous population of agents, i.e. farmers or households, and landscape components, particularly when this heterogeneity is considered fundamental in understanding observed patterns (e.g. land use) or to explore potential dynamics resulting from an intervention in the system (e.g. adoption of technical innovation or agri-environmental measures) (Bonabeau 2002; Berger et al. 2006; Schreinemachers and Berger 2011). Furthermore, ABM proves useful to render heterogeneous interactions, such as those occurring in clustered social networks (Bonabeau 2002), or those that are spatially differentiated (Schreinemachers and Berger 2011). The possibility of implementing agents’ learning and adaptation abilities, as well as articulated bounded-rationality decision-making, also contributes to the non-linearity of agents’ behaviour, although agents are often represented in an over-simplistic or unrealistic manner with profit maximization as a dominating decision criterion (Bousquet and
Le Page 2004; Matthews 2006; Feola and Binder 2010). Finally, the strength of ABM approaches is that of being highly compatible with a spatially explicit implementation, e.g. through coupling with geographical information systems (GIS) (e.g. Etienne et al. 2003). This feature allows for modelling the spatial heterogeneity of interactions between bio-physical and social processes which might be differentiated depending on the landscape characteristics (e.g. different location of farms within a watershed, with consequent different effects of water management choices on other farms). In addition, the spatially explicit representation of model results might facilitate their communication to non-scientific model users such as policy makers or farmers.

ABM is characterized by some acknowledged limitations, partly due to it being a relatively young modelling approach with procedures and standards still in early-stage development. Spatially explicit, connected ABMs have high requirements in terms of development costs, empirical data and validation (Berger et al. 2006; Nolan et al. 2009). Data requirements are mainly due to the fact that ABM often aims to capture large numbers of micro-level processes in different socio-economic and bio-physical subsystems (Bonabeau 2002). This challenge is often overcome by combining quantitative and qualitative data following creative, but not always accepted procedures. Validation of ABMs is also considered a challenge (e.g. Matthews 2006; Barnaud et al. 2008). Validation against actual data (e.g. Freeman et al. 2009) is often not possible, and in some cases substituted by one which is more qualitative when carried out in participatory processes (e.g. Voinov and Bousquets 2010).

In broader terms, however, it is important to stress that ABM in farming system research are increasingly applied in a constructivist, rather than deterministic manner (Röling 1997; Bousquet and Le Page 2004; Matthews 2006; Voinov and Bousquets 2010). That is, ABMs of agricultural systems are not developed to predict exact economic or environmental outcomes, but rather to unravel the complexity of such systems and explore patterns or development paths and create a common understanding among scientists, farmers and other decision-makers. This approach is based on the assumption that people construct their own realities through learning in social processes, where ABM is considered a platform of interaction in the collective decision-making process (Bousquet and Le Page 2004). Recent research has developed increasingly effective procedures for such companion modelling and model-aided collective decision-making (e.g. Etienne 2011). In this perspective, the concept of model validation at the same time shifts focus from replication of observed system behaviour to entail the very process of companion model building and model use.

Finally, the scientific communication of model is also considered an open issue (Nolan et al. 2009). While protocols for model description and formalization have been proposed, among which the ODD protocol (Grimm et al. 2010), ABM tend to lack a standard communication format which is instead well established in other modelling approaches, such as econometrics. The standardization and formalization of model communication would improve accessibility, thorough understanding and analysis of the models, and, consequently, a wider acceptance of ABM in the scientific community.
Conclusions: Potential and challenges of integrated simulation models in Farming Systems Research

Integrative (i.e. bio-physical or socio-ecological) simulation modelling is a promising research tool in farming systems researchers’ toolbox, as testified by the numerous application of linear programming (LP), system dynamics (SD) and computational agent-based models (ABM) presented in this chapter. These three simulation modelling approaches, which are among the most frequently adopted ones in Farming Systems Research, all share a high potential for further application and development in this particular research. They help unravelling the complex and dynamic interactions and feedbacks among bio-physical, socio-economic, and institutional components across scales and levels and, in so doing, are a useful support to formulate complex problems and in taking decisions to foster sustainable farming systems. Importantly, the three approaches presented in this chapter are clearly not equivalent and a thoughtful choice is required before the investigation to match the research problem and goals with the most appropriate modelling approach.

One particular strength of integrated simulation models is that of providing a platform for the integration of research approaches, knowledge and data in the frame of interdisciplinary or trans-disciplinary processes. Furthermore, integrated simulation models have a wide range of applications in terms of research problems, farming systems, and research goals addressed. The high applicability also concerns the scale of analysis, which potentially spans from the highly local (e.g. plot) to the global (e.g. countries or macro-regions). Interestingly, simulation models offer the tools to investigate cross-scale phenomena, such as the aggregated effects of individual decisions at macro level, or the micro level effects of macro level changes. Simulation modelling also has a high potential in Farming Systems Research as a tool for social learning, i.e. to develop trans-disciplinary research with different types of stakeholders, whereby the modelling process is a basis for e.g. problem framing, consensus building and mutual exchange on pathways to system change. In this respect, SD and ABM probably offer more practical examples and standard procedures for participatory modelling than LP (Fig. 13.5).

The adoption of simulation modelling in farming system research is also challenging in many ways.

Firstly, integrating bio-physical and social modelling requires relying on different data sources and types (i.e. quantitative and qualitative) and on potentially different research paradigms. This implies the handling of different degrees of data uncertainty, of concepts of model validity, and of validation procedures. In effect, while some modelling approaches have a rather established model-testing procedure (e.g. SD), others have not yet reached an acceptable agreement on such a procedure (e.g. ABM). In addition, an interesting trend is that of combining different modelling approaches (e.g. LP and ABM), a technique, which is facilitated by some ad hoc software released in recent years (Anylogic, Simile). This is a promising trend, which potentially exploits the advantages of each modelling approach and minimises their limitations. Nevertheless, apart from the challenge of validation, this
also raises the challenges of merging approaches with i.e. different theoretical assumptions, programming languages, and data needs. What the limits and trade-offs of such combinations are, is still an issue of debate.

Secondly, it was underlined in this chapter how participatory modelling is increasingly seen as a tool for fostering social learning and sustainability transition processes. A broad range of case studies suggest that this might be a fruitful trend, in that the simulation model offers a learning tool or platform, through which stakeholders can more easily interact, explore, communicate and visualise alternative futures.

Fig. 13.5 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
Nevertheless, not all simulation modelling approaches seem to offer appropriate standard procedures in this respect, and probably a more intense exchange of experiences among modelling communities might facilitate the development of best practices in participatory modelling in Farming Systems Research. Finally, simulation models tend to represent social agents too simplistically, and therefore often to overlook the importance of the behavioural rules in farming system dynamics. Many models make assumptions (e.g. perfect information) about human behaviour (e.g. farmers) which have been shown both to be unrealistic, and to ignore the understanding of farmers as agents in a complex farming system. More articulated representation of farmers’ decision criteria and goals are possible, but these significantly raise data needs and model complexity, and are therefore often avoided. This, however, poses limits to the validity of the model and its usefulness in achieving a realistic and solid representation of social agents in simulation models in Farming Systems Research.

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Chapter 14

Reshaping boundaries between farming systems and the environment

Stéphane Bellon and Jean-Louis Hemptinne

Abstract In modern societies, farmers not only have to be efficient in food production, but also ensure that ecological services such as pollination, pest control or biodiversity conservation are effective. Therefore, the role of the environment needs to be reconsidered in redesigning or assessing farming systems. This chapter questions and redefines the usual boundaries between a farming system and its environment. It includes three sections. First, we examine the dynamics of literature related to environmental perspectives in farming systems analysis, encompassing several levels of organization. Then, we analyse the contribution of some proposals derived from ecological forms of agriculture (e.g. organic, integrated), in terms of system properties and boundaries, as well as the delineation of expected functions. Finally, by examining agroecology, we address how farming systems can integrate ecological issues, and identify research perspectives which may inform the further development of farming systems thinking and practices.

Introduction

Agriculture appeared during the Neolithic Period, when our ancestors started to manipulate the distribution and abundance of certain plants they preferably collected and ate (Murphy 2007). By doing so, they were in fact practicing ecology...
even though they might not have been openly aware of this. Many of their modern
descendants probably still doubt that ecological principles are at work in agriculture.

So far, 90% of the history of humanity consisted of hunting and gathering. Farming Systems Research (FSR) has been around for only a tiny period in the history of agriculture. In many parts of the world, fields appeared after forest or bush clearance. By cutting trees to give room to herbaceous crops, early farmers simplified ecosystems. The degree of simplification progressively increased with time and probably mirrored the development of new technologies. The proportion of trees in the landscape decreased when power was available to cut big trees and remove large stumps. Then, fields became larger, in keeping with technological advances enabling higher productivity of labour. As a consequence, fields have less species than forests and this has an impact on their functioning. Nutrient cycling, for example, is different in forests than in fields. A long-term study at the experimental forest of Hubbard Brook (New Jersey, USA) shows that this broad-leaved temperate forest accumulates 7.6 kg NO$_3^-$ and 2.3 kg NH$_4^+$ per ha and per year. On the other hand, the plots of the Broadbalk experiment at Rothamsted (UK), which has been set up in 1865 and is still running, loses between 19 and 56 kg N/ha/year (Begon et al. 1996).

The availability of cheap fossil energy rapidly made the connection between agriculture and ecology even less clear. The link with ecology was severed, as mineral fertilizers were used to maintain soil fertility without having to bother about species fixing atmospheric nitrogen or recycling organic matter. Likewise, impressive and sophisticated machines helped in cultivating, sowing and harvesting. It also became possible for farmers to rely on an impressive range of pesticides to maintain field populations of pests in a desired state of low diversity. However, whether this approach to agriculture is best suited to respond to current challenges is an on-going subject of debate.

Agronomists often perceive cropping systems as composed of three main compartments: the atmosphere, the soil and the plant population. They tend to manage each compartment – and their interactions – so as to maximize the production of the plant population. However, this management has several drawbacks. Firstly, the price of fossil energy is growing; secondly, fertilizers and pesticides have environmental and health consequences; thirdly there is a vivid debate on biodiversity. Questions such as how many species we can afford to lose without affecting ecosystem services are obviously relevant for agriculture. Books with attractive titles were published advocating a new interplay between farming and nature (Fukuoka 1985; Soule and Piper 1991; Jackson and Jackson 2002; Imhoff 2003; Scherr and McNeely 2007; Denisson 2012). But such proposals are counterbalanced by the debate on food security: producing enough food for a growing world population once again seems to be the prime objective for agriculture, even if this is at the expense of other objectives. Efforts to map ‘yield gaps’ stimulate efforts to close these perceived gaps, and run the risk of becoming an overriding objective. It is between these potentially opposing trends that an agroecological viewpoint can provide a middle-way, as well as an opportunity to assess the strengths and weaknesses of food and farming systems.
A system can be described as a limited vision of reality. How the boundary of a system is defined – and which components or subsystems are considered – is importantly affected by the way we see the world. In other words, how scientists perceive farms, what system they define, which components they include, and which indicators they chose to assess system performance, will depend on their interests. How a farm’s ‘environment’ is defined may thus have very different meanings, and give way to various interpretations. In this chapter we focus on the biophysical environment, and especially on the ‘natural’ environment, which is increasingly seen as a driver for farming systems dynamics and research.

Although the ‘environment’ is usually considered as the remainder of the universe, that which lies outside the boundaries of the system, it has been shown that the interactions between the biophysical environment and farming systems are so meaningful, as to inform the further development of farming systems thinking and ecologically based agricultures (Fig. 14.1). In other words, the interactions with the environment need to be redefined, the standard view of a set of connected compartments needs to be replaced. This position also questions disciplinary boundaries, especially between agronomy and ecology, and the role of social scientists. However, since agronomy can also be seen as “ecology applied to the cultivated field and land development” (Hénin 1967), disciplinary frontiers between agronomy and ecology are perhaps not that distinct.

This chapter questions and redefines the boundaries between the farming system and its environment. First, we examine the literature related to environmental perspectives in farming systems analyses, encompassing several levels of organization. Then, we analyse the contribution of some forms of ‘ecological’ agriculture, in terms of system properties and boundaries, as well as in terms of expected functions.
Finally, building on agroecology, we discuss how farming systems may integrate ecological issues, and identify research perspectives to inform the further development of farming systems thinking and practices.

**Dynamics of relationships between farming systems and environments**

During the past decades, the way relationships between farming systems and environment were conceptualized has evolved significantly. In the late 1970s Farming Systems Research was driven by technology generation and understanding effective dissemination. The environment was little more than background scenery for the agriculture. Some years later, environmental issues and the environmental impact of agricultural practices became increasingly relevant in determining the features of farming systems. As a result, the components of farming systems that were considered important changed. The research focus shifted from farm-based production to larger scales, thus allowing a focus on the spatial organization of cropping systems at watershed level, as well as the study of their effects on ecosystem services. These developments made room for new interdisciplinary arrangements, for the involvement of new stakeholders and for new assessment criteria.

**Benchmarks in an on-going history of changing relationships**

With an historical perspective Norman and Malton (2000) consider four phases in the evolution of agricultural systems approach. A first phase focused on sub-systems, due to institutional research mandates, disciplinary approaches, development of food chains, and commodity-based agricultural organisations. Norman and Malton (2000) also mention a shift from crops or animals to cropping systems or livestock systems. This shift allowed an integration of other dimensions, whether temporal (crop sequences and management methods) or spatial (decisions related with farmland land use and crop arrangements). Considering such broader entities also questioned a process of farm specialization and renewed research approaches (e.g. Boiffin et al. 2001; Nesme et al. 2010), but it usually did not take into account the landscape matrix or the interactions between territorial development and agricultural management.

In the second phase the focus was at the farm level, with farm management studies focusing on operational or decisional aspects. Agricultural scientists paid greater attention to decision making processes and technical facts (e.g. Sebillotte 1990). Their understanding of practices and their determinants did not question or redefine explicitly, environmental issues. They also worked with economists, especially in defining optimal and rational decisions regarding crop or livestock management and planning.
This anthropocentric approach revealed why recommended technologies were so rarely adopted by farmers. Conversely, giving more weight to the farmer also led to minimize the role of nature as an actor in agricultural production (Goulet and Barbier 2011).

The third phase involved the reinforcement of studies ‘with a whole farm focus’ and a growing focus on natural resources. Both types of studies build on interdisciplinary approaches integrating social and technical disciplines. This type of study showed that many farmers have an intimate understanding of their spatially variable and temporally risky production environments, based on their traditional farming systems which have evolved over time with their environment (Girard et al. 2001). But ecologists or ethnologists were poorly represented. However, most of the research outcome was about the environmental side-effects of agricultural practices, about the competition between population growth and agricultural areas, and about poverty. Intensification was not always considered as the only solution; at least it needed to be balanced with other functions (Giller et al. 1997), and is subject to contradictory dynamics (Marriott et al. 2004).

The fourth phase focussed on ‘sustainable livelihoods’, and integrated three sets of objectives: economic efficiency, social equity and environmental sustainability. This was intended to provide a framework to guide decision-making at hierarchical scales varying from household level, to community, regional and national levels (Hart 2000; López-Ridaura et al. 2005). It also resulted in renewing performance criteria (such as adaptability and robustness of farming systems) and the target beneficiaries (from resource-poor farmers to the next generation).

However, such phases overlap, and technology-oriented studies persist. Viewpoints and approaches also changed (Aubry et al. 2006). Whereas systems used to be restricted to the cropping or livestock levels for technology generation, they were more farm-level oriented when the aim was technology adoption. When shifting to farm realities, researchers realized that technologies would need to be adapted to farmers’ more complex situations, i.e. effective under ‘uncontrolled’ conditions, which differ significantly from experimental plots, greenhouses and monocultures. Farming Systems Research followed two main directions. Firstly, methods to assess the trends and flows of resources at farm-household level were developed. This development coincides with a shift to more participatory approaches, which also allowed an integration of farmers’ knowledge of their environment (Jiggins and Röling 1999). The development of indicators (e.g. Bockstaller et al. 2008; Rodrigues et al. 2010) or nutrient balances (Nesme et al. 2006) at field or farm level illustrate this first direction. Another example is participatory plant breeding, which goes beyond genotype/environment interactions and considers management as part of the breeding context, and understands it as co-evolving with environment. In the second direction, methods were developed at regional level, which allowed taking into account farmers’ practices and land use patterns in relation to environmental issues (Bellon et al. 1999; Thenail et al. 2009). Indeed, farmers were targeted by EU agri-environmental schemes (e.g. EU regulation 2078/92), thus requiring procedures to enable the local adaptation of policy measures to farming situations. However, in many EU countries these schemes were restricted either to
specific areas or to specific practices, such as input reduction. Such a focus on resources suggested a paradigm shift from resource sufficiency to functional integrity, especially in livestock management (Hubert and Ison 2011).

**From environmental impacts to environmental issues**

The brief historical review shows that the development of Farming Systems Research has progressively laid greater emphasis on the availability of resources, on their long-term use and sustainability, and on collaborations with the wider field of environmental studies and development (Brossier et al. 2012, this volume). System boundaries are not clear-cut. Indeed they still can be defined by the adopted viewpoint (‘system of interest’ in the terms of Ison 2012, this volume) or through an elected environmental problem.

Initially, farming systems were usually described through their allocation of inputs or resources, sometimes with a more detailed characterization of land use patterns and practices. The attached vision of environment was often restricted to one or several compartment(s) in relation to the problem addressed. Another option was to consider farms either as open systems or as part of a hierarchy of systems (from soil to region) and in a set of flows (Doppler 1999). This second option does not solve boundary issues; but it enables connections between various levels of organization and several disciplines. Subsequently, the environment was both enlarged and specified, e.g. as natural, economic, institutional.

Natural environment was also ‘systemized’, with two symmetric approaches. The *ecocentric* approach, where the reference is an ecological system (e.g. a watershed) and human activities are assessed through their consequences on that system. Alternatively there is an *anthropocentric* approach, where the reference is a social system which determines the value of environment and constructs related issues (Larrère and Vermersch 2000). Finally, a *technocentric* approach also appears, confident in the human capability to mitigate environmental problems (including the use of ecological engineering or restoration).

Environmental issues combine these approaches. They also are an invitation to overcome disciplinary frontiers, without prerogative. A focus on the natural environment leads to new methodological proposals, including interdisciplinary approaches, which also questioned what is perceived as an environmental issue. Scientists are not objective observers of what environmental issues are and how they can be dealt with. Such issues are socially constructed. They emerge out of, and give rise to, decision-making in dynamic, uncertain and complex situations inherently difficult to understand (Lemon et al. 1999). We are dealing with both managed and natural entities whose spatial and temporal spans usually mismatch (Pelosi et al. 2010). This opens the way to learning processes (Hubert et al. 2012, this volume)

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1 A functional focus within Farming Systems Research is also referred to in Dixon et al. (2001: 10).
supporting the definition of both environmental issues and systems at stake. Although more related with the firm theory than the farm approach, considering the internalization of ‘externalities’ (technological, environmental, or monetary) also suggest how fuzzy or relative boundaries can be.

In Europe, the agri-environmental focus in the late 1980s shifted environment from a political issue to the scientific field. Changes also appeared in environment research topics addressed within the IFSA community and more broadly. A specific IFSA conference was dedicated to environ perspectives, and divided into five workshops (Doppler 1999). Interestingly, one of the workshops was dedicated to the role of institutions, emphasizing the role of agricultural and environmental policies in the orientation of farm structures, productions and practices (e.g. van der Ploeg 1999). In the beginning of the next decade, more attention was given to crop protection and biodiversity conservation, whereas climate change and related topics become prevalent in recent years (from Barbier et al. 2012, this volume).

More generally, three main orientations can be differentiated in the scientific literature relating farming systems and environment: (i) assessment of agricultural impacts on one or several environmental compartments; (ii) environmental valuation, considering environment as an asset in farming systems management, and (iii) inclusion of environment in sustainability issues, among other dimensions. Accordingly, attached methods also vary: case studies at different levels, comparative analyses among agricultural regimes, supported by various methods (indicators, Life Cycle Analyses and models).

In the next section we will introduce some examples of ecologically-based agricultural regimes, acknowledging that “most intellectual maps of agriculture fail to recognize in it the basic interface between human societies and their environment” (Dahlberg 1970, quoted by Bawden 2005).

How the development of ‘ecologised’ forms of agriculture reshape boundaries between the system and its environment

The development of ‘ecologised’ forms of agriculture explicitly referring to systemic dimensions is discussed in this section. Such forms include farming practices that aim at (i) maximum use of ecological processes to decrease the need for external, costly or potentially disruptive inputs, (ii) diversification of activities and (iii) production of added values in keeping with societal expectations. Several agricultural regimes (organic, integrated…) may be considered, each of them contributing to redefine the boundaries between various systems involved (production systems, agroecosystems) and environment. After describing a general picture of ecologically-based agriculture, we define two of them; we delineate their expected functions and relationships with environment. We also characterize their differences or complementarities in the perspective of agricultural transitions.
An overall view of ecologised forms of agriculture is presented in Fig. 14.2, based on their use in scientific communities and based on a scientometric analysis\(^2\) (Ollivier and Bellon 2011; Ollivier et al. 2011).

There is a wealth of initiatives contributing to finding answers to the limitations of mainstream agriculture. On the right and bottom quadrant of Fig. 14.2, precision agriculture (PrecAgr) is rather isolated and little connected with other types of agriculture. This management method aims at optimizing field management and minimizing environmental impacts. It relies on technologies like satellite imagery, information technology, and geospatial tools. It also continues the first phase mentioned in the previous section. Due to its main focus on the field level and technological rooting, it will not be developed in this section. On the other side (left and

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\(^2\)To briefly describe the approach, bibliographic elements of articles including the roots “agr” or “farm” or “eco” were extracted from the CAB database (period: 1973–2009). Groups were identified, based on agricultural qualifications (e.g. low-input agriculture, LowAgr in Fig. 14.2). Queries were done for each qualified agriculture, leading to a matrix combining agricultures and authors. This combination is mapped as a network (using Netdraw software and a visualization algorithm). Each point in Fig. 14.2 represents an author and the agriculture(s) s/he refers to (with an occurrence threshold >2 articles). The size of a point reflects the author’s contribution to one or several agricultures (centrality of intermediarity). For instance, two authors mentioned at the bottom of Fig. 14.2 refer to both organic and precision agriculture.
upper quadrant), we observe a dense polarity, with numerous interconnections and a central position of sustainable agriculture (SustAgr). In this second polarity, most of the ecologised agricultures are also scientifically rooted, thus translating an awareness to change the boundaries between farming systems and environment. Instead of defining and referencing the various forms of ecologised agriculture, we briefly examine two forms of agriculture defined as production or farming systems, namely organic agriculture (OrgAgr, bottom left in Fig. 14.2) and integrated agriculture (IntAgr on top of Fig. 14.2).

**Organic agriculture** has a worldwide recognition, namely through certification schemes. It appears as a link among various topics addressed in the IFSA community (Barbier et al. 2012, this volume). In the overall scientific literature on organic agriculture, farming systems are frequent keywords (Ollivier et al. 2011). Several definitions exist, generally referring to “a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. [Organic production] emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems” (EU council regulation 834/2007). Relationships between organic agriculture and environment vary: (i) from assuming organic agriculture as ‘naturally’ environmentally-friendly, due to its objectives and methods (as mentioned in the above definition); (ii) to assessments of its environmental impacts and meta-analyses moderating the previous appraisal (Stockdale et al. 2001; Pacini et al. 2003; Pimentel et al. 2005); or (iii) considering environmental resources as a development asset for organic agriculture, including with its ‘ecofunctional intensification’ (Niggli et al. 2008) and to fulfill its assigned societal role to contribute to the provision of public goods (EU reg. 834/2007). Indeed farmers’ perception of nature differs from the one held by biologists and ecologists (Hansen et al. 2006). Ecologization is thus also relevant for organic agriculture (Lamine and Bellon 2009; Francis 2009), namely to counteract other dynamics such as conventionalisation (e.g. Darnhofer et al. 2010).

**Integrated agriculture** embraces several interpretations: vertical/horizontal integration; crop/livestock integration; integrated production/protection; integrated farming/agriculture. All interpretations somehow translate the project to reconnect what has previously been segregated. We focus on one of these. The IOBC, a scientific community linked with producers and extensionists, proposed a definition that goes far beyond crop protection. For Boller et al. (2004): “Integrated Production/Farming is a farming system that produces high quality food and other products by

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3 Beyond a general identification of organic agriculture to certified products, two other interpretations can be mentioned. In the first one, ‘organic matters’ is a metaphor giving a central role to humus in the sustainable management of soils fertility and land (‘land care’). In a second one, organic refers to the idea of living organism, which can be applied at various levels, including at farm level.

4 International Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC). The West Palearctic Regional Section (WPRS) covers European and Near East countries, as well as North African countries.
using natural resources and regulating mechanisms to replace polluting inputs and to secure sustainable farming”. Emphasis is placed on: (i) a holistic systems approach involving the entire farm as the basic unit, (ii) the central role of agroecosystems, (iii) balanced nutrient cycles, and (iv) the welfare of all species in animal husbandry. Biological, technical and chemical methods are balanced, carefully taking into account the protection of the environment, profitability and social requirements. “The concept is based on the use of natural resources and regulating mechanisms to replace potentially polluting inputs. The agronomic preventive measures and biological/physical/chemical methods are carefully selected and balanced taking into account the protection of health of both farmers and consumers and of the environment”. In spite of IOBC’s vision of the farm as a relevant application domain, recommendations are mostly applied to individual crops or groups of crops (e.g. stone fruits), albeit giving room to original interdisciplinary projects (Habib et al. 2001). Beyond the preservation and improvement of soil fertility, of a diversified environment, other essential components such as the observation of ethical and social criteria appear as more difficult to achieve. Farmers referring to integrated production face difficulties in economic valuation and market recognition of their efforts, which prevents its development at a wider scale (except in countries such as Switzerland). Still, integrated production is growing. Indeed it can enable farmers to improve their results (while reducing the use of off-farm inputs), to anticipate on future restrictions in the use of pesticides, and may be a mid-way (or intermediate step) to conversion to organic agriculture. More generally, integrated agricultural systems have many properties (diversity, complexity…) likely to facilitate their adaptation to emerging challenges. However, how such systems are shaped by the environment and how they shape the environment is still unclear. Future integrated agricultural systems need to work with environmental limitations rather than overcoming them and be capable of enhancing environmental quality (Hendrikson et al. 2008).

Both the general mapping and the previous examples show that ecologisation is an on-going process, with possible connections or transitions among candidate agricultures. They also reveal the existing distance between ecological integrity as a driving concept and agricultural integration of proposed principles or methods (Robertson and Swinton 2005). In this process, agroecology has a growing influence (Ollivier and Bellon 2011).

The contribution of agroecology in reframing relationships between farming systems and environment

Defining the properties of agroecosystems and analysing their relevance to address environmental issues could help identifying farming systems characteristics relevant to reshape their relationships with the environment. The contribution of agroecology is introduced, namely to address farming systems transition and redesign. The potential role of ecology is presented and exemplified.
The agroecology perspective

Agroecology is extending in various communities interested in agriculture, food or environment. In Latin America, it gives room to congresses with thousands of participants, including many students (Ferguson and Morales 2010). Sometimes used to describe a combination of agronomy and ecology, agroecology is a polysemic term that can be understood alternatively or jointly as a science, a movement and a practice (Wezel et al. 2009). Topics and levels of organisation addressed in agroecological research evolved: (i) from plants domestication and biological pest management, (ii) to farm and agroecosystem design and (iii) more recently to the ecology of food systems. The first phase had strong linkages with entomology, and biological control as promoted by IOBC (Warner 2007). The second one enabled us to conceptualize agroecosystems as a basic unit of agroecological analyses resulting from a co-evolution of nature and societies (Gliessman 2004). The latter one lead to a renewed definition of agroecology as: ‘the integrative study of the ecology of the entire food systems, encompassing ecological, economic and social dimensions’ (Francis et al. 2003). This definition entails multidimensional and interdisciplinary approaches and practices (Buttel 2003; Dalgaard et al. 2003).

Five ecological principles may be helpful guidelines when (re)designing agricultural systems (Reijntjes et al. 1992, quoted and completed by Altieri 2000):

- Enhance recycling of biomass and optimizing nutrient availability and balancing nutrient flows;
- Secure favourable soil conditions for plant growth, particularly by managing organic matter and enhancing soil biotic activity;
- Minimize losses due to flows of solar radiation, air and water by way of microclimate management, water harvesting and soil management through increased soil cover;
- Diversify species and genetic composition of the agroecosystem both in time and in space;
- Enhance beneficial biological interactions and synergisms among components, thus resulting in the promotion of key ecological processes and services.

Each of these principles will have different effects on productivity, stability and resilience of the farming system. Their interconnection supports an agroecological design, where overall biological efficiency is improved (with optimal use of sunlight, soil nutrients and rainfall), biodiversity is preserved, and the agroecosystem productivity and its self-sustaining capacity are maintained (Altieri 2000).

Agroecology also proposes a conceptual framework that could address agricultural systems transitions. The ESR model describes them as a stepwise, evolutionary process: input Efficiency – input Substitution – system Redesign (Hill 1985, 1998). The first step (E) consists of making inputs more efficient as regards production costs and accounting for their use (traceability). The second one (S) replaces chemical by biological and environmentally less harmful inputs. Neither of these two steps entails profound changes within the systems, whereas the third entails a paradigm...
shift, arising from the transformation of system functions and structure. Redesign (R) refers to the construction of diversified agroecosystems, enhancing ecological principles, where interactions between system components guarantee fertility, productivity and resilience properties. Gliessman (2007) expands this framework to a fourth level related to food systems, re-establishing a more direct connection between those who grow the food and those who consume it. This means the development of a kind of ‘food citizenship’, where everyone is understood as part of the system, and thus is both able to influence change and is influenced by it (also see Lamine et al. 2012, this book).

This framework has been widely adopted in agroecology and extended to build future sustainable farming systems (Lichtfouse et al. 2009). It should not be considered as linear, temporally determined or exclusive. Initially proposed as steps and then called levels, ESR must be addressed as polarities. Non-linearity can be exemplified with conversion to organics, which entails inputs substitution. After conversion in its formal duration (2–3 years, and hence differing from transitions which entail larger time spans), a farmer can optimize the use of eligible inputs (thus increasing the efficiency and effectiveness or organic practices) without redesigning his system (Lamine and Bellon 2009). There have been various debates, e.g. about whether conversion to organic farming is innovative (Padel 2001), and whether organic farming integrates the principles of agroecology (Guthman 2000; Altieri and Nicholls 2003). The ESR polarities may also not exclude each other, as e.g. efficiency and redesign can be implemented in parallel on a farm. Crop protection provides an example. A farmer can both develop ecological infrastructures or alternative crop rotations, whose functionalities will be effective after some years, and use biological control agents in the meantime. This is linked both with whole farm planning (Janke 2004) and with system innovations (Elzen et al. 2012, this book; Klerkx et al. 2012, this book).

Agroecology cannot be reduced to a specific agricultural system or regime, in spite of its relevance for other agricultures (Koohafkan et al. 2012) and its contribution to transitions and redesign, differing from incremental approaches that involve relatively small changes in practices within dominant production systems. Its support to agricultural transformations (NRC 2010; Reganold et al. 2011) has given legitimacy to agroecology in international arenas (McIntyre et al. 2009; De Schutter 2011), while reconnecting agriculture with environment and food. It is problem-oriented and change driven, more than technology or object driven, even though it also refers to systemic concepts such as agroecosystems and food systems. Its ties with social movements also make it an engaged science (Rosset et al. 2011), with an accepted political dimension in the true sense, questioning the choice of issues we address and the way we frame them (Fig. 14.3). In other words apart from farming, framing also matters. The methods and the criteria we use to assess or to alter situations (Astier et al. 2011) also reshape the boundary between science and politics, especially when considering that policies can support changes in farming. Agroecology also appears as an interdisciplinary programme reshaping relationships between nature, science, society and policy.
In the relationships between agroecology and Farming Systems Research, some questions remain open. We would like to address three of them.

**Extending agroecology**

In the relationships between agroecology and Farming Systems Research, some questions remain open. We would like to address three of them.

*The scaling-up of agroecology* is one challenge, with two main positions. Some authors consider that small farmers are a target group for agroecological transitions (e.g. Altieri 2002); whereas others support extending agroecology into industrial agriculture (e.g. Warner 2007).

- With the first position, contextuality and universality of forms of knowledge are confronted through: horizontal exchanges among farmers (Rosset et al. 2011); recognition of their design work and agroecological practices or innovations (Hassanein and Kloppingen 1995; van der Ploeg 2010); specification of the kind of knowledge produced (Doré et al. 2011). A diversity of socio-technical solutions is consistent with food sovereignty or ecosystem services challenges, but it does not necessarily contribute to global challenges. Accordingly, the role of the state is minor, although land appropriation is a major issue in this first case, building on peasant rationale, community participation and horizontal methods of exchange to work (Altieri et al. 2011).

- With the second one – i.e. extending agroecology into industrial agriculture – circulation of knowledge is also at stake. Given that agroecology cannot be transferred like a technology, networks between research, extension and farmers need to be reoriented towards participatory social learning. For instance in California (Warner 2007), hundreds of actors and dozens of institutions co-created agroecological partnerships using this alternative extension model. Three main discourses
emerge from grower’s perceptions of the biological production factors and the specific configuration of agronomic, ecological, social, and economic factors shaping social and ecological relations in the cropping systems: (i) agroecological populism, (ii) green agro-managerialism and (iii) eco-rational technology (Warner 2008).

However, the formal certification of agroecological practices remains marginal, in spite of recent achievements (Cuéllar-Padilla and Calle-Collado 2011).

Secondly, a research agenda for an action-oriented agroecology needs to be defined. Two European research teams (Tichit et al. 2010; Stassart et al. 2011) contributed to this and namely underlined (i) the values of diversity and spatio-temporal variability of resources as an asset to explore situations departing from referenced optima, as well as (ii) the role of combining a diversity of knowledge from the construction of problems and of target groups to the identification of solutions. Tichit et al. (2010) also suggested the following research orientations: the design and evaluation of innovative farming systems encompasses economic, ecological and social dimensions (e.g. work, employment, social equity, flexibility); transitions towards agroecological systems integrate learning processes and adaptive management, entailing new skills and activities for farmers (and extensionists); assessment methods must be adjusted to the level of complexity addressed (Bellon et al. 2007), supported by new models for support and guidance; the co-evolution of agroecosystems and social systems at territory level entails coordination or conflict issues (related with spatial management of plant health, with crop diversification, with waste recycling or with the development of local food chains); the role of public action to favour transitions must be considered. In Brazil, Canuto (2011) identified ten research topics in agroecology and their implementation in complex systems, as compared with simplified systems. In the USA, Tomich et al. (2011) specified the contributions of agroecology to answer seven interrelated sets topics (‘agroecological nexus’), as identified in recent scientific publications. This shows that research in agroecology is extending, with subsequent dedicated journals, congresses and institutions. The specific contribution of ecology will be detailed in the next section.

Thirdly, relationships between agroecology and Farming Systems Research are not straightforward. Bawden (2005) proposed a construct of agroecosystems as lying at the interface between natural and social systems, acting as ‘perturbations’ and ‘forces’ potentially influencing the performance and stability of the agroecosystems that they frame. This position would be departing from the views of authors writing from an ecological perspective (rather than from a systems perspective) in the 1980s, with a strong focus on inputs and outputs. Later on, key emergent qualities of ecosystems (energy flow, nutrient cycling, population regulation and dynamic equilibrium) were reconsidered when addressing agroecosystems (Conway 1985; Marten 1988; Okey 1996; Gliessman 2004; Médiène et al. 2011). Bawden (2005) also argues that in the Hawkesbury experience, trainers intended to provide a pedagogy that focussed at the twin goals of ‘learning’ and of ‘systems approaches’ to agriculture, namely for farmers. As for Francis (2009), “agroecology is the term
best suited for serious study of the many interacting components in the complex structure and function of agricultural systems, and a palatable way to introduce practical systems research into academia” (Fig. 14.4).

So far, there is no major contradiction, both authors referring to the integration of system thinking and practice into learning processes. However, during the IFSA Europe meeting from 1996 in Granada (Spain), Sevilla-Guzman and Woodgate (1998) suggested that some shortcomings of Farming Systems Research could be overcome by the radical approach and agenda represented by agroecology. The debate was thus opened. Among the shortcomings briefly mentioned, some are just symmetric with the previous arguments (Bawden 2005): in Farming Systems Research, system approaches would fail to recognise that both people and natural resources as elements of living ecosystems, and that the richness and vitality of agroecosystems rely upon a wide diversity in both natural and cultural elements. Other criticisms are related to the multi-level perspective (Klerkx et al. 2012, this book) and to the methods used in Farming Systems Research: producers’ technological dependency and the influence of globalisation on agricultural production should be considered in Farming Systems Research; most Farming Systems Research would fall short of true interdisciplinarity; in on-farm research, the relationship researcher-farmer is one of patron-client rather than one of equals as

![Fig. 14.4](image-url) Although all too often agronomy and ecology seem to be divided by a deep chasm, it is clear that in the interest of developing sustainable farming systems, they need to work together. Finding the common ground is not easy however, since both disciplines tend to be based on different premises: while agronomists focus on food production for humans, ecologists tend to focus on the functioning of natural ecosystems. Yet much could be gained by integrating insights from ecology (e.g. regarding the self-regulating nature of many natural systems) into agronomy.
developed in Participatory Action Research (Sevilla-Guzman and Woodgate 1998). Agroecology is then presented as an alternative approach, described with eight key premises: crisis of modernity; coevolution of nature and society; diversity of knowledge systems and re-empowerment of peasants or local groups; recognition of endogeneous potential and political engagement of agroecologists with local groups; ecological management of biological systems and collective forms of social action; systemic strategies aiming at biological reproduction and self-sufficiency; ecological and cultural diversity; moving towards sustainable societies. Such proposals are consistent with their positions of rural and environmental sociologists, also familiar with addressing transitions in agricultural models from a transformative perspective (Altieri and Toledo 2011). However, they do not define a research agenda for agroecology and Farming Systems Research evolved afterwards. Sevilla-Guzman is also responsible for training courses in agroecology, up to PhD level, where many European and Latin-American scholars, extensionists and political officers have graduated. Contribution of social sciences in agroecology cannot be overlooked, especially when considering the role of social movements (Wezel et al. 2009). With another angle, Bland and Bell (2007) also suggested a holon approach of agroecology whereby incommensurability among dimensions of agroecology can be handled (Rickerl and Francis 2003), and where unforecasted relationships within a particular ‘system of interest’ can be integrated, including those who operate at other levels. This would open to an ecology of contexts, without predetermined connections among systems components.

The role of ecology in agroecology

The term agroecology and some of the most popular textbooks in agroecology underline that managing land to produce food and fibre should clearly be within the scope of ecology. This brings us back to the ancestral and implicit alliance between agriculture and ecology, as mentioned in the introduction. These textbooks envision fields and farms as agroecosystems (e.g. Bohlen and House 2009), and more precisely as compartments connected between them through fluxes of matters or energy. In his fight to establish ecology as a science Odum (1971) emphasized a systemic approach and gave credentials to the concept of ecosystems through which matters and energy circulate. He also introduced the properties of agroecosystems (Odum 1984), their specificities as compared with ecosystems. Agroecology, as seen by Altieri (1987) and Gliessman (2007), fits well in Odum’s framework. Ecologists also feel comfortable with the shifting borders of ecosystems that depend on the question they ask. For example, the meadow ecosystem is not exactly the same if one is interested in the coexistence of legumes with grasses or in the conservation of plant diversity. This is because the set of interactions between organisms and their environment that are relevant to understand both questions are not exactly the same.
Therefore, ecosystem has more of a concept, indeed also questioned in ecology (O’Neill 2001). In addition, as it is considered that exchanges of matters or energy between compartments are better in complex than in simplified systems, bringing elements of complexity in the fields to improve ecological processes appears as a fruitful option. However, demonstrations that this works in a predictable manner are still rare and rely mostly on observations rather than experiments. This is not a criticism because it is a tough matter and ecologists struggled for decades, and somehow are still struggling to unravel the relationships between biodiversity and ecosystem services. Nevertheless, there is some irony in the fact that agronomists, whatever the agriculture they favour, share a strong taste for systems.

However, ecology evolved since Odum and others (Loucks 1977; Elliott and Cole 1989). For instance, the way with which Vandermeer (2011) examines the ecology of agroecosystems opens interesting perspectives. Ecologists are indeed interested in communities: how they assembled, persist in time and function are central themes in ecology. However, communities are not black boxes. They are made up of individuals. This means that organisms within communities are not abstractions or at best species names; they are represented by individuals that differ in size, longevity and personality to quote but a few traits. To put it simply, individuals occupy the centre of the stage because they are carriers of genes. As natural selection acts on genes or gene combinations, carriers of genes picked up and favoured by natural selection are advantaged over those carrying poorer gene combinations. Individuals endowed with the best genetic make up in relation to environmental conditions in which they live will acquire more resources, produce more descendants, and outcompeted poorer carriers. That is, genes of the good carriers will spread more rapidly in communities and gradually become more frequent. It is said that these individuals are fittest and ecologists have several methods to measure or calculate fitness. By calculating fitness, we have a mean of avoiding anthropocentric bias when looking at nature and so a possibility to see the world through any organism eyes, be it a plant, an insect or a bacterium: we just have to estimate his fitness. A large ice pack is a very hostile place from a human point of view. However, it is the best possible habitat for polar bears…

If agroecology has to forge an efficient alliance between agronomy and ecology, the concept of individual has simply to become actor of the play. Both agronomists and agroecologists should accept to go beyond a vision of compartments connected by fluxes. They must enter into those compartments to see what is living inside and how they live. Shifting this frontier is probably easier to say than to do because the cultural gap between agronomists, farmers on one side and ecologists on the other is quite deep. When the former pay attention to performances of plant populations and measure yield per hectare, the latter are interested in how individuals perform (Weiner et al. 2010). The following two examples briefly indicate the path to follow to develop a fruitful dialogue between agronomists, farmers and ecologists (Box 14.1).
According to Weiner et al. (2010), competition between crops and weeds is the major source of yield loss. This is confirmed by the intensive use of herbicides. It is theoretically possible to tip the outcome of competition in favour of crops if the four following assumptions are met. Firstly, the crop should have a high competitive ability; secondly, it should produce bigger seeds and larger seedlings than weeds; thirdly, the advantage of large initial size in competition should increase with density, and finally the relationship between yield and density should be flat for a large range of densities. Cereals fulfil these criteria. However, experimental attempts at suppressing weeds by high cereal densities have never been efficient. Weiner et al. (2010) suggest that the discrepancy between expectations and experimental results is due to the fact that the pattern growth of individual cereal plant compared to individual weed is not taken into consideration. In actual cropping systems, when cereal density is increased it is mainly in rows. The inter-rows remain largely free for weeds to colonize. Therefore, intraspecific competition between cereal plants increases faster than interspecific competition between cereal and weeds. There is however another way of playing with density. Cereal plants are advantaged over weeds because they germinate from bigger seeds. They grow faster and quickly occupy a volume of soil with their roots. If cereal seeds are disposed so that all possible volumes of soil are occupied when weed seedlings try to establish, cereal plants will win the contest. Life-history traits of plants, such as seed size, conditions favouring germination, initial growth rate, have to be taken into consideration when designing cropping systems, not just population performances. Management methods also interact strongly. For instance, a rapeseed crop can be sown at a high density (to favour crop settlement and competitive ability against weeds) and then hoed (especially for weed suppression), leading to another crop architecture.

Crop protection offers a second interesting example because agroecology emphasizes the benefits of ecological interactions to control pests. Carnivores eat herbivores in food webs of various sorts. This interaction may lead to the biological control of herbivores by carnivores. Eating is frequently represented in textbooks by an arrow connecting the herbivore compartment to the carnivore compartment. This arrow indicates that a flux of matter takes place between these two compartments. However, the feasibility of biological control depends on at least two assumptions. Firstly, carnivores should determine the abundance of herbivores, and not the reverse. Secondly, accepting the first assumption, carnivores must reduce and stabilize the herbivore abundance at
The relationships between agriculture and environment changed. Such changes are reflected in Farming System Research dynamics, as shown in the first section of this chapter. Multiple identities of actors are still confronted with various natural entities and processes. None of them can be manipulated as such. Among others, disciplinary assumptions are still under investigation. The first assumption is that consuming a proportion of the individuals of a population does not necessarily mean regulating the number of those individuals. In fact, there are two kinds of food webs. In the first type, consumers at the top of the web determine the abundance of those of compartments below them: predators reduce the abundance of herbivores, and plants relieved from their consumers produce more biomass. In the second type, it is plant biomass that sets the abundance of herbivores. The latter in turn determines how many carnivores stay on top of the web. The first type is called a top-down food web, and the second a bottom-up web. Obviously, top-down webs are more suited for biological control. Therefore, agroecologists must learn to distinguish top-down from bottom-up webs. A simple rule says that if the life duration of the herbivores is longer than that of the carnivores, the food web is of the top-down type. On the contrary, if herbivores have a shorter life than their natural enemies, it will be a bottom-up web (Kindlmann and Dixon 1999). Once again, one has to pay attention to individuals.

In light to this simple rule based on the length of life, ladybird beetles are unable to regulate aphid abundance (Dixon 2000). This statement runs against worldwide expectation but is confirmed by field experiment. However, this does not mean that biological control of aphids is doomed to failure. A possibility resides in the additive impact of several populations of natural enemies acting together. Even if these natural enemies live longer than aphids, the sum of their killing ability might regulate the abundance of aphids if interspecific competition is weaker than intraspecific (Northfield et al. 2010). The difference in competition intensity guarantees coexistence. However, one should understand how to create agroecosystems that assemble populations of the right natural enemies. This is far from being achieved; it exemplifies a research challenge that agronomists and ecologists should tackle together, forced to look at what is happening inside compartments.

Conclusions and outlook

The relationships between agriculture and environment changed. Such changes are reflected in Farming System Research dynamics, as shown in the first section of this chapter. Multiple identities of actors are still confronted with various natural entities and processes. None of them can be manipulated as such. Among others, disciplinary
and academic frontiers remain strong, albeit environmental issues question them. The environmental field is fertile and generates new encounters at the interface among disciplines, with renewed scientific concepts or methods. Farming Systems Research enables the expression of a range of proposals for ecologically-based agricultures, not least based on redesign principles. This ‘grass-rooting’ can be used as a marker of new connections established between the many dimensions involved in agricultural activities and methods.

Frontiers among farming categories or methods are not that strict when referred to farmers’ trajectories and to agricultural transition perspectives. Possible combinations among farming styles and transition levels (e.g. in the ESR framework) also reveal an overall transformative potential in agriculture. As shown in the second section of this chapter, the ecologisation of agriculture and public policies entail a normative shift, where productivity cannot be the unique performance. Other emergent properties are also at stake, such as adaptive capacity (Milestad et al. 2012, this book), co-existence (Bossel 2002), or sustainagility (Jackson et al. 2010). Agricultural production and nature conservation can also be envisioned in terms of synergies instead of trade-offs (Power 2010). Whatever the organisation level considered with farming systems approaches, agroecology invites us to address co-evolutions or metabolisms in socio-ecological systems. Borders among natural and cultivated (*ager, saltus* and *silva*), become fuzzy since they are crossed by communities (beyond land appropriation). This leads to debates about the integration of various functions of agriculture in territories and about the specific contributions of ecology (Scherr and McNeely 2007; Fischer et al. 2008).

The role of individuals and a sense of humanity are also at stake. Researchers indeed produce knowledge on the actors’ action logics. They are also involved through their commitment to change (e.g. transition issues, learning processes, new pragmatic concepts). They propose tools for interaction between researchers and actors in co-design, or in identifying and analysing grass-roots innovations (systemic, organisational, technical, institutional) and the conditions for their dissemination. Homestays should also be considered, since they are often heart and part of redesign perspectives. The built environment is in the biophysical environment. It refers to the human-made surroundings that provide the setting for human activities, from the personal homestead and farm buildings, to neighbourhoods and cities with their supporting infrastructures (e.g. water supply, energy networks). Design principles can be common to agriculture and other domains, such as architecture, as suggested in proposals such as permaculture (Holmgren 2002).

Finally, the power of agroecology also lies in its etymology, which is a strong incentive at jumping over long established borders, for example between agricultural sciences and ecology. However, success in life is often a question of well-balanced trade-offs so that we should not lose critical judgment when crossing borders. For those who set to explore the realm of ecology, natural ecosystems are powerful attractors providing inspiration for the design of new farming systems (Altieri 2000; Gliessman 2007). Ecosystems reflect an image of stability and resilience frequently attributed to their complexity and to the resultant rich pattern of connections between species. Exploiting interactions between organisms to maintain or enhance soil
fertility or harnessing biological diversity to protect crops from pests seems an obvious way to go. However, natural ecosystems are not exactly the same theatre scenes than fields. Long-term evolutionary constraints that have shaped ecosystems are not necessarily those that act in the fields. Therefore, understanding is more important than copying. One may also expect that implementing strategies of interactions in agroecological farming systems would be more tractable than blindly copying patterns observed in nature (Denisson et al. 2003). Beyond these questions, a gate leads to a host of research challenges, and to an educational agenda that should innovate in integrating agricultural sciences, ecology and evolutionary biology.

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References


Part III

Insights from System Sciences and New Perspectives
Chapter 15

Dynamics in farming systems: of changes and choices

J.B. (Hans) Schiere, Ika Darnhofer, and Michel Duru

Abstract Much changed in agriculture on the doorstep of the third millennium regarding farming practices and concepts in agricultural research. We discuss backgrounds of what was, what changed and what may happen as we increase our understanding of systems and their dynamics. We start with a brief review of the mechanistic approaches behind agricultural development which conceptualized change as a shift from one rather static state to another, as if it was ‘a war has to be won’. However, it increasingly became clear that farming systems, as a combination of biophysical and social-ecological systems, have their own dynamics: there is ‘a ghost in the machine’. We look at how farming systems, conceptualized as a subset of complex adaptive systems, co-evolve with their environment, a notion that we call ‘behaviours’. This dynamic conceptualisation helps to move towards adaptive approaches in agricultural development. The key point is that human agents can chose to ‘design’ sustainable farming, rather than to take easier ‘default’ options embedded in ‘locked-in’ regimes.
Introduction

Agriculture is the art and practice of making a living with and against nature, our struggle to produce food, fibres, social status and income. In this process many kinds of farming systems emerged, disappeared and re-emerged, each with their own merits and drawbacks. For example, Mesopotamian agriculture ‘boomed’ and ‘busted’, partly due to a combination of unsustainable practices, unfavourable climate and poor management choices. In medieval times, Western Europe suffered from plague, affecting people already weakened by crop yields that could not keep up with an increasing population (Crotty 1980; Ponting 1991).

A major transition to more modern forms of farming in Europe started between the two World Wars as organization and use of inputs as well as machinery underwent considerable change. In the 1950s, the international community faced a problem of a perceived shortage of food production in the ‘Third World’. The underlying assumption was that high enough yields would equate to ‘no hunger’. Combined with a curious mix of humanism, enlightenment thinking and fear of communism, it drove the western powers to launch a ‘war on famine’ in the guise of the Green Revolution (Stakman et al. 1967; Scoones et al. 2007; Spiertz 2010). The same is professed to be behind current work on genetically modified organisms, even if this latter drive may be fuelled by corporate interest as much as concerns about food supply for the poor. Be that as it may, even today the call for ‘more food’ persists, half a century after the Green Revolution.

It shows that mankind has so far failed to ‘control’ nature (Fig. 15.1) or been able to design food systems that would ensure continued and adequate food supply for all.

Fig. 15.1 The agricultural research and development community could be compared to a sorcerer’s apprentice who is becoming aware that he raised himself above his mandate. While initially the ‘magic’ worked and yields increased, the ‘price’ for this success is increasingly becoming clear and include environmental damage, as well as changes in socio-cultural structures.
This might be linked to the fact that hunger and plenty are not only a matter of food production and high yields. Food distribution is perhaps a more crucial issue than production alone. Only 160 years ago, the Irish potato famine showed how some starved in a sea of plenty: hungry peasants left for the United States from the same harbour where Irish grain was shipped to Britain. The term ‘entitlement’ thus refers to this difference between food availability and access to food, whether due to human mismanagement or natural causes (Sen 1983). Next to the biophysical aspects of farming and food production systems there is a socio-economic dimension, which may explain complex community behaviour, including aspects of choice and ethics (Bawden 2012, this book).

Agriculture and food supply in ‘mechanistic thought’ were conceived within a ‘war on famine’ paradigm. Farming was thought of as a ‘machine’ that can be made to function better by adjusting nuts and bolts – i.e. fertilizers, herbicides and pesticides, seeds, irrigation – and by ensuring a stable context for these technologies. This paradigm achieved large yield increases in Western countries and in ‘the South’ (Fig. 15.2). However, success came at a price, such as the environmental cost of using agro-chemicals, or of excess nutrients from intensive livestock farming (FAO 2006; Horlings and Marsden 2011). The ‘price’ also included changes in socio-cultural structures (Plucknett and Smith 1982; Conway and Barbier 1990). Limits of the mechanistic paradigm also became clear after seeing that results achieved under favourable conditions could not easily be repeated under more variable agro-climatic conditions or in remote areas (Conway and Barbier 1990).
Increasingly, it became accepted that the biophysical and socio-cultural context together determined the success of crop and livestock improvement programmes. It was also noted that this context was affected by those very improvement programmes. Notions of farming systems as machines started to show cracks which for mechanistic thinkers were manifeststions of ‘a ghost in the machine’ (Koestler 1967). An example of such a ‘ghost’ – which entices systems to display unexpected dynamics – is the dustbowl in central US after the farming boom of the 1930s (Lockeretz 1978), a sort of ‘replay’ of the boom and bust in ancient Mesopotamia. Similarly, in 1983 a combination of drought and poor farming practices led to a dust storm in Melbourne, triggering the ‘Landcare’ movement (Roberts and Coutts 1997; Ison and Russell 1999). Western Europe had dust bowls much earlier, so-called ‘Wüstungen’ (Slicher van Bath 1963). In a way, ‘Wüstungen’ are the same as algal bloom, acid rain, or eutrophication. The underlying pattern is a society that exhausts its resources – i.e. behaves like a predator exhausting its prey – whether the ‘prey’ be good soil, clean air, fresh water or skills. It is on this ‘ghost’ of systems, dynamics going beyond control, that we focus the larger part of this chapter, using current terminology of ‘system behaviours’ and ‘complex adaptive systems’.

Hopes to fight and win a ‘war on hunger’ once-and-for-all did not materialise. Publications like ‘Silent spring’ (Carson 1962), ‘Limits to growth’ (Meadows et al. 1972), ‘Our common future’ (WCED 1987), the ‘Rio declaration’ (UNEP 1992), ‘Livestock’s long shadow’ (FAO 2006) and ‘Agriculture at a crossroads’ (IAASTD 2008) all stress the need for changes in the paradigm that guides agricultural research. Our ability to take into account several factors and their interactions across spatial and temporal scales needs to be improved (Conway 1987; Vereijken 1997). Taking into account multi-causality and interactions will help to better understand the dynamics and how they change over time. This highlights the need for continuous adaptation (Gunderson et al. 1995; Röling 1996; Ison and Russell 1999), and the fact that there cannot be a ‘solution’ that will solve the ‘food problem’ once-and-for-all. This chapter thus focuses on how Farming Systems Research might benefit from conceptualising farming as a ‘complex adaptive system’, i.e. a system which is subject to on-going, unpredictable changes that result from internal and external pressures. The main aim of this chapter is to help farmers, consumers, educators, researchers and policy makers to exert choice and shape change, rather than be driven by ‘default’ dynamics.

Farming Systems Research: a change that happened

Socio-cultural and bio-physical changes due to modern, intensive farming practices, together with the continued need to produce food and sustain rural livelihoods impelled researchers to seek new approaches (Norman 2002; Langeveld and Röling 2006). These were the roots of Farming Systems Research as it emerged in the 1970s, implying
a shift from ‘modernist’ to ‘post-modern’ paradigms (Funtowicz and Ravetz 1994). The shift also implied a move from a ‘reductionist’ focus on genes and bugs towards a holistic approach which considers farms and their environment as part of co-evolving wholes (Conway and Barbier 1990). Early farming systems work was partly based on insights from General Systems Theory and system ecology (Shaner et al. 1982; Klir 1991; Ison et al. 1997; Ison 2012, this book). It was also inspired by approaches borrowed from system dynamics (Forrester 1968), from social sciences (Ulrich 1987; Luhmann 1995) and/or from business (Ackoff 1974; Checkland 1999). New insights emerged on how farms operate, how technology and parts of the farm interact, how villages decline or survive, and how ‘non-equilibrium’ is a rule rather than an exception (Scoones 1996; Gunderson and Holling 2002; Scoones et al. 2007).

The change thus far has perhaps not yet brought dramatic increases in terms of food production, but its principles are making inroads in the agricultural research community. It has also changed the perception that some scientists and policy makers had of farmers: from ‘laggards’ and passive ‘receptors of technology’ to active ‘innovators’ (Chambers et al. 1989; Norman 2002; Van Der Ploeg 2003). Neither farmers’ knowledge nor indigenous technologies are necessarily environmentally friendly (Box 15.1), nor are scientific solutions. The new paradigm is that stakeholders have to work together.

Box 15.1 Default Trajectory vs. Designed Trajectory

Farming systems, although they change, tend to remain in a ‘default’ trajectory. This default is based on topical patching of acute problems within a ‘business as usual’ approach. This can have disastrous effects once thresholds have been reached, and lead e.g. to soil erosion (Fig. 15.3c).

However, even if this default trajectory is the most likely evolution, it is neither inevitable nor predetermined. Stakeholders may exercise choice, engage in designing their system, nudging it into a different trajectory (Fig. 15.3d). An agricultural community can thus fatally accept default scenarios of increased erosion (whether of soil, genetic resources, local skills). It can also exercise choice, envision a better future and, through experimentation and collective action, design a more sustainable farming system. This choice can be enabled or constrained by context, i.e. by changes such as migration, markets, new skills, technologies or policies. Indeed, the context plays a crucial role in enabling the community to exert choice.

The pictures in Fig. 15.3 only display visible characteristics of the farming system such as forest cover, grass or crop pattern. But the trajectory of a farming system includes many more variables, such as networking, access to information...
Farmer-led initiatives in Europe (e.g. Milone 2009) and in Australia (e.g. Roberts and Coutts 1997; Woodhill 2010) demonstrate, however, that local initiative and choice can turn tides from degeneration to regeneration. Such initiatives show that while some developments are more likely than others, they are neither necessary nor predetermined. Choice can alter default dynamics. Shifting from one to another mode of farming can indeed be a matter of choice, if stakeholders actively engage in ‘design’ (Fig. 15.3d) rather than remain in a ‘default’ mindset (Fig. 15.3c). This default approach to agriculture is often related to the concept of ‘efficiency’ which aims at improving the input/output ratios, e.g. by better monitoring pests and adjusting management practices. Such stepwise improvements have limits, and Hill (1985)
points out that to achieve deep sustainability, system redesign is often needed. This implies a fundamental revision of a farming system to better fit the long term needs of stakeholders and their production context.

Design is thus distinct from passive, deterministic acceptance of predicted future impacts that would be typical for taking a default choice. Default is a case of 1st order learning that takes events at face value, leaving unexamined the beliefs and expectations that underlie the system. Such a system continues in ‘business as usual’ mode. Choice, as understood here, is linked to (re)design and 2nd order learning (Argyris and Schön 1996). In such (re)design the beliefs, ethics, assumptions and expectations are made explicit, being constantly examined and monitored to better understand interdependencies and how they evolve over time (Ison and Russell 1999; Gharajedaghi 2011:133ff; Bawden 2012, this book). Design aims for qualitative change, identifying new alternatives and redefining the ‘rules of the game’. Such a (re)design is often an interactive process involving both conceptual abstraction and active experimentation (Meynard et al. 2012, this book).

Redesigning a farming system needs to take into account the variety of structural factors that constrain options, or limit perceived feasibility of options. However, taking a dynamic approach, these structural factors change as a result of the actions of the community members. In other words, perceptions, context and farming systems co-evolve as farmers explore new modes of farming. As a result, farming systems are in continuous co-evolution, never in equilibrium.

Change has been acknowledged before, but conventional thinking tends to focus on easy-to-quantify indicators, often based on a simplified view of cause-effect relationships, which seeks to explain change by one or a few factors. This reductionist approach, with its suggestion of improvement, efficiency, growth and linear increase (see Fig. 15.2) ignores the oscillating behaviour of agro-ecosystems (Vandermeer 1997). It also ignores the many other factors which change farming systems. These are often factors which are hard to quantify, such as preferences and worldviews. However, these are the very factors that feed the ‘ghost in the machine’ and thus the unpredictable dynamics of social-ecological systems.

Based on recognising the importance of underlying dynamics, systems thinking shifts the focus from asking ‘what’ changed towards ‘why’ it changed. Answers to the ‘why’ question take into account several criteria and their interactions. In Farming Systems Research, transects have been widely used to illustrate why farming systems differ. For example a transect of valley will reveal how farming changes as one moves from a hilltop into the valley and up the other slope (Fig. 15.4). These different farming systems are the visible outcome of a large number of social and bio-physical factors, and of their interactions. The farming system thus changes through space as a result of changes in soil type, water level, solar irradiation, distance to urban centres, and social values. Remarkably, while the farming systems differ, they also display similarities and repeat patterns. For example: the slope facing south is almost a mirror image of the other slope, even if some crops and local culture may not be quite the same (Fig. 15.4).

Farming systems are thus shaped by a wide array of interacting factors that change over time, together with the farming systems. Changing consumption
patterns, new economic incentives, climate uncertainty or new regulations all require adaptation by farmers and policy makers alike. A better understanding of ‘the ghost in the machine’ – i.e. of the underlying dynamics of the system could – contribute to making better choices while avoiding, as far as possible, unwanted side-effects in space or time. Understanding the dynamics underlying a farming system allows us to understand why ‘more of the same’ is rarely successful over the long term, i.e. why success of mainstream thought in the past does not guarantee success in the future. Without explicit understanding of the dynamics underlying the system behaviour we may unnecessarily repeat the same patterns.

**Morphing of farming systems**

Farming systems thus ‘morph’, ‘change’, or also ‘emerge’ as result of internal dynamics, and as a result of co-evolution of the farming system with its context. This ‘morphing’ designates a change which although generally unpredictable, is neither random nor deterministic. Instead, certain basic modes act as attractors (Schiere and Grasman 1996), and certain patterns (behaviours) tend to repeat. In farming systems these patterns can be identified in time transects (Fig. 15.3) and space transects (Fig. 15.4). Repeating patterns may be found in unthought-of aspects, revealing similarities e.g. in nutrient flows, exchange of labour between farms, planting of trees in infertile areas.

Morphing with its similarities and repetition of patterns indicates that the large variety of farming systems may be reduced into a limited set of basic ‘modes’ that emerge according to the rules of the game (Cohen and Stewart 1994). To illustrate this notion of morphing, we use an analogy with so-called Platonic or regular solids.
These solids may morph subject to rules set by a ‘designer’. For example, rules may state that faces of each solid must be regular and the same, resulting in the solids morphing only into shapes with triangular, square or pentagonal faces and so on (Fig. 15.5). If the rules are changed to exclude square faces then some solids (e.g. the cube) are no longer acceptable.

A central point of morphing (emergence) is that within a given rule set (e.g. prices, policy, tradition), the number of basic modes that farming systems can take is limited. These basic modes may be classified in various ways, e.g. by degrees of diversity of farm activities (mixed vs. specialized), by market-orientation (home sales vs. commodity markets) or by degree of autonomy (e.g. farming styles). Importantly, each of the basic modes also has certain characteristics, e.g. being more or less resilient, stable, flexible, robust, etc. (Scoones et al. 2007). There is always variation and overlap between modes, and any classification is a simplification, but that does not affect the basic reasoning.

While a basic mode may be efficient (optimal) in one context, it is likely to be maladapted under a different set of conditions. In other words, what is appropriate and what is efficient, is all context-dependent. As contexts change, systems tend to morph into new modes as described for mixed farming systems by Schiere et al. (2006) and at a conceptual level by Ashby (1958).

Understanding the morphing of farming systems while they adapt to change is not meant to indicate that farmers are the ones who need to adapt their farming practices to the new context. It also indicates that farmers may just as well influence the context so that it may change to fit their needs. How the ‘rules of the game’ can be changed so as to make more desirable modes of farming feasible is the focus of studies on ‘socio-technical transitions’ which will be discussed later on in this chapter.

Morphing is not a new concept. It is implicit in the ‘location theory’ developed by Von Thünen (1826) who showed how distance to the city influences shape and function of farming systems in space. Von Thünen was followed some 50 years later by Rosscher who developed the stage theory, showing that farming systems evolve in
developmental stages over time (Nou 1967).
1 Such ‘stages’ in space-time in mechanistic understandings of change2 are often conceived as a linear process, a stepwise improvement leading to ever higher levels of development (Hodgson 1996). This contrasts with more contemporary concepts that allow for ‘back and forward’ movement, as well as a level of diversity, i.e. several ‘stages’ being simultaneously present. Heterogeneity rather than standardization is a feature in every farming system (Chayanov 1925; Van Der Ploeg 2003). We also reject a deterministic notion of ‘necessity’ in such trajectories of farming systems. The key argument is that consumers, farmers, teachers and politicians have agency: it is up to each of them to exercise choice rather than perpetuate ‘default’ options. Still, we fear that many stakeholders do not exert choice as much as they could. Many feel ‘locked-in’ as discussed later in this chapter under notions of ‘behaviours’ and socio-technical regimes.

Conceptually the focus on how farming systems morph, contributes to studies of transitions, and to studies of how farming systems respond to changing resource availabilities (Chayanov 1925; Hayami and Ruttan 1985; Gunderson and Holling 2002; Schiere et al. 2006). The point of seeking the logic underlying the ‘morphogenesis’ of farming systems is thus not to find ‘deterministic rules’, but to identify levers and processes that encourage creative patterns of change. If one better understands morphing and typical patterns, it may help to anticipate future trajectories. This could allow making better choices, replacing default with design. Our arguments are exploratory, leaning on notions developed in the study of complex adaptive systems (Box 15.2).

Box 15.2 The notion of ‘Complex Adaptive Systems’

Complex adaptive systems are systems that involve many components (agents) which adapt (learn) as they interact (Holland 2006). This is distinct from systems where interaction between components is fixed, i.e. where ‘rules of the game’ remain the same over time as in a game of chess. In complex adaptive systems the linkages between elements change and agents change their perception as a result of learning; as a result the ‘rules of the game’ change. Future development (behaviours) of such systems are impossible to predict. On the one hand this is due to computational challenges as encountered in all complex systems (e.g. the effect of small uncertainties in measuring initial conditions may result in large errors in long-term predictions). On the other hand unpredictability is due to the fact that changes in the rules of the game are the result of a co-evolutionary dynamic, which is not predetermined.

(continued)
Applying these concepts to farming may help our understanding of how farming systems evolve as a result of endogenous and exogenous processes. Examples of endogenous processes are learning by farmers (e.g. how to best make use of on-farm resources), or changing preferences by the farm family (e.g. in the course of the family life cycle). Exogenous processes are those over which farmers have little influence, e.g. actions of colleagues, policies, prices, weather patterns or climate change. As a result of both endogenous and exogenous changes, the farming systems are continually adapting in a process of ‘becoming’ (Scoones et al. 2007; Armitage et al. 2008; Gibon et al. 2010).

This constant unpredictable change may be a nuisance for administrators who like fixed and predictable conditions, but it is necessary for survival of the farming system. Indeed, a system that ‘works’ well today is unlikely to do so a few years later in a changed context, e.g. because there is less family labour available, because markets require quality assurance schemes, or because new skills have been acquired.

From a complex adaptive systems-perspective, farmers are agents who can explore various options for future action, who decide on the need to adapt the farm, who construct new, alternative pathways. The difference between ‘design’ and ‘default’ re-surfaces here. Design implies that information gathered is used to continually reassess what is important to explore in more depth, and which pathways may be excluded from further exploration (Scheffer and Westley 2007). Farmers engaged in design are thus always balancing exploitation (current activities) and exploration (of potential future) activities, with the balance between the two activities shifting over time (Martin et al. 2012). The farmers’ designing activities are not limited to the farm, but extend to the context in which they work. In other words: farmers actively influence the rules of the game, e.g. influencing political processes, developing new marketing channels to fit their needs, or countering economic pressures by co-owning machinery. Thus ‘design’ farmers, unlike the ‘default’ farmers not only reinterpret rules imposed by government and society, they also actively influence their development.
breadth of variation within a feasibility space, showing that e.g. dairy farmers might be economical farmers, intensive farmers, breeders, or machine men (Van Der Ploeg 2003). Each of these farming styles is only one of several modes of ordering the social, technical and economic domains in which farmers operate.

The feasibility space is shaped by flexibility in rules of the game, incl. prices, labour availability and regulations (Fig. 15.6). ‘Room for manoeuvre’ is not only created through alternative technical combinations. Indeed, farmers actively stretch rules to increase their feasibility space, by interpreting rules or by seeing ‘loopholes’. This flexibility builds on 2nd order thinking and leads to feasibility spaces rather than specific recommendations and forms, as in the characteristic for understanding 1st order thinking. Over time the feasibility spaces change, not least through innovative actions of farmers and other stakeholders. Policy measures as well as institutional frameworks shape the feasibility space by encouraging or discouraging the emergence of new modes of farming. The debate around ‘conventionalisation’ of organic farming serves as example of how on-farm practices which are seen as feasible within organic farming have changed and diversified over the last 20 years (Guthman 2004; Lockie and Halpin 2005). This feasibility space was built through time as a result of the co-evolution of farmers’ practices, policy measures, and market demands.
To summarize: specific farming systems emerge from the co-evolution of farmers’ perception and projects with the context in which they farm, biophysical as well as socio-economic. Farming systems that are not compatible with their context are not feasible, even if they can be successful in another space-time context. The ways in which contextual factors affect a farming system depend on how these factors are interpreted and perceived by the stakeholders, and on the history of that farming system. Farming systems can thus be said to have ‘behaviour’, in that both their elements and the whole, respond to change, as shown on time scales in Figs. 15.2 and 15.3 and on a spatial scale in Fig. 15.4. The specific response to a change is not predictable in a mechanistic sense, even if certain trajectories and certain behaviours are more likely than others.

From ‘being’ to ‘becoming’: behaviours and properties

Many dynamic patterns, or also system behaviours, are now identified, e.g. by research on ecological systems, which are a subset of complex adaptive systems. Understanding of behaviours can help guide learning by actors in agriculture and society, e.g. suggesting ways of increasing robustness and resilience of a farming system. Collaborative learning by scientists and farmers may also help them to identify typical behaviour which could devise strategies that allow breaking out of default responses.

As a first case of system behaviour, we briefly discuss the strongly simplified one predator-one prey model (Fig. 15.7), showing that a too ferocious predator may extinguish its resource base. This dynamic interplay between predator and prey is similar to the dynamic underlying the mining of soils by farmers, or consumers ‘starving’ farmers via low prices. In both cases, over time, resources are depleted. Following ‘overconsumption’, population of both predators and preys can crash. The crash can only be avoided if the dynamic is recognised early enough, and if design takes over from default (as in Fig. 15.3). The shift from default to design occurs if predators learn to change consumption patterns; when they start to actively cultivate their prey or when they adopt other survival strategies. ‘A predator cultivating prey’ occurs where farmers choose to cultivate the land base rather than to further exhaust it, as in ecological intensification of sustainable agriculture (e.g. Pretty 2008). The one-predator-one-prey model shown here is strongly simplified, as ‘waves’ occur in many shapes and sizes (Fig. 15.7). Still, the model serves to remind us of the dynamic nature of relationships in which effects are often only seen over time. Taking into account this time-lag is necessary in order to take timely action (Holling 1973, 1995; Schiere and Grasman 1996).

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As an aside: mechanistic science may learn much about system behaviours from farmers, who tend to capture them in stories and metaphors.
Fractal self-similarity is another system behaviour which is helpful in order to illustrate a range of relationships (Mandelbrot 2000; Briggs and Peat 1989). The essence of self-similarity is that a certain behaviour is repeated at various scales of space and time. For example, the same pattern can be seen in curling cigarette smoke, a whirlwind, a cyclone or a galaxy. Similarly, patterns found in mixed farming systems can repeat at the level of a field, a farm, a community and a region (Schiere et al. 2006). If self-similarity suggests that system properties and patterns repeat at different levels of a system, it helps to reduce apparent variation and it simplifies the understanding of complexities in system behaviour.4

Bifurcation is a behaviour in which systems respond to internal and external pressures or opportunities by developing a variety of different forms. This contrasts with the one-problem-one-solution assumption. In farming, when a basic system form morphs from one form into another, not all farmers shift from one ‘monolithic’ system into another. Rather, they choose from a variety of possibilities, bounded by the feasibility space. In line with the notion of bifurcation, Chayanov (1925) stressed variation of farming modes due to changes in family composition. The work by Van Der Ploeg (2003) on farming styles follows a similar line of thought, emphasizing the role of farmer preferences and values. Darwin noted that variation is nature’s way of increasing output and a similar point is made by others, e.g. in the law of ‘requisite variety’ (Ashby 1958) and in empirical research (Coppack et al. 1986; Lewis and Stewart 2003). The implication is that for maximum system output, it makes sense to facilitate the emergence of alternatives instead of promoting one specific mode of farming. Even mathematics shows us that there are situations with no solution, and situations with multiple solutions are more widespread than the notion of one-problem-one-solution.5

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4As caveat on repetition of form with implications for design: logic indicates that as system behaviour moves up the ‘fractal ladder’ it may require ‘denser’ energy sources. e.g., moving nutrients at farm scale can be done by wheelbarrow, while needing trucks and fossil fuel at regional scale. The same could be true for small and large scale food sheds.

5For example: $1+1=2$ (one solution), $\sqrt{4}=\pm 2$ (one problem, two solutions), $\sqrt{-1}$ (one problem, no solution… unless we start to re-interpret the rules of the game!).

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Fig. 15.7 Basic predator-prey dynamics (a), models of interactions between farmers and their resource base and showing how effects of these interactions need to be seen over time. Depending on the nature of the interactions, the dynamics can lead to different dynamics over time (b), with regular and higher amplitude (arrow in c). They are never stable or linear as suggested by the central line. Since in practice many factors interact, the real dynamics are difficult to isolate (d).
**Perverse system behaviour** occurs where systems do the opposite of what they were expected to do, the essence of the ghost in the machine. Typical examples are: a message stating ‘no need for panic buying’ which causes panic purchases; strict enforcement of laws encourages cheating; or excessive irrigation and/or use of agro-chemical that reduce system efficiency. One more ‘behaviour’ is *path-dependency*, emphasising importance of past events in (co-)determining current choices (i.e. ‘history matters’). Linked to this is the notion of *lock-in*, referring to tendencies of systems (bureaucracies as well as in farming) to get used to particular routines, leading to ‘default’ rather than ‘design’ (Nelson and Winter 1985; Arthur 1990). Often this is reinforced by stakeholders with vested interests in the current structure of the system (Vanloqueren and Baret 2009) as in the case of the Belgian Blue later in this chapter.

**Hysteresis** is an asymmetry in alteration and restoration paths, i.e. a behaviour where it is impossible to smoothly shift back and forth from one pattern into another. In social-ecological systems it tends to be linked with a ‘lock-in’ behaviour. Examples are loss of genetic diversity, degradation of soils, and disappearance of traditional skills (Stewart and Peregoy 1983; Scheffer et al. 2003).

Some caution is needed in using these behaviours for the analysis of dynamics displayed by farming systems. First: ‘behaviours’ indicate tendencies and likelihood, not necessities. In other words, there is no inevitability. Distinguishing ‘default’ from ‘design’ and identification of underlying behaviours requires a context-sensitive approach. Second: reasoning on likely and desirable patterns should not be reversed. Much depends on ‘other factors’ to be in place. The ‘golden rule’ is an example from the arts: it is a generally useful ratio to obtain an interesting image composition, but it does not guarantee good results. An example from agriculture is where organic farming may generally be desirable as a way to reduce use of pesticides. However, in some cases, less spraying by an isolated organic farmer may induce more spraying by fearful, neighbouring conventional farms. Third: hard choices are likely to be encountered between default options that are attractive in the short-term, and designing for options which are attractive for the long term. Responding to every long trend in short term conditions makes a system unnecessarily ‘nervous’ (Nelson and Winter 1985).

Many system behaviours can be identified, each offering messages for design. Any behaviour can help to understand the dynamics in a farming system (the ghost). The challenge we face, is that usually it is not a single behaviour that is active, but several types of behaviour which interact (Fig. 15.6d). To cope with this complexity, two frameworks have been developed that allow us to assess system behaviour at higher levels of aggregation. The first is ‘resilience thinking’, which was developed with a focus on the dynamic interactions in social-ecological systems. The second is ‘socio-technical transition’ which was developed in order to understand how technology mediates social relations. In the following discussion, both are applied to farming systems, allowing emphasis on specific properties and dynamics relevant for this type of systems.
Two approaches focusing on the dynamics of systems

Resilience thinking and adaptive cycles

Research on the resilience of social-ecological systems seeks to understand the dynamic interplay between human and natural systems, focusing on key concepts like resilience, adaptability and transformability (Gunderson and Holling 2002). Resilience refers to the ability of a system to persist despite changes in its environment. Resilience is thus the capacity of a system to absorb disturbance and reorganize so as to essentially retain the same function, structure, identity and feedbacks (Holling 1973; Walker et al. 2004). As the definition shows, adaptability is part of resilience, representing the capacity to adjust to changing external drivers and internal processes (Folke et al. 2010).

Using resilience as a guideline for design can be challenging, as increasing efficiency tends to decrease resilience (Mario Giampietro, personal communication). Resilience, as it includes the ability to actively adapt to changes, also refers to the capacity of a system to learn, to combine experience and knowledge, and use this to adjust internal processes. These processes are supported by redundancy (Darnhofer et al. 2010). Resilience is also strengthened by diversity, e.g. in farm innovations. In assessing innovations it may thus be useful to differentiate them in their proximity to existing technologies (e.g. cultivars, pesticides), to existing management practices (e.g. type, timing, intensity), and to existing organization of systems (e.g. structure of internal flows of matter, crop rotations) (Martin et al. 2012). To ensure diversity, both exploitative innovations (i.e. incremental innovations designed to improve existing farming systems, thus remaining in default mode) and exploratory innovations (i.e. those designed to meet emerging aspects of the context or create new output) are needed (Fig. 15.8). Given that exploratory innovation and design involve a departure from existing technologies and management practices, they necessarily require changes in the values and goals of the farmer (i.e. 2nd order learning).

The adaptive cycle is a useful conceptual framework to illustrate the dynamics that will influence behaviour of a system at higher levels of aggregation (Fig. 15.9). The adaptive cycle describes how in ecological systems change is neither continuous and gradual, nor consistently chaotic. Rather, change is episodic: there are periods of slow accumulation of natural capital (e.g. biomass, nutrients), punctuated by releases and reorganization. These changes may be triggered by internal or external disturbances (e.g. a fire or the arrival of invading species may lead to the collapse of an ecosystem).

The adaptive cycle can also be used for farming systems and points out that to persist, a farm will need to use different strategies during different phases of the adaptive cycle (Darnhofer et al. 2010). For example the ‘exploitation phase’ is fairly

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6Cutting many corners one may say that the amplitude of the ‘waves’ in Fig. 15.6 indicate the ‘resilience’ while the proximity to the central line indicates ‘stability’.
By repeating the same ‘default’ practices, farmers risk to get trapped in an ever deepening gully, i.e. enter a path dependency. To ensure resilience, and thus adaptability, the ability to make choices must be preserved: farmers, researchers, and education communities may then choose between alternative paths or alternative framings at various times.

The adaptive cycle illustrates that in social-ecological systems change tends to be episodic: there are long stable periods punctuated by rapid change (the speed of change is indicated by the density of the arrows). During each phase of the cycle a farming system is confronted with different dynamics and thus needs to adapt its strategy mix accordingly (Source of graphic: Holling 1995:22, reprinted with permission from Columbia University Press).
unstable but redundancy and diversity allow spreading of risk. Indeed, if farm activities in this phase are fairly diverse, it is likely that one of them will succeed, however the context may develop. Once the system has built a more stable structure (i.e. going from exploitation to conservation phase), incremental changes to increase farm efficiency seem a promising strategy.

One of the design messages that can be derived from the adaptive cycle, is that management strategies will need to change over time, so as to enable the morphing of the farming systems in response to the context. The appropriate strategy will depend on the phase of the adaptive cycle the farming system is in. Farm management strategies may thus benefit from balancing (a) activities which exploit current opportunities to ensure effective production and stabilize the current farm; and (b) activities to promote diversity and ability to flexibly respond to new opportunities (Darnhofer et al. 2010; Martin et al. 2012).

Another design message is that rather than engaging in futile attempts to predict the future, it might be more sensible to make management choices that expand the feasibility space. Indeed, efficiency and stability tend to imply loss of resilience and flexibility. This trade-off implies choice away from ‘default’ in much agricultural policy of Europe: that farms must strive for efficiency, and that stability is needed for farms to survive. In contexts characterised by rapid changes and uncertainty it may be crucial to design systems that are flexible and adaptable rather than stable, efficient and rigid (see Holling and Meffe (1996) for natural resource management; Martin et al. (2011) for farming systems.

Next to drawing attention to the episodic nature of change and the need for adaptability, resilience thinking also draws attention to the necessity to involve a range of stakeholders to learn about dynamics in the social-ecological system (e.g. farmers, consumers, policy makers). Indeed, management of natural resources such as water and ecosystem services usually involve a larger spatial scale than the farm. Thus, on-going coordination and negotiation between a broad range of stakeholders is necessary for taking into account trade-offs at different scales in space and time (Gunderson and Holling 2002; Pahl-Wostl 2007; Ostrom 2009). Participatory processes linked to adaptive management also allow coping with ambivalence of worldviews and ontological uncertainty of knowledge (Checkland 1999; Ison and Russell 1999; Westley et al. 2002; Voß et al. 2007; Crane 2010).7 Resource management conflicts (e.g. about water use) or vagueness of sustainability goals (e.g. species richness vs. functional biodiversity) exacerbate the challenge to cope with the dynamics of farming systems. Most often, uncertainty regarding the dynamics of a system is a result of the diversity of interacting abiotic and biotic factors; of the properties that emerge at various levels (e.g. from plant to community, from field to watershed); and of the adaptive character of the social system. Since the dynamics of social-ecological systems can only be predicted to a limited extent, adaptive management is recommended for building resilience (Engle 2011). It is driven by the need to:

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7This emphasis on participatory processes and collective learning relates closely to the work on learning and collective action within Farming Systems Research (see e.g. LEARN 2000).
• understand collective consequences of stakeholders’ individual decisions,
• identify uncertainties and ways to test hypotheses about these uncertainties,
• use of management intervention as tool to strategically probe the functioning of a system, to change and to learn from the system.

Resilience thinking originated in ecology. Based on the insight that most ecological systems are heavily influenced by social systems, attention shifted to understanding the interdependencies. As a result, insights from social sciences were included, and a conceptual framework for social-ecological systems was developed. This heritage is still visible in that application of the resilience thinking to farming systems focuses on extensively used natural resources such as rangelands (e.g. Fraser et al. 2011). However, consensus starts to build that the notion of resilience can be fruitfully applied to farming systems, as these can be conceptualised as subsets of social-ecological systems (Gunderson et al. 1995). Many of the insights on the dynamics of social-ecological systems seem to be applicable also on a smaller scale, following the fractal behaviour of many systems.

**Socio-technical transitions**

Work on resilience focuses on the need to cope with different types of change, and on the utility of participatory approaches to manage natural resources. Complementary to the insights from resilience thinking, the research on socio-technical transitions focuses on how technologies and societal structures enable or hinder a transition to sustainability (Foxon et al. 2009). Work on societal transitions aims to understand the complex interplay of agency, social learning, institutions, and technological innovations, and how this interplay can shift productive process towards more sustainable patterns (Grin et al. 2010; Elzen et al. 2012, this book). The multi-level perspective offers a framework to distinguish between processes at various societal scales, i.e. niches, regimes and the broader societal landscape (Geels 2005). By analysing past societal transitions the aim is to understand underlying dynamics, especially the interplay between technological innovation and societal structures. If these are better understood, they may help ‘design’ for transitions to sustainability. The focus of early transition studies was on processes that changed a whole societal system (e.g. transportation or the agro-food network). Following the fractal principle, lessons from these large-scale transitions can also be applied at a smaller scale (Elzen et al. 2004, 2011; Fares et al. 2011).

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8We use the term ‘transition’ to keep with literature on socio-technical transitions. It may be important to clarify that this term does not imply a ‘simple’ shift from one steady state to another. In keeping with complex adaptive systems, farming systems undergo constant change. However, building on the adaptive cycle, some periods are marked by rapid and disruptive changes, which is what ‘transitions’ refer to.
Transitions, i.e. morphing across stages of sustainable farming, requires using paradigms based on ecological principles rather than on mechanistic worldviews (Doré et al. 2011). The sorcerer’s apprentice may have to get back to accepting that there is a ghost in the machine. Indeed, increased input efficiency or input substitution is not sufficient to achieve a deep sustainability (Hill 1998). The process of changing agricultural practices must increasingly consider key characteristics and the dynamics inherent in the entire food chain. For example, alternatives may need to be legitimated through definition of norms. Similarly, networks between farmers and food distributors need to be built to achieve convergence in values and goals (Lamine 2011).

An obstacle for transitions is the system behaviour called lock-in. One example is the Belgian blue cattle regime, locked-in because different actors have vested interests to maintain the current regime, despite shortcomings like low animal welfare and environmental impacts of intensive farming practices (Stassart and Jamar 2009). In such a case, to initiate a transition, the production norms and values of stakeholders along the chain need to change (Fig. 15.10). Such change is only likely if landscape-level changes weaken and destabilize the ‘regime’, e.g. because undesirable side-effects have become unbearable. Research on the livestock system in The Netherlands shows how processes at the different societal scales may lock the system in, or align to enable change (Grin et al. 2004).

Most agro-food regimes have a dominant (conventional) practice, as well as a few alternatives. Some of such alternatives remain in niches, others have managed to anchor themselves in the dominant regime, e.g. by securing legal norms (Elzen et al. 2012, this book). For example, organic farming or Protected Geographical Indication are agro-food chains which involve farmers, advisers, food processors, supermarkets and consumers (Sautereau and Bellon 2010). These alternatives propose responses to problems associated with the dominant regimes (e.g. environmental impact and social cohesion in rural areas). For farmers and actors of the
agri-food chains, the challenge is to cultivate this diversity as a seemingly redundant but crucial store of opportunities.

**Taking dynamics into account: reflections and implications**

Which lessons emerge from notions of complex adaptive system behaviour? What are the implications of a paradigm shift from a mechanistic worldview towards an understanding of farming systems as dynamic? The mechanistic approaches underlying the efforts to ‘fight the war against hunger’ conceptualized change a biotechnical challenge, as a shift from one rather static state to another. The failure of this one-sided approach to ‘eradicate’ hunger indicates that there is a ‘ghost in the machine’. Mechanistic concepts of change – while helpful for specific issues – are not broadly applicable.

Based on notions of complex adaptive systems, new conceptual frameworks for societal change emerged, e.g. resilience thinking and transition studies. Both these frameworks integrate an understanding of the dynamics of social systems, and focus on the ability of a system to learn (Foxon et al. 2009; Smith and Stirling 2010). Developing our understanding of system behaviours is a key to develop our ability to design systems and to develop their adaptive capacity (Röling 1996). Both conceptual frameworks emphasize that management strategies need to be adaptive by cultivating diversity and redundancy. They also emphasize co-evolution of technologies, institutions, business strategies and user practices, within an overall notion of complex adaptive systems. They thus challenge researchers, farmers, policy makers, bankers, consumers and educators into new approaches that enable change rather than to encourage lock-in: the crucial difference between design and default (Fig. 15.11).

A shift to a dynamic approach in Farming Systems Research means that we no longer focus on studying how systems ‘are’, but that we increasingly study how systems ‘become’, i.e. how they ‘morph’. Much more is now known about behaviours of complex adaptive systems than when Farming Systems Research emerged in the 1970s. The behaviour of a farming system depends on its context and it is shaped by a mix of mind and matter factors. These will guide how the system will morph in time and space. The morphing is affected by the internal dynamics of its building blocks and by the external rule sets (e.g. fossil fuel prices, legal rules, social norms, consumer preferences). Identifying these behaviours, even if they are a simplification, will reveal patterns, which can help to understand the origins of current problems, as well as the future effects of current choices. For example, when a farming system moves from ‘exploitation’ to ‘conservation’ in the adaptive cycle (Fig. 15.9), that farming system may well become more efficient because internal links are optimised and redundant ones discarded. At the same time it is becoming rigid and brittle, thus more susceptible to shocks. There is thus an inherent trade-off between efficiency and adaptability.
This chapter started with an analysis of how the mechanistic approaches that led to great changes and production increases conceptualized change as a mechanistic shift from one rather static state to another. Understanding the limitations of this conceptualisation led to the development of Farming Systems Research. Since then there have been significant advances in systems sciences and in understanding the dynamics of systems. It is time to integrate these insights into Farming Systems Research. This will allow it to move from focusing on the (static) analysis of farming systems to understanding their dynamics. We need no longer limit ourselves to studying how things ‘are’, but can start to understand how they ‘become’. Farming systems can fruitfully be conceptualised as complex adaptive systems, i.e. as dynamic systems that co-evolve with their environment. This dynamic view of farming and rural development provides insights into how they may be designed, recognizing, e.g. the need for diversity, flexibility and adaptability. This dynamic view also introduces the notion of societal transition and strives to identify the conditions necessary for a transition to sustainability, for enabling collective action in a design mode. This collective action will be all the more successful, the better we understand the processes underlying change, the more patterns we have identified, the more nuanced our appreciation of system behaviours. These are the insights needed to allow us to make informed choices in co-designing farming systems, enabling them to face a forever uncertain future.
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References


Chapter 16
Farms and farmers facing change: The adaptive approach

Rebecka Milestad, Benoit Dedieu, Ika Darnhofer, and Stéphane Bellon

Abstract In the last decades, there have been profound changes in the understanding of farming systems: farms are no longer seen as facing a stable environment, thus allowing a focus on optimising production systems. Rather, farms are conceptualised as evolving and adaptive, so as to be able to respond to an ever-changing environment. The adaptive approach in Farming Systems Research focuses on ensuring sufficient room to manoeuvre, identifying transition capabilities and extending the degrees of freedom. The concepts of resilience, diversity and flexibility help in understanding how to make constructive use of unforeseen change. Understanding farmers’ rationalities; the interactions between the farming family’s activities; diverse approaches to production management; farm trajectories, and options to increase farmers’ autonomy are central issues of research. Farmers face the triple challenge of ensuring liveability, making efficient use of their resources, and keeping their farms adaptive so as to find responses to both external and internal drivers of change.

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Introduction

A number of transformations and pressures are affecting European farms. Sources of change include the various reforms of the Common Agricultural Policy (CAP), new environmental regulations, more stringent quality and traceability requirements, an increasing frequency of extreme weather events, competing social expectations regarding food and energy production, preservation of the cultural landscape and recreation areas, or changing quality of life expectations by members of the farm family (Fig. 16.1). These partly contradictory demands are embedded in wider trends, such as continued urbanisation, the effect of emerging countries on commodity markets, agriculture’s role in mitigating climate change, or societal debates surrounding technologies such as GMOs, which all contribute to making the future unpredictable. In co-evolution with these societal transformations, farming as an activity is rapidly changing in most European countries. There is a trend towards fewer farmers and larger farms, and while family farming is still the dominant model in Europe, alternative business models are emerging. Such new forms of organisation may reflect farm families’ changing expectations about work-life balance.

Fig. 16.1 Farmers have to juggle with a broad range of changes on a daily basis. These changes affect both the material dimension of farming (e.g. technological change or markets) and the social dimensions which are linked to changing perceptions and shifting expectations. The sources of change are both endogenous and exogenous to the farm
Many of the technical innovations were designed to help farmers to increase productivity or improve product quality, which later was supplemented with reducing negative impacts on the environment. This emphasis fuelled the modernisation trend in European agriculture: the use of high-yielding varieties, as well as a reliance on external inputs and ever larger machinery. At the same time, a second trend is discernible, which is linked to traditional foods of high quality, closer producer-consumer relations, as well as highlighting landscape as a critical element of local sustainable development.

However, uncertainty in the future development of these two trends remains high. Taking this uncertainty seriously and thus accepting that in many situations the future cannot be predicted (i.e. extrapolated from past events), shifts the research emphasis onto ensuring that institutions, people and farming systems are fundamentally able to cope with change. Farms thus cannot rely solely on long-term plans (however well thought through), but must balance these with the ability to buffer the effects of unexpected developments (‘surprises’) and have sufficient resources to be able to take advantage of them. Farms can no longer focus solely on being efficient, but must balance efficiency with resilience and flexibility (Dedieu 2009; Darnhofer 2010). Indeed, the rapid pace of change and the often unforeseeable direction of change require farmers to keep their farms adaptive to be able to respond to new challenges as they arise (Darnhofer et al. 2010a).

In this chapter, we will focus on the farm level, well aware that adaptability and resilience can and need to be addressed at other scales as well. We will start by showing how this focus on coping with the dynamics has contributed to broadening Farming Systems Research. We then discuss how the concepts of resilience, diversity and flexibility can provide important conceptual insights. We will highlight that striving for adaptability needs to be balanced with maintaining efficiency and also ensuring liveability. Indeed, maintaining the quality of life and work satisfaction for all members of the farm family is a core consideration to ensure the renewal of the farming population.

**From ‘command and control’ to accepting the inevitability of change**

Much of the work on technical and economic farm management focuses on production efficiency, on creating optimum conditions so as to maximise output. Because fluctuations are problematic when production goals are to be met, managers seek to

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1 This term is a translation from the French term ‘vivable’ and has no equivalent term in English. It means ‘acceptable living conditions at work’. Some researchers distinguish between ‘working conditions’ and ‘living conditions at work’, which is more specific to the farm, which is both place of work and the homestead of the farm family.

2 The following three sections are partly based on Darnhofer et al. (2010a).
control processes and to stabilise the productivity of the farm. This approach to management – which is guided by the desire to control variation and to make the future harvest predictable – has been referred to as “command-and-control” (Holling and Meffe 1996; Briggs 2003). The attributes at the core of this approach are: efficiency, constancy and predictability. After a problem (e.g. low crop productivity, threat from pests) is perceived, a technological solution is developed and subsequently implemented to achieve a predictable outcome (Fig. 16.2). The goal is to reduce the range of natural variation of the production system, aiming at making it more predictable, and at ensuring a stable supply of goods and services to satisfy societal needs.

The proposed technological solutions were efficient at achieving their primary aim, as demonstrated by the strong increase in productivity in the 1970s and 1980s both in crop and in animal production. The increase in productivity was enabled by a supportive economic and political framework (i.e. ready access to cheap fertilizer, government-guaranteed output markets, stabilised prices). Indeed, ‘technological package solutions’ (Norman 2002) were adopted by farmers in favourable production environments (i.e. good soils, reliable water supply), which led themselves to continuous enlargement and specialisation.

The command-and-control approach may thus have seemed quite successful. However, the limits of controlling the variables to ensure stability became increasingly evident: unanticipated ‘side-effects’ appeared elsewhere (e.g. nutrient leaching from intensive agriculture, loss of top-soil due to erosion, water scarcity). Also, unanticipated events are bound to happen (e.g. floods, epidemic diseases, sudden price swings on the market for agricultural commodities). Highly specialised farms and monocultures are notoriously susceptible to the effects of drought, insect or pathogen outbreaks, and market vagaries. Consequently, to maintain them, they require large inputs of energy (fertilisers, pesticides, herbicides, irrigation) as well
as societal subsidies in the form of price supports, guaranteed loans, disaster relief and surplus buyouts (see Jay 2007). These farming systems are fundamentally not resilient to natural or social perturbations and the ways the environmental variability can be mastered in order to assure stability are no longer acceptable (Dedieu et al. 2008). Indeed, Walker and Salt (2006) describe management for maximum output as the opposite to management for resilience. The shortcomings of this reductionist approach to productivity within agricultural research became increasingly evident, leading to the insight that the farmers’ production environment was not amenable to standardization and ‘control’. Indeed, the approach builds on an (implicit) conceptualisation of production environments as being stable and predictable, thus deviations from the ‘norm’ are outliers, an error or a momentary lapse, which needs to be corrected. In systems terms, this would be a closed system, which strives towards an equilibrium, i.e. stable state.

However, farming systems are better characterised as open, and as complex adaptive systems (Petit 1978). Such systems are inherently dynamic, and given complex feedbacks and interactions, changes are often not predictable. Dynamic theories that explain the driving forces requiring the adaptations of the system over time, and the mechanisms through which they operate, have come to be labelled ‘evolutionary’. In the context of farms, concepts from evolutionary theories can be used to explain how farms generate, and adapt to change, and how these processes are intertwined with what happens both at the lower level of individual behaviour and the higher level of markets and the farm’s environment in general (see Rathe and Witt 2001; Teece 2007). This evolutionary perspective allows for a definition and assessment of adaptability of the system, i.e. its ability to perform well according to unknown future boundary conditions, unprecedented occurrence of perturbations including severe crisis and goals that might change over time due to endogenous or exogenous reasons.

In an evolutionary framework, continual development and innovation at the farm level is needed to maintain its ‘fitness’ relative to the systems it is co-evolving with. Subsequently, this ‘imperative to innovate’ highlights that there can neither be any best state, nor a stable equilibrium nor an optimal path of development (Rammel 2003). If there are no single optimal solutions, no universal stable equilibrium, the objective must include initiating and maintaining a diversity of alternative options so as to increase the chance of finding an adaptive response to unpredictable change (Rammel 2003). Next to diversity, the flexibility offered by a technology is often an important consideration for farmers (Sebillotte 1990). Farmers take into account various sources of uncertainty, and – based on their perceptions and preferences – implement diverse strategies to ensure that their farm will endure (Lev and Campbell 1987; Lemery et al. 2008).

Furthermore, farmers were no longer seen as atomistic decision makers, but the role of collective processes was recognized. Earlier approaches conceptualised change based on a ‘technological blueprint’ approach, i.e. a rationalist linear process of information-decision-implementation, where the scientist is the primary expert. The work of e.g. Jiggins and Röling (1994) showed that change and innovation is primarily a people-centred learning process. Thus, there is more emphasis on group
dynamics and on farm management choices as an on-going process that is continuously adjusted as new information arises, as farmers design new experiments, discuss the outcomes and learn from them.

In the early 1990s work within Farming Systems Research thus started, e.g. on the extent to which technologies increase farmers’ flexibility to adapt their production to stochastic shocks and to constantly changing economic environment (Lev and Campbell 1987; Chambers 1991). In the early 2000s, with the increasing awareness of the growing speed of change and the complex interdependences caused by globalisation, scientists realised that it was necessary to understand the (co)evolution between a farming system and its environment. Attention was given to the dynamics of farming systems, among others through studying farmers’ trajectories over long time periods (e.g. Levrouw et al. 2007; Moulin et al. 2008; Dedieu and Ingrand 2010).

Against the multi-dimensional background of socio-economic, political and environmental dynamics, changes and adaptations were recognised as essential elements. It can thus no longer be the aim to ‘modernise’ farms, assuming a protected and certain development trajectory. The uncertainties of future developments must be taken into account. Previous concepts that guided research – such as stability, income maximisation, technical fine-tuning or biological optimisation – are increasingly replaced by such concepts as elasticity and plasticity, robustness and adaptability, resilience and flexibility (Sauvant and Martin 2010). The emphasis of research thus shifted from efficiently achieving a given goal, towards the ability to adapt and to the levers used by farmers to ensure this adaptability (Darnhofer et al. 2010a).

In sum, diverse strands within Farming Systems Research built an understanding of farms and their environment as much more complex and dynamic than previously conceived. Farmers’ goals are not just about output or income maximisation, but also about adaptability and acceptable workloads; their environment rarely stable, but mostly dynamic; changes not only predictable, but often marked by surprises; farmers’ choices not only based on economic and technical rationality, but also on personal preferences and collective learning processes. As a result, both the means and the ends are understood as changing over time: farmers’ goals will evolve, e.g. as a result of their preferences and perceptions; and the means to achieving these goals will also change, not least through new opportunities that arise in the environment (markets, technology, consumer preferences, etc.).

Thus it was recognized that the research approach needed to be more integrative, systemic and comprehensive (Hart and Pinchinat 1982), and that multiple spatial and temporal scales needed to be taken into account (Bourgeois and Krychowski 1981; Lev and Campbell 1987).

**Adaptive management of farms**

Adaptive management was developed in the late 1970s, based on the observation that scientific research conducted separately from the management of natural resources was not producing useful recommendations and predictions for managers.
Fig. 16.3 When the focus of managing a farm is to optimize the production system (e.g. maximising milk production through optimal fodder rations, while minimising cost) the result tends to be a farm that is well adapted to the current context (market demand, price ratios), but not necessarily flexible. A farm that strives for autonomy, e.g. in fodder supply and replacement heifers, and whose production level is adjusted to the agro-ecological context is more likely to be able to buffer shocks (Lee 1999). It was thus developed as a response to the perceived shortcomings of the conventional tools of risk assessment, planning and design, as these were understood as incomplete, inadequate, and inappropriate in situations where surprise becomes increasingly determinant of outcome (Jiggins and Röling 2000). The aim is thus reflexivity regarding the limits of prognostic knowledge and actual control of complex processes of change. Adaptive management has been defined in a number of ways and is usually applied at larger spatial scale (e.g. a watershed); however, the principles can well be translated onto the farm level (Jiggins and Röling 2000).

A key aspect of adaptive management is the acknowledgement of uncertainty about what practice is best. It thus builds on devising experiments to test that uncertainty and collect information about the system, learning from the outcome of such experiments and re-crafting management practices based on the knowledge gained. The outcome of the iterative process of adaptive management is learning about the farm and the farming system, i.e. an ongoing reconsideration of the efficiency of measures taken, the accuracy of the projected consequences of actions, the relationship between actions and indicators, learning about trade-offs. As the objectives of the management are not fixed, adaptive management may also take into account objectives by the farm family. Thus, adaptive management does not just focus on technical, ecological and economic aspects of the farming system. It also includes social relations, understanding that people have different ways of perceiving the world, that values and intentions matter. Working conditions, professional identities, lifestyles and inclusion of family into the farm workforce matter as well (Lemery 2003; Dedieu and Servière 2011). Social learning is thus an integral part of adaptive management in farming systems (Röling and Wagemakers 1998). Indeed, the capacity to learn is essential for farms to be able to adapt (Sundkvist et al. 2005; Milestad et al. 2010).

This approach to management emphasises the capacity to deal with surprise, to learn, and to support flexibility more than traditional farm management (Fig. 16.3). In contrast to strategies aiming at short-term optimisation and economic efficiency,
Rammel and Staudinger (2002) argue that the conditions and circumstances maintaining variability and momentary sub-optimal alternatives are highly relevant for a socio-economic system which aims at sustainable development. Instead of trying to get rid of disturbance, the existence of uncertainty and surprise as well as their unpredictable nature needs to be an accepted part of farm management (Funtowicz and Ravetz 1993; Folke et al. 2003). Surprise and crisis create space for reorganisation, for renewal and novelty and provide opportunities for new ways of organising the farm. Acknowledging the limits of our knowledge and of our understanding of complex adaptive systems, it emphasizes the importance of continuous processes of learning and adjusting.

Lee (1999) argued that the key solution is to increase adaptive capacity by strengthening the ability to adequately respond to change, rather than reacting to the adverse impact of that change. This requires the ongoing development of a portfolio of alternative activities and resource use patterns that can be implemented quickly if needed. Adaptive management is thus concerned with the establishment of a continuous learning process that attunes to new information by reformulating hypotheses and models, and understanding activity implementation as experiments (see also Westley 2002; Lopez-Ridaura et al. 2005).

The basic requirement for this potential is adaptive capacity, meaning the ability to address changing conditions through a process of continuous adaptive learning and the possibility to initiate new development trajectories (Rammel 2003). Indeed, every successful adaptation is only a temporary ‘solution’ to changing selective conditions, which could be altered by the ‘solution’ itself. It is the diversity and repertoire of alternative options and innovative activities, which increase the possibility to leave maladaptive developments and exhibit sustainable change. At the farm level, resilience, diversity and flexibility appear to be key characteristics, which enable adaptive management and enhance the adaptive capacity of farming systems (Darnhofer et al. 2010a).

**Key concepts in the adaptive approach**

**Resilience**

Resilience is the capacity of a system, e.g. a farm, to absorb disturbance and to reorganise while undergoing change so as to essentially retain the same function, structure and feedbacks (Walker et al. 2004). The opposite of resilience is vulnerability. Vulnerability can be described as the susceptibility of harm caused by stresses associated with environmental and social change combined with the absence of the capacity to act (Adger 2006; Chambers 2006; Fabricius et al. 2007). While the initial resilience work focused on the buffering capacity of ecosystems to absorb shocks, the current is concerned with the opportunities that disturbance opens up in terms of recombination, renewal and emergence of new trajectories (Holling 2001; Folke 2006).
Indeed, resilience is linked to adaptations, which aim to reduce vulnerability by responding to, and by shaping change (Smit and Wandel 2006). Whereas resilience may be considered a precondition for adaptive capacity (Folke et al. 2003), adaptive capacity is also the ability of actors in a social-ecological system to manage resilience. Walker et al. (2006) point out that adaptive capacity depends on the available social, human, natural, manufactured and financial capital as well as the system of institutions and governance (see also Daly 1990; Rigby et al. 2000).

The concept of resilient farming systems implies the recognition of dynamic systems, the presence of non-linear changes and the notion that human action and social structures are integral to ecosystems (Milestad and Darnhofer 2003; Darnhofer et al. 2010b). A farming system can therefore be described as a social-ecological system, emphasising social-ecological resilience rather than social or ecological resilience (see Folke et al. 2003). The concept is thus for a farm management that secures the capacity of the farming system to sustain societal development and progress, while at the same time providing essential ecosystem services.

When specifying what resilience might mean for a certain farm, it is helpful to both consider what Folke et al. (2010) named specified resilience as well as general resilience. Specified resilience means the resilience ‘of what, to what’; resilience of some particular part of a system, related to a particular control variable, to one or more identified kinds of shocks. General resilience is the resilience of any and all parts of a system to all kinds of shocks, including novel ones. Thus, it is imperative not only to focus on the parts of the system that are well understood and that can be monitored, there also has to be resources left to leave space for general resilience to develop. These resources can be difficult for farmers to find, since they face trade-offs between strategies that ensure the adaptive capacity of their farm over the long term and those ensuring profitability over the short term (Darnhofer 2010).

**Diversity**

Evolutionary systems do not relate to stability in a static sense as they are faced with moving equilibria and the dynamics of co-evolutionary interactions, which cannot be foreseen ex-ante. Given this permanent process of unpredictable change, any kind of optimising must be understood as local and myopic (Rammel and van den Bergh 2003; Walker and Salt 2006). If optimality exists, it will be temporary, because through evolution, selection and innovation, and environmental change, it is easily transformed into a maladaptive trait. Under such conditions, diversity is a key element of long-term stability and even survival. Managing complex systems and building farm resilience implies spreading risks and creating buffers, i.e. not putting ‘all the eggs in one basket’. As Rammel and van den Bergh (2003) argue, long-term sustainability calls for an evolutionary potential. This potential builds on a diversity of co-existing alternatives. Indeed, since every successful adaptation is only a temporary ‘solution’ to changing selective conditions, maintained diversity represents a repertoire of alternative options. This repertoire increases the possibility
that altered conditions can be successfully met through pre-adaptations and further evolution, which Rammel and van den Bergh (2003:127) refer to as “evolutionary potential”. This diversity has been shown to play an important role in the reorganisation and renewal process following disturbance (Folke et al. 2003).

Both functional diversity and response diversity increase the variety of possible alternative reorganisation pathways following disturbance and disruption (see Elmqvist et al. 2003; Walker et al. 2006). Functional diversity refers to the number of different functional groups: the more types of actors there are, the more functions can be performed. Response diversity (or ‘functional redundancy’) refers to the types of response to disturbance within a functional group. Since efforts to increase the short-term efficiency of farm production tend to focus on removing apparent redundancies, this also reduces the options of a farm to adapt to change and thus farm resilience (Walker et al. 2006). Recognising that diversity is more than an insurance against uncertainty and surprise, it implies that diversity should be actively nurtured to allow for reorganisation and renewal. Livestock Farming Systems Research also explore functional diversity (animal productive trajectories, forage resources) as a basis for the system regulations (Courmut and Dedieu 2004; Andrieu et al. 2008; Martin et al. 2009; Tichit et al. 2011).

More generally, diversity also buffers and protects the system from management failures that are based upon incomplete understanding of the system dynamics under biological and climatic stresses. Mistakes and feedback systems allow farmers to learn and therefore actively adapt their farm management (Milestad et al. 2010). Learning benefits from combining different types of knowledge, e.g. experiential and experimental knowledge (see also Scoones and Thompson 1994), from expanding from knowledge of structure to knowledge of function, from understanding about the dynamics of complex systems, from understanding the complementarities of different knowledge systems and the significance of people’s knowledge.

One way to approach diversity is at the whole-farm level. Here activities of the members of the farm household can be diversified, which includes both on- and off-farm activities. But this strategy is not yet well understood. As Penrose (1997:35) points out: “of all of the outstanding characteristics of business firms perhaps the most inadequately treated in economic analysis is the diversification of their activities, sometimes called ‘spreading of production’ or ‘integration’, which seems to accompany their growth”. The role of diversification in the process of growth reinforces the view that a farm is essentially a pool of resources that can be used and combined in different ways, depending on the farmer’s preferences and priorities.

**Flexibility**

In management sciences, the concept of flexibility is seen as a means to face uncertainty and thus also defined in relation to adaptive capacity (Reix 1979). Tarondeau (1999) distinguished operational flexibility from strategic flexibility. Operational
flexibility refers to the short-term regulation properties of a system facing hazards. Strategic flexibility refers to long-term choices and to the capacity to change the structure, the resources, and the competences of the enterprise in anticipation of or reacting to changes in the environment. Tarondeau (1999) identified three sources of flexibility within production systems: the products (diversity, exchangeability), the processes (the organisation of the technical system authorizes several processes) and the inputs specification (when different sources of inputs can be combined or substituted instead of depending of one specific input). In this way, flexibility can be used to analyse the adaptive capacity of socio-technical systems (see also Astigaraga and Ingrand 2011). Flexibility is not only internal to the farming system. Authors also consider an external flexibility (Tarondeau 1999) in relation with social networks, market and consumers relations and with a wide range of non-productive activities (e.g. gifts, intertwining events) that strengthen the links within communities (Ancey and Ickowicz 2009). In some countries, non-productive activities are major levers for reducing family vulnerability to crisis by increasing the buffer capacity of the system. Diversification of buyers and contracts also offer opportunities for adaptive management (Chia 2008).

In a sense, in a flexible situation, the final products and services produced by a farm at any given time merely represent one of several ways in which it could be using its resources. This means that for a farm, what matters is the way in which the resources are used, not the resources themselves. The ‘productive opportunities’ of the farm, even with an unchanged set of resources, are not objectively given, but depend on the conceptions of individual actors (see Rathe and Witt 2001:339). What a farm can produce thus hinges critically on the conceptions and capabilities of the members of the farm family. This approach stresses the role of creativity and imagination of the farmer, the farm being much more than a device to exploit economies of scale and scope as a response to technological progress. We need to recognise the crucial role of the farmer for the development of a farm over time. Therefore the conceptions of the farm family about what business to conduct and how to conduct it must be better understood.

Flexibility of a farming system is also enhanced if the selected technological paths enable reversibility. For instance, in fruit production, orchard planting systems based on better understanding of tree biology as well as interactions among research and extension workers provide a more regular yield, favour fruit quality and demand fewer pesticides (Lauri et al. 2008). They also enable transitions towards alternative orchard patterns. This means that farms are interpreted as learning systems whose survival and growth strongly depends on the successful generation and absorption of new knowledge. The impact of farms’ cumulative searching and learning, the accumulation of knowledge and capabilities on organisational transformation and systematic developmental change, needs to be considered. In other words: developmental change at the level of the individual farm deserves to be explored in its own right.
Research to understand and strengthen the adaptive capacity of farms

Several research themes can be derived from the theoretical considerations related to adaptability: exploring flexibility and the ‘room for manoeuvre’; understanding farmer perception of uncertainty; understanding the long-term trajectories of farms; and the role of creativity.

Exploring the flexibility properties and the ‘room for manoeuvre’ that a farming system offers, can be a key issue. As an example of a research approach assessing adaptability in livestock feeding systems, Roggero et al. (1996) identified four components of flexible strategies: (i) organisation and planning of local resources, taking into account their renewal in space and time, while giving priority to grazing, (ii) use of existing diversity and diversification of the resources, (iii) integration and multiple use of resources, having various utilisation patterns, (iv) adaptation and development of security devices, including anticipation of climatic hazards (also see Bellon et al. 2004). Dedieu (2009) proposed to qualify flexibility in livestock farms as a combination of (i) static levers (e.g. overcapacities), (ii) reactive (based on the regulation properties of the system, mainly based on links between components of processes and on diversity (of forage resources,) of lambing/calving and replacement periods, of product types) and (iii) proactive components (adaptive management with anticipation, redundancies, opening to various production processes and final products).

Understanding how farmers perceive and understand uncertainty, how they debate the need to adapt within their social networks, has also emerged as a major research topic. As an example of such an approach at the farm level, Lemery et al. (2005) have described two strategies implemented by suckler cattle farms in Burgundy, which are tightly linked to the farm trajectory:

- ‘To do with’: sub-optimal combinations of activities were deliberately kept, to be able to easily cope with changes in the context of production. This strategy was associated with two farm development trajectories: (i) farming extensively at all times, or (ii) engaging in pluriactivity (either on- or off-farm) enabling the farmer to adjust the extent and the objective of each activity depending on the context.
- ‘To act upon’: a long-term target was defined for the farm and short-term pressures for change were met in a non-sensitive and non-reactive approach. This strategy was associated with intensive farming systems that were committed to collective action (cooperatives) so as to protect them from hazards. Another farm trajectory was scale increase, where enlargement phases guided the rhythms of change.

Understanding the way farmers construct their long-term development path, their trajectory in order to stay in business, is another research theme related to adaptability and co-evolution. Some researchers have developed an understanding of farmers’ ‘long term action logics’ (Cialdella and Dedieu 2010). The goal is to identify the combination of principles through which farmers adapt their farming systems in relation to their context, and the way they consider how to cope with a future full of uncertainties. Differences between what farmers consider important to last have been found in several registers: (i) to specialise (to deepen competences, to benefit
from scale effects) vs. to diversify (not putting all the eggs in one basket); (ii) enlargement (scale effect) vs. staying small (being able to master the system); (iii) optimisation vs. flexibility (i.e. being technically efficient as the critical guideline or developing an overall approach of optimisation including economic, fiscal and work-load issues vs. keeping room to manoeuvre in order to face uncertainty, either financial, productive and work); (iv) being innovative and taking risks as a necessity vs. seeking for experience and improved local knowledge; (v) investments and debts as necessary to last vs. a ‘no debt’ behaviour. Results from comparative studies suggest that the long term action logics (or adaptive patterns) appears to be the same in European Union countries and countries in South America, i.e. contexts with far less security networks either social or sectorial (such as CAP subsidies) (Dedieu 2009).

These patterns emphasize that there are a number of trade-offs, which farmers must navigate, for example the trade-offs between efficiency and adaptability (Giampietro 1997). Whereas efficiency takes advantage of existing favourable conditions, adaptability sustains the long-term survival by maintaining high compatibility in the face of a changing environment. There is thus a need to shift the weight from economic efficiency and short-term optimality to conditions fostering adaptive flexibility and long-term sustainability (Chia and Marchenay 2008). To manage a farm, both short-term optimisation and long-term goals need to be pursued. It is not a question of either or, but rather a question of finding the right mix. What the ‘right’ mix is will be dependent on the family members’ projects, preferences, as well as the perceived opportunities and drawbacks. The challenge for the farmer is thus to find the right balance, i.e. a balance between ensuring adequate output levels (income levels), ensuring the adaptability of the farm, while also taking care not to overload the family members with work.

Stressing the role of creativity and imagination of the various members of the farm family to cope with adaptation is yet another research theme found within farming system research. This research points out that the farm is much more than a device to exploit economies of scale and scope as a response to technological progress. Rather, what a farm can produce with given resources thus hinges critically on the conceptions and capabilities of the farmer and a multifunctional use of farm resources (Milestad et al. 2011). This research has identified a need to recognise the role of the farmer for the development of a farm over time. Furthermore, there is research which identifies innovation, transition and redesign processes mastered by the farmer as a crucial area (Nicourt and Cabaret 2010; Pahl-Wostl 2009; Lamine and Bellon 2009). Connected to this is research that focuses on farmers’ experiments and knowledge production on their farms. Experimentation can be considered a strategy to deal with change and to be proactive in relation to change (Kummer et al. 2008, 2010).

**Farm work organisation and liveability research**

Considering farming systems as adaptive, this means that the farmer can be considered an adaptive manager – prepared for change and to adjust the use of farm
resources accordingly. However, the farmer is also a work organiser and a person who seeks meaning in work and in life. Work organisation is linked to the strategies the farmer pursues in respect to adaptation and farm development (enlargement, diversification, technical management, etc.). This, in turn has consequences on workload; work distribution throughout the year; everyday work distribution (e.g. taking care of animals), marketing, weekly work, as well as work that can be dealt with when time is available. At the same time, changes in workforce availability and knowledge may have a strong impact on the production process. Personal issues such as how much free time the farmer wants, what motivates him/her to be a farmer, the relation to other farmers and members of the family are also important in order to understand the capacity of a farmer to be adaptive and organise work accordingly (Crawford 2006). In these interactions between adaptive systems and the multiple dimensions of work it is the people involved who are central for understanding the outcomes. This is especially so in work intensive production systems such as dairy (Crawford et al. 2010). In addition, work constraints are often reported to put a brake on innovations in peasant societies in the South (Mak 2001).

Work is a core theme in social sciences: literature is abundant in disciplines such as sociology, psychology, ergonomics, management and economics (Fig. 16.4). Technical sciences have also attempted to develop frameworks that model the interactions between management (the prescription of tasks) and workforce (Papy et al. 1988). Farming system research focused on livestock farming has had a more interdisciplinary approach: researchers have tried to connect farmers’ practices to work organisation (who is doing what, where and when), ergonomics (Madelrieux et al. 2009), time efficiency (economics), flexibility indicators (management) (Hostiou and Dedieu 2012)
and motivation for work (psychology – sociology) (Porcher 2002; Fiorelli et al. 2010). In France, a research, education and extension community has emerged within this theme particularly focusing on livestock farming. The aim of this research, education and extension is to propose significant tools and knowledge to accompany changes in farms, improve the livelihood from the farming system (Kling-Eveillard et al. 2010; Dedieu and Servière 2011) and approach future farmers who are generally reluctant to work in agriculture.

Research on farming styles (Commandeur 2006) also shows the different strategies of farmers in respect to work organisation and adaptive capacity. Thus, if the farmer can be described as an “entrepreneur” or a “craftsman” it will have implications for adaptive management patterns on the farm.

Liveability is a characteristic of a farming system which includes farmers’ expectations with respect to farming and relations with family and other activities (Macombe et al. 2010). Research on liveability has especially focused on the situation for livestock farmers in relation to the workload that these farmers experience (e.g. Cournut and Chauvat 2010). For farmers, liveability often means acceptable working conditions in terms of labour and hours as well as the possibility of having free time and holidays, but also self-esteem (Fiorelli et al. 2010). However, since farmers think differently about how much work is acceptable, about what motivates them, liveability also means improving work organisation in general (Fiorelli et al. 2010) and this depends on the production system on the farm. For example, Hellec and Blouet (2010) found that organic dairy farmers were more satisfied professionally than their conventional colleagues. Liveability research can help to identify challenges with promoted changes in farming systems. Diversification and transition to short supply chains is often promoted as a means to strengthen income stability and resilience of farmers (e.g. Milestad et al. 2010). However, Petit and colleagues (2010) showed that short supply chains increase the workload and the complexity of decision making at the farm level. This impacted liveability negatively from the farmers’ point of view.

The way work is organised on farms, and the way farmers try to achieve liveable farming and living is closely related to the adaptability of farms. As changes occur that farmers have to deal with, these have implications for work management, work force composition and farm activities. This in turn impacts the room for manoeuvre that the farmer has to further adapt to new changes.

Conclusion and outlook

Modern, conventional farm management recommendations often seem to create simplified, specialised farms with an impoverished diversity and a limited capacity to adapt to environmental and societal change. By trying to remove or ignore surprises, they also remove incentives for responding to environmental feedback. They impede the building of a social-ecological knowledge system and thereby hamper learning. However, change is ubiquitous and its pace is accelerating. Learning to
live with change and uncertainty requires a fundamental shift in thinking, from assuming that the world is in a steady state and can be preserved as it is by controlling change, to recognising that change is the rule rather than the exception. Farms thus need to be managed so as to live with and shape change, and need to be managed for resilience, diversity and flexibility.

Including this adaptive, dynamic perspective within the farming systems approach seems to be a promising way forward. It underlines the importance of empowering farmers and their families, to take a participatory approach, to include a wide range of disciplines and to focus on the interactions between the components of the system.

To better understand these dynamic aspects that characterise both society and ecology, requires a shift of research interests towards identifying management strategies that allow farms to recognise change, and to identify the opportunities that are offered by changes. Researchers need to understand the required level of diversity that balances the inevitable trade-offs between short-term survival and long-term resilience, i.e. between efficiency and adaptability. Assessing the diverse sources of flexibility in the various farming systems and farm types can contribute to better understand the strategies farmers implement to cope with surprises and to shape transition processes.

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Chapter 17

Observing farming systems: Insights from social systems theory

Egon Noe and Hugo F. Alrøe

Abstract  In Denmark, agriculture is becoming increasingly specialised, and more and more actors are becoming involved in farm decision making. These trends are more or less pronounced in other European countries as well. We therefore find that to understand modern farming systems, we have to shift the focus of analysis from individual farmers to communication and social relations. This is where Luhmann’s social systems theory can offer new insights. Firstly, it can help observe and understand the operational closure and system logic of a farming system and how this closure is produced and reproduced. Secondly, it provides a theory of functional differentiation and structural couplings that opens up for a new approach to look at sustainability by way of decoupling, recoupling and new forms of coupling.

Introduction

In this chapter we will introduce our usage of Luhmann’s systems theory and actor network theory (ANT) to observe farming systems, especially to see how farms are organized and how decisions are made, but also to see and understand some of the problems of sustainable development of food chains. Both theories are analytical and can be used to observe and understand different aspects and development pathways of farming systems, but they are not normative theories describing better ways to decide or organise. Luhmann’s systems theory offers, with some modifications, the opportunity to see farms as autopoietic systems and to observe functional differentiation (specialisation) and structural couplings (coordination) between systems in food networks. ANT provides us with a perspective to observe and understand the very heterogeneous corpus of a farm consisting of natural, technical, economical and social elements and interactions.
Normally these two theoretical bodies are seen as very much in opposition to each other. However, what binds them together is their foundation in semiotics and communications, where relations are not causal but interpretations of causes. Luhmann’s systems theory sees systems as communicative systems where utterances get their meaning through their relations to other utterances, and in ANT elements become agents through their network relations. Readers of rural sociology and human geography journals will be familiar with the widespread use of ANT, especially in relation to studies of agri-food networks, whereas Luhmann’s systems theory is only rarely referred to. This chapter is meant as an appetiser to these theories and their application to farming systems, and as a source of inspiration on where to proceed if you would like to learn more. In accordance with this, the chapter begins with an introduction to our background for choosing Luhmann’s systems theory and ANT and combining them. This is followed by a brief introduction to how we have operationalised these two theories to observe farming systems, with examples of insights we have obtained by applying this theoretical framework to see and understand farms as systems and the transformation processes going on within farming systems. The last section is devoted to a more comprehensive analysis of the increasing problems of developing sustainable food networks, drawing especially on Luhmann’s notions of functional differentiation and structural couplings.

Why Luhmann’s systems theory and ANT?

Through our involvement in a research group on ‘farming systems studies’ during the last 20 years, we have been researching sustainable development of farming systems in Denmark based mainly on longitudinal case studies involving private farms.

In relation to these studies we have seen a development that has increasingly challenged our common theoretical and conceptual understanding of a farm as a coherent unit of organisation, with a farmer and his family living on a farm in the middle of his farmland, making decisions on how to produce food and maintain the production capacity.

In Denmark farm sizes have increased dramatically. From 1990 to 2010 the number of fulltime farm enterprises has decreased from about 34,000 to about 12,000 (Landbrug og Fødevarer 2011). There are a range of characteristics in this development of agricultural production and food systems which pose increasing demands on the abilities of farmers and other actors to handle knowledge and complexity, and which are also highly challenging to our theoretical understanding of farming systems (Noe and Alrøe 2003).

We have seen that the farms have become still more specialised, so that almost all Danish farms now are specialised in one branch (such as pig production), and often only in parts of a branch (such as piglet production), compared to the situation in the 1960s, where almost all farms were mixed farms.

In connection with this specialisation, developments in knowledge and technology have lead to an increase in the number of different technical solutions. The
revolution in computer technologies has especially given options for individually
tailored solutions for automation and rationalisation of work tasks and routines on
farms. An example of this is the different milking systems from automatic milking
systems (AMS) to milking carousels, which have formed the basis for very different
dairy farming systems (Noe and Kristensen 2003).

At the same time, we have witnessed that more and more people and organisations
from outside the farm have become involved in the operations within the farm as
well as in decision making, knowledge exchange and learning processes. Examples of
this are the veterinarian who is responsible for the reproduction control, the
inseminator who is responsible for the breeding strategy, and contractors who
are responsible for the arable production. Moreover, when we look at what we
normally consider as strategic decision making, more and more farms have estab-
lished ‘farm boards’ involving for example the bank advisor, other advisors, and
managers from other businesses.

We have also witnessed that the focus of farm management has gradually shifted
from maintaining coherence between internal processes on the farm and reproduction,
to managing relations with external actors and systems, inputs and sales, specialised
advisors, financial partners and handling active capital.

These developments have led to a tremendous increase in productivity and
efficiency of agricultural production, especially in terms milk yield per cow, number
of piglets per cow, and number of hectares managed per labour units (Landbrug og
Fødevarer 2011). At the same time we have witnessed the development of Danish
agriculture which is moving away from multifunctional farming. Former semi-
natural areas such as permanent grassland are either abandoned for agricultural pro-
duction or transformed into intensive agricultural production. The landscapes are
gradually reshaped to fit into the production systems, forming very large fields by
removing all the hedges, roads and biotopes that disturb the operations. Due to spe-
cialisation the number of crops included in crop rotation has been reduced, which
among other things has resulted in an increased use of pesticides.

These development trends are not unique to Denmark. They are common to more
or less all the western European countries, although there are different development
pathways. In the 1980s there was a huge debate on how to define family farming in
opposition to the rising numbers of industrialized farming systems, and a discussion
of the values related to these different systems (see e.g. Gasson and Errington 1993;
Djurfeldt 1996). In terms of the processes of industrialisation and structural devel-
opment, Denmark can be seen as an extreme case, compared to most other European
countries, but also as a possible future scenario for them.

In our farming systems studies we have realised that we increasingly have to
include descriptions of the involvement of other people, contractors and capital, and
not only what we used to include, like buildings, machinery, land husbandry and
labour, in order to describe and understand the organisation and flow of operations
of a farming system. The boundary of what belongs to the farming system and
what belongs to its environment becomes increasingly difficult to draw or define,
especially in a biological and physical sense.

This development raises questions like: How can we understand farming systems
in more and more network-like food production systems? What is a meaningful way
to draw the boundaries between system and environment in order to be able to hold, observe and understand this development? How can the individual system or farm enterprise handle this seemingly increasing chaos, and what are the necessities of reducing complexity? On a larger scale, what does the specialisation and differentiation of agriculture and food production mean for the challenge of developing a multifunctional and sustainable agriculture that not only considers efficient food production, but also the environment, climate, landscape and rural development?

In our search for ways to describe and understand farm management and farm development, we have found the combination of Luhmann’s systems theory and actor network theories fruitful. In the following we introduce some of our work in this area.

**Farming systems organisation and farm management**

In this section we will look at the challenges to farming systems organisation and farm management given the increasingly complex network organisation of food production. As described, we have observed a growing involvement of external actors in farm operations and decision making, such as advisors, veterinarians, financial partners, contractors, input suppliers, and operators and maintainers of new technology and equipment. This growing dependency on external actors has not only challenged the management of the farming system to cope with this increasing complexity, but also our understanding of a farming enterprise as a system organised through internal relations between objects and subjects within the farm. A key theoretical question is how the internal order, the organisation that keeps the system from breaking down, is sustained and developed in farming systems that have to cope with a more and more complex surrounding world.

**Mapping the relational structures of farming systems**

The first step in addressing the question of organization is to look at the relations that make up the network of a farming system. In addressing this question, we find it useful to use the language of **Actor Network Theory** (ANT). ANT focuses on the heterogeneous relations between the entities of the social, biological, and technical domains of the world (Latour 1997). Its strength lies in the general and open mapping of the relational structures of networks, and this approach is well suited to address the heterogeneity of agri-food systems.

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1 We use the notion ‘farming system’ and not farm, for two reasons. The first is that the notion of a farm is widely associated with a well-defined physical unity of farmland, buildings, animals, machinery, family and labours, but in reality the organisation of agricultural production is much more complex. The second reason is that new forms of arrangements and organisations of agricultural production are emerging, involving new sources of capital and new forms of cooperation and coordination, which is not covered very well by the notion of a farm.
ANT strives to take a comprehensive semiotic view on human interaction and organisation (for a detailed discussion of ANT and semiotics, see Noe and Alrøe 2006). As Law puts it:

I simply want to note that actor-network theory may be understood as a *semiotics of materiality*. It takes the semiotic insight, that of the relationality of entities, the notion that they are produced in relations, and applies this ruthlessly to all materials – and not simply to those that are linguistic. (Law 1999:4)

The perspective we get from understanding farm enterprises from an ANT approach is that the entities enrolled get their forms and performances through their relations (Law 1999:4). This means that the way the individual actor or element enters into the dynamics of farm processes and operations is not determined by the objects, but by the agency it obtains through the interactions. To illustrate this, there is a *surplus of possibilities* for how a cow can be enrolled in a farming system (Fig. 17.1). A particular cow could eat grass from the field on one farm and on another farm stay in the stable and eat concentrate. Theoretically, the same cow may produce 12,000 kg milk in one system and 7,000 kg milk in another. The same kind of difference can be explored for the other entities that are enrolled, such as wheat varieties, computers, etc.
In the language of semiotics and ANT there will, as a continuous process, be a ‘negotiation’ between the object and the representation. Let us again use a cow as an example to illustrate this relationship. The representation of a cow in a particular farming system could be that it is an actant that can produce 14,000 kg milk per year. The cow, as an object, will ‘negotiate’ with this representation either by producing the amount under the present circumstances or by striking back, e.g. by not fulfilling the expectation or by getting serious health problems. On the other hand, the negotiation process also affects the object, and thereby it can add to the range of possibilities of the object through for instance selection of genetic breeds that code for high milk production.

This means that a farming system is not defined by what elements and actors are parts of it, but by what role they play, or in ANT language, by how and in what relations they enter as actants in the network.

In a farming system seen from an actor network perspective, there are many objects that are translated and enrolled as actants into the Actor Network of a farming system, e.g. dairy cows, various kinds of machines, fields, sunshine, rain, computers, various kinds of plants, labour, family labour, experience, skills, knowledge, values and goals (Fig. 17.2). The kinds of objects that are enrolled or not enrolled as

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**Fig. 17.2** A farm seen as an Actor Network, that is, as a complex network of relations between the elements enrolled as actants in the network of the farming system. This encompasses both elements that we commonly regard as belonging to the farm but also elements that are organised by other actor networks like a harvesting machine owned by a machine pool. The lines illustrate these interactions and are just examples, and in reality the actor networks of farming systems are much more complex than this. As an empirical approach, the actor network can be explored by taking some of the key actants on the farm as the point of departure and exploring the way interactions are formed with other actants (Illustration from Noe and Alrøe 2006, reprinted with permission from Imprint Academic).
actants into the network, and how they are enrolled, depends on the characteristics of the enterprise, e.g. whether the commercial consultants or the consultants of the farmers’ unions are enrolled and to what kind of performances they are enrolled. Empirically the actor network is far too complex to include all actors and relations, but in our experience a good analytical strategy is to start with the key actants of the system, for example the cow if it is a dairy farm: What kind of milking systems are enrolled (AMS, carousels or other systems) and what are the interactions between milking system and cows, who is involved in milking, and what skills are involved. What kind of fodder is offered to the cows, what foddering systems are in place? What is the interaction between the cow’s fodder system, fodder quality, milking system and labour? Often just by looking at the interactions between these four elements of a dairy farm, one is able to detect the major differences between how dairy farms are organised, and also whether the strategy of the farming system is coherent.

Given the many possibilities linked to each object, one may easily realize how important it is for the coherence of the production strategy and the economical results of the farming processes that the interactions in the actor-network are negotiated in accordance with the strategy of the farming system.

The self-organisation of a farm through selection of meaning

Luhmann’s theory of social systems is based on a theory of biological organisation developed by Maturana and Varela (1980, 1987). The central idea of Maturana and Varela is that biological organisms are open for material flow, but organizationally closed and self-referential, that is, they are autopoietic. It is the organism itself that constructs its own components and reproduces its own organisation. That the autopoietic system is self-referential means that every input for organisation is produced by the system itself. A good example to illustrate what is meant by self-reference is pain. It is the sensory cells that produces the nerve impulses that makes us feel pain if we hit a needle, and not the needle itself. Without the sensory cells and our nerve system there will be no way the needle could cause our reaction.

Luhmann has adopted this foundational systems theoretical idea about autopoiesis and closure to social systems as communicative systems. Luhmann defines a system as the difference between the system and its environment. The communication itself determines what belongs to the communication system and what belongs to its environment.

Autopoietic systems are systems that are defined as unities as networks of production of components that recursively, through their interactions, generate and realize the network that produces them and constitute, in the space in which they exist, the boundaries of the network as components that participate in the realization of the network. (Luhmann 1990:3)

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2We are aware that many authors, not least the founders of autopoiesis theory Maturana and Varela, have augured against the use of the notion of autopoiesis on social systems. For a more comprehensive discussion on that see Noe and Alrøe (2003, 2006).
Luhmann distinguishes between three kinds of autopoietic systems: biological systems operating in life, psychic systems operating in thoughts, and social systems operating in communication. Both psychic and social systems operate in meaning. None of these system definitions fits readily to heterogeneous social systems such as a farming system. From an ANT perspective we have the insight that the negotiation process of a farm is not only communicative or cognitive; that it is continuously taking place in all interactions between actants enrolled in the farming system.

But still Luhmann’s theory of autopoietic systems provides some fruitful notions for the study of farming systems as self-organizing systems. To apply Luhmann’s ideas of social systems and organisational closure from autopoietic systems theory on farming systems, such as a farm enterprise that consists of a complex network of social, technical and biological relations, it is necessary to develop an understanding of system closure that goes beyond communicative closure and self-reference.

In Luhmann’s terminology, meaning is linked to the fact of complexity that every operation enforces a selection. Meaning is a representation of complexity. Meaning is not an image or a model of complexity used by a conscious or a social system, but simply a new and powerful form of coping with complexity under the unavoidable condition of enforced selectivity. (Luhmann 1990:84)

The phenomenon of meaning appears as a surplus of references to other possibilities of experience and actions. … Reference actualizes itself as the standpoint of reality. It refers however, not only to what is real (or presumably real), but also to what is possible (conditionally real) and what is negative (unreal, impossible). The totality of references presented by a meaningfully intended object offers more to hand than can in fact be actualized in any moment. Thus the form of meaning through its referential structure, forces the next step, to selection. This inevitability of selection enters into consciousness of meaning, and for social systems, into communication about what is meaningful. (Luhmann 1995:60)

Heterogeneous systems such as farms may be organized in numerous ways according to different goals and purposes, e.g. organic or conventional production. The farm as a heterogeneous social system must select a meaning in the surplus of possibilities offered by each object that is mobilised into the system/network, to be operational at all. But the network or system needs a kind of meaningfulness to make a situation of coherence possible and likely. According to Luhmann the production or reproduction of such system meaningfulness must be an internal process of the social system, in this case the farm. The encompassing world offers a surplus of meaningfulness, and the system has to select and develop its own to be operational and settle on a coherent strategy.

The farm as a heterogeneous social system is not only forced to select in the contingency of the objects that can be mobilised into the farming processes like pigs or cows, but also in the contingency of the potentiality related to each object that is enrolled; e.g. a computer can be enrolled as device for the yearly accounting or as part of a daily steering system. Any decision making system faced with such a degree of contingency needs to reduce complexity, both internally in terms of which elements are enrolled, and with regard to its environment in terms of what is important to observe and what is not. Otherwise it will break down immediately due to the overload of possibilities. The formation of a farming system needs a first choice to be made: an operational closure in terms of a selection of possibilities within the
autopoietic system and a closure towards the possibilities left out. In other words we use the notion of operational closure for farming systems as description of the distinction between what is possible and what is not possible to consider within the system. Like a cell creates its own operational closure in terms of its cell membrane, open for material diffusion but closed in terms of its own operation of production and reproduction, a farm needs to create itself through the selection of possibilities open for internal operation (Fig. 17.3).

The self-organization of social systems as autopoiesis is then a process of reducing complexity by selection of meaning. The selection of meaning must be a system-internal and self-referential operation by which the system draws its own operational boundaries.

**System rationality or the inner logic of the system**

Another characteristic of an autopoietic system is that it has its own internal system rationality or logical schema at its disposal. Autopoietic systems are operationally closed systems. This means that the system must produce its own input for operation.
For instance the needle does not produce the feelings of pain while the person who feels the pain does. The nerve cells are only transmitting impulses, and it is in the mind that this disturbance is translated into pain. So, it is the internal schema of the system and not the specific quality of the perturbation that defines how a system reacts to a certain perturbation. The ability to be irritated by the needle (to feel pain) is a quality of the system and not of the needle.

The environment is a world horizon that corresponds to the system’s internal horizon. Therefore, a system’s rationality cannot be clarified by referring to a superordinate, encompassing system. (Luhmann 1995:474)

Translated into the language of causality, this idea decrees that a system must control its effects on the environment by checking its repercussions upon itself if it wants to behave rationally. A system that controls its environment in the end controls itself. (Luhmann 1995:475)

The notion of self-reference also leads to a general understanding of observation, namely, that it is the internal complexity of the system that is limiting the capability of the system to observe itself and the capability to observe the encompassing world. This is in line with the biosemiotic understanding of each biological species having its own subjective or phenomenal world, or Umwelt, in the tradition of Jakob von Uexküll (1982).

As illustrated by the example of the needle above in autopoiesis theory, influences from the environment can only be irritations, and it is an ability of the system to become irritated it is the system that determines its reaction to them. This is of course not always as reflex reaction; if I’m hit by a needle I will presumable react before knowing it, but if the doctor is giving me an injection I will feel the pain in another way and react differently. Over time, the system may change its structures of expectation and thereby establish structural couplings with its environment, corresponding to the classical ideas of learning and adaptation. A structural coupling is “the specific form in which the system presupposes specific states or changes in its environment and relies on them” (Luhmann 1991:1432). In this way structural couplings reduce and facilitate influences from the environment.

According to Noe and Alrøe (2003), the ontological understanding of a farming system as a self-referential autopoietic system expands the possibilities for observing and understanding the complexity of farms. For example to observe the rationality and values around which a farming system is organized; explore what kind of internal and external observations are involved in the management; and observe whom and what is involved in the management processes. All these aspects are adding to the exploration of farm management based on the inner system logic (Noe 1999).

**Insights in types and styles of farming**

Experienced extension practitioners will know that what could be a good advice for one farm could be a disaster for another. Our personal experiences from working with extension practitioners are that they often explain these differences as
Insights from social systems theory

good and bad farmers, depending on their own view on farming. But systems theory leads us to see a deeper explanation. Every operation and object is woven into the network of semiotic relations of the farm; and farm management is a continuous process of negotiations of coherence in all the involved network relations. This explains why there is not just one optimal strategy for production that all farming systems should strive for. Every farming system will have to make some initial choices to become an organisation (to obtain operational closure). This means on the one hand that it can start to operate and on the other hand that a lot of potential possibilities are omitted.

The negotiation of internal coherence (operational closure) is not only a matter of negotiation (in the semiotic sense described earlier) between the actors that are closely linked into the farming process, but also with the machinery, advisory systems, suppliers, etc. This negotiation process therefore needs to be a co-evolutionary process between various organisations. The ‘styles of farming’ can be seen as an approach to study the development of farm management strategies into clusters of different types or ‘styles’ (van der Ploeg 1994). A social systems approach can add to this the understanding that the clustering around certain internal production logics can be seen as a necessary reduction of possibilities in the structural couplings between the different organisations and actors involved. An insight we have used to study, among other things, farmers’ use of decision support tools (Langvad and Noe 2006).

Finally, this autopoietic understanding of farms implies that the coherence of a farm cannot be explored by studying only the elements that are enrolled into the system. The coherence needs to be studied from the perspective of the system or network, that is, it is the strategy of the farming system to achieve coherence and closure that needs to be studied.

Insights in farmers’ reactions to legislation and support

People involved in regulation of agriculture will know that farms do not always react in the expected way to new legislation and incentive structures. This could be seen as a cognitive problem: the farmers do not have the right knowledge, or they have the wrong attitudes. Knowledge and attitudes do of course play a role, but Luhmann’s social systems theory helps us to understand the strength in the resistance towards reacting in a specific way.

Applying the autopoietic understanding of farming systems, the system has to produce its own input to react to changes in the environment. As it is described above, it is the internal logical schema of the system and not the specific quality of the perturbation that defines how the system reacts to a certain perturbation. For example, if the milk price is going down, the farming system first of all has to be able to recognise that there is a decrease in milk price. Secondly, the recognised difference must be interpreted by the system: Is it due to a decrease in the quality of the delivered milk, or to temporary price fluctuations? Or is it a sign of
a permanent decrease due to decreased demand or harder competition on the world market? How these observations are made by the system will vary from system to system, and needs to be investigated as an empirical question. It could be the bank advisor who raises the problem, it could be the cowman. Finally, the reaction by the system to this situation will again depend on the system itself: some will just carry on, believing that the situation will improve again, others will start working harder, some will change their strategy, and again others will give up dairy farming.

This means the different farming systems (with different farming styles) will be sensitive to different perturbations. If the farming strategy is organised around market opportunities, even small changes in price relations could lead to changes in the internal operations. If the strategy is organised around high yields, even large changes in price relations may not change the internal operations.

**The sustainability challenges of differentiation and specialisation**

*Specialisation* can be seen as a necessary consequence of the increase in complexity. Developments in research, technology and society create an increasing range of possibilities, and at the same time other possibilities are closed. Specialisation leads to a reduction of the environmental complexity that the system needs to deal with; but at the same time this means that the single farming system moves further and further away from the perspective of multifunctional and sustainable agriculture. In this section we will apply the insights of the previous section in exploring the challenge of multifunctional and sustainable agriculture. As a background for this, we will first provide a brief narrative that describes the specialisation and differentiation of Danish agri-food systems. Similar developments have taken place and are taking place in other countries, though within different timeframes and with variations due to the different structures of agricultural production.

**Increasing differentiation and specialization of agri-food systems**

When we look at the development of industrialized agri-food systems, there are at least two major parallel historical developments which are mutually conditional, but which it is analytically appropriate to separate:

- *Vertical differentiation* into more links of the food chain through specialisation of operations into autonomous organisations.
- *Horizontal differentiation* into separate branches of agricultural production.
The *vertical differentiation* can be described as two processes. One process is the genesis of more links in the food chain. Take for instance the production of pig meat, where piglets and fattening of pigs have increasingly become divided into two different farm enterprises, selling and buying piglets at market prices, and the slaughtering and processing of pig meat have been separated into two or more different independent enterprises.

The other process is the increasing separation of links in the food chains. For instance the input suppliers and dairies in Denmark were originally cooperatives organised by the farmers around the needs and problems of processing and selling the products of the farms. But these cooperatives have grown into very large and highly independent companies that focus on optimizing their own business operations, buying and selling raw products at the global marked, and investing in companies in other countries.

While there has been a long historical process of vertical specialization and differentiation within agriculture, the *horizontal differentiation*, in particular at the level of primary production, is of relatively newer date. Until the mid-1960s almost all Danish farm holdings were mixed farming systems with a balanced production between plant, cattle, pig and poultry production. Livestock fodder was produced on the farm, fields were used for grazing, and manure from the livestock production was spread on the fields of the farm. A number of simultaneous developments, including mechanization and the development of agrochemical components, made a horizontal differentiation possible. Within a decade (1965–1975) there was an almost total specialisation and functional differentiation in different production branches, and the mutual bindings or structural couplings between the different productions branches diminished. Simultaneously, the professional and political organisations in the fields of pigs, cattle, poultry, eggs and plant breeding evolved as independent organisations.

If we look again at pig production, there was at first an internal differentiation between plant production and meat production at the farm, and gradually the two operations became more independent of each other and increasingly driven by different optimization rationales. The main purpose of the plant production was now not necessarily to feed the pigs, and the pig production did not necessarily have to adjust to the productivity of the plant production. Many factors have influenced this development of specialisation and functional differentiation (Noe and Alrøe 2012), and this is well described in literature (see e.g. Goodman et al. 1987; Goodman and Watts 1997). Seen from a social systems theoretical perspective, the fundamental driving forces behind this development is the logic of reduction of complexity.

**Reduction of complexity and the challenge of sustainability**

According to Luhmann’s social systems theory, the specialisation and differentiation of agriculture and food production is an unavoidable consequence of the increase of complexity. Here we will analyse why and how this poses challenges to the development of a *multifunctional* and *sustainable agriculture*. 
The driving force behind the organisational specialisation and differentiation is the striving for reduction of complexity. The single organisational system reduces the range of complexity that it can be disturbed by, enabling it to handle the remaining complexity and even increased complexity, within the selected range. Reduction of complexity in the single organisational system, through differentiation and specialisation, thus forms the basis for the ability of the network to handle increased complexity overall. Complexity is only reduced from an internal systems perspective, and marginalisation of complexity may therefore be a better expression.

The two forms of differentiation of organisational systems within agriculture and food described in the previous section are based on different forms of reduction (or marginalisation) of complexity in systems operations:

- reduction in the complexity of consecutive operations (vertical)
- reduction in the complexity of parallel operations (horizontal)

As described above, these two movements in terms of reduction of complexity free the focus of the production systems to optimize internal operations. It frees piglet producers to become more and more efficient in producing piglets, dairy farmers to produce more and more kilos of milk from each cow, the abattoir to reduce costs of slaughtering the individual pigs, etc. This increase in efficiency can be seen very clearly in the increase in productivity that has happened over the last 50 years.

However, with this reduction of the internal complexity, these organisational systems also reduce the complexity of their environment (their Umwelt or phenomenal world in the semiotic sense), that is, the systems reduce the types of differences in the encompassing world that are allowed to disturb them, and there is an increasing degree of de-coupling.

The first form of reduction, which is related to the vertical differentiation into more links in the chain, means that the farm businesses seemingly have to worry less and less about what consumers think, because the relation with the consumers are more left to the processors, and even increasingly to the retailers using private labels. The farming system’s environment is constituted by the processors and who will pay the highest price for its products.

This vertical differentiation therefore makes it possible to de-couple some of the quality dimensions that were previously mediated through the food chain; quality dimensions that may have been associated with long-term sustainability (Noe and Alrøe 2011). When you buy pork meat in the supermarket you have to look carefully to see where it has been produced. Unless you buy special products, there are no links between what you buy and how the pigs are produced, like the housing condition of the piglets, nutrient emissions, use of fossil fuels, changes in soil quality, etc. This type of decoupling can therefore be one of the causes of the sustainability crises because of the lack of a feedback mechanism between producers and consumers linked to the products (Noe and Alrøe 2012).

The second form of reduction, which is related to the horizontal differentiation into parallel production branches, means for example that pig meat production systems no longer have to worry about soil fertility and a sustained production of animal feed. The development within the agrochemical industry means that arable
farming systems no longer (at least in the short term) have to worry about the sufficient supply of manure, crop rotations that match the availability of nutrients in the soil, etc. Recycling of nutrients is often much more difficult and harder to control than the use of inorganic fertilisers. The horizontal differentiation allows a decoupling from processes like recirculation of nutrients and organic material and crop rotations that are to increase soil fertility, processes that are of central importance for the long-term sustainability of agricultural production.

**Insights into addressing sustainability problems through new structural couplings**

The reductions of environmental complexity entailed by processes of horizontal and vertical differentiation reduce the possible disturbances (or irritations) to the system. Thus individual agricultural activity has to cope with fewer disruptions through responses in the internal organisation and management of the system. However, as mentioned above, there will also be an extension of disturbance possibilities and possible couplings within the specialised area of the system. A logical consequence of these differentiation processes is that the agricultural praxis is generally moving away from a position that can handle the plurality of perspectives involved in the semantics of sustainability; and away from a condition where they are sensitive to irritations that are expressions of the various dimensions of sustainability.

An example to illustrate this problem is the decomposition of humus in agricultural soil as a result of monocropping and heavy mechanical treatment of the soil, resulting in a loss of carbon in the form of greenhouse gas emissions that contribute to global warming. The humus content of the soil is crucial for the natural fertility of the soil, but the agrochemical components in terms of fertilizers and micronutrients makes a decoupling from the soil fertility possible, and allows farm enterprises to not be disturbed by changes in the humus content and therefore not to include these concerns in the decisions of internal operations. Only if the greenhouse gas emission is reintroduced as a major disturbance in terms of governmental economic or legislative means, or as a special market quality, can the concerns of the humus contents be reintroduced into the operations of the systems.

Based on a Luhmannian systems theoretical analysis we are led to the conclusion that the sustainability crisis can be seen as a more or less unavoidable product of the processes of specialization, differentiation and decoupling that take place, and that the general societal development moves us away from perspectives that can observe and handle the complexity of a sustainable development of agriculture and food production.

According to Luhmann the complexity reduction in the differentiated systems is symmetrical with the increase of complexity in society (in terms of the functional differentiation of society, see Luhmann 1995:23–28), and these reductions are irreversible. Therefore the sustainability problem cannot be resolved by a
return to a former, more ideal state. A systems theoretical approach to deal with sustainability problems will be to seek to reintroduce the various concerns in terms of re-couplings between the systems in form of new structural couplings (Noe and Alrøe 2012).

One way of doing this is through new structural couplings to general perspectives in society (function systems, in Luhmann’s terms), which farm enterprises produce to reintroduce changes in the surrounding world to their environment, for instance through forms of ethical accounting. A second way is through new structural couplings between organisations, which can handle other dimensions than price and quantity. For instance couplings that are mediated by labels such as the organic label, or new couplings in alternative food networks based on agreements within the network, which provide new options for co-evolution.

The further development of social farming systems theory

The investment in getting into social systems theory is large, but once you are there, we definitely find that it is worth the effort. For more than 15 years we have been applying Luhmann’s social systems theory together with actor network theory. In this chapter, we have argued that the binocular use of these two theories has provided a range of insights into the development of farming systems and how it may be observed and studied. We hope that this short introduction to our work has stimulated the readers’ interest and curiosity to what these theories can contribute to studies of farming systems and sustainability. And we hope that it will inspire some of the readers to take up the challenge and to contribute to the further development of ‘social farming systems theory’.

References


Abstract  Agriculture is considered to be responsible for environmental degradation. At the same time, the demands for food and non-food products are increasing and the contribution of agriculture to a sustainable development of territories is at stake. All these elements require a shift towards new production systems. In line with Farming Systems Research, farmers and other stakeholders cannot be considered as recipients of inventions, but are actors of innovation processes. We present definitions and applications on how the design of innovative farming systems can be organised. Two approaches, i.e. ‘de novo’ and ‘step-by-step’ design, are described. Innovative design must mobilize a collective and distributed intelligence. We present concrete examples of interactive design processes either with heterogeneous stakeholders or with extension and public bodies, as well as the methodologies that support these processes.
Introduction

In Europe, the number of citizens with a link to agriculture has considerably diminished. Yet, the number of people who feel concerned about farming activities and their consequences is increasing. Farming practices leave the farmer’s private sphere to become subjects of public debate, of negotiations, standards and regulations. The press focuses on productivist practices and the technical and genetic innovations which are felt to be associated with them (e.g. pesticides, mineral fertilisers, GMO, animal confinement). The stream of information about food production (traceability, quality labels) continues to increase. Public authorities are increasingly involved in the changes taking place in agriculture, via agricultural, health, environmental and territorial policies. Very clearly, growing pressure is being exerted to provoke radical changes in farming practices; made by a wide diversity of players, frequently joined by the farmers themselves.

We will assess the driving forces of this transformation in farming systems by attempting to anticipate the forms it may take. Then we will sketch in a panorama of the approaches which enable farmers and Research & Development (R&D) bodies associated with agriculture to participate, with other stakeholders, in innovation and design of new production methods.

Why is it indispensable to redesign farming systems?

The last 50 years have seen radical changes in the production methods of European agriculture, and a significant increase in its productivity per hectare, per animal and per worker. This fulfills objectives that have been clearly stated by agricultural policies (e.g. self-sufficiency in food, price reductions, food safety, labour force freed for other economic sectors). The evolution of policies and public debate over the past decade predicts a period when society expectations as regards its agriculture are far less clear. Four major driving forces of the transformation of farming practices are at work (Meynard et al. 2006).

The driving forces behind changes in farming practices

Deterioration of the environment and the recognised responsibility of agriculture

The Millennium Ecosystem Assessment (2005) concluded: “In the last 50 years, mankind has generated changes to ecosystems more quickly and more extensively than at any other period in the history of humanity, mainly to satisfy a rapidly-growing demand for food, fresh water, fibre, wood for building and energy.”
According to this report, agriculture bears a special responsibility for (i) the degradation of the quality of surface and ground water (pollutions by nitrate, phosphorus, pesticides), of soils (erosion, contaminations by pesticides or heavy metals), and of the air (pesticides, greenhouse gases); (ii) the loss of biodiversity (disappearance of habitats, mortality due to pesticides, expansion of a very small number of hyperproductive animal breeds); and (iii) the consumption of non-renewable resources (oil, phosphates, potassium, water). The FAO report ‘Livestock’s Long Shadow’ (Steinfeld et al. 2006) carried out a diagnosis along the same lines, in particular identifying methane emission by ruminants as contributing to the greenhouse effect. The impacts of agricultural practices on the environment are expressed at both global and local level. For example, European livestock farming systems encourage the development of soybean cultivation in South America, where its ecological and social impacts are far from being controlled (deforestation, homogenization of landscape mosaics, reduction in local employment, see Botta et al. 2011). To reduce these harmful effects, or adapt to them (in the case of climate change), considerable changes in agriculture and livestock farming practices, even the location of these activities, is essential. But – as stressed by the Millenium Ecosystem Assessment – this will have to be accompanied by political and institutional changes.

The evolution in the demand for food and non-food products

Many analysts (e.g. Guillou and Matheron 2011) emphasize the necessity of increasing food production at world level, to satisfy the needs of a growing population. For Europe, where numerous farming systems are already highly intensified, it is not certain that increased production is desirable everywhere, and certain agronomists wonder about “the cost (economic, energetic and environmental) of the last quin tals” (Loyce et al. 2012). Reconciling the twin ambitions of productivity and respect for the environment will require the development of systems based on ecological intensification (Griffon 2006; Steinfeld et al. 2010) or ecological modernization (Horlings and Marsden 2011). This means taking climate change into account, to various extent, depending on geographical areas.

Keeping prices of basic food products low responds to a consumer demand relayed by mass distribution. But the markets, which used to be governed around sectorial agreements and used to be centred on a standard quality, are now becoming more and more segmented. Collection companies, processing industries and distributors multiply contracts, imposing specific quality criteria on the product, or restrictive specifications on cropping and livestock farming practices. Quality issues now concern not only the essential characteristics of the product, but also the definition and control of the conditions under which it is produced (Casabianca and Matassino 2006). The sensitivity of consumers towards food safety leads to questions about how plant and animal diseases are controlled. The emergence of animal rights movements, hostile to industrial livestock farming conditions, is also a driving force for the evolution of practices and regulations (for example the obligation of keeping pregnant sows in groups rather than in individual stalls).
The development of agro-fuels and agro-resources for ‘green chemistry’ presents an opportunity for new outlets, but it is also a potential source of disruption for production systems. For example, (i) new crops giving a diversified cropping pattern, (ii) increasing the surface areas of certain species (in particular for bioenergy production), which may pose increased specific insect populations, (iii) new management patterns adapted to particular outlets.

Work and income of farmers, in a globalised world

The globalisation of trade, which in Europe leads to considerable fluctuation in the prices of farm products, can be seen in a new composition of productive choices and a combination of activities in farms. Specialised systems are being developed at the expense of mixed crop-livestock farming systems (Schott et al. 2010). At the same time, territories whose farming used to be based on a monoculture that is now in crisis (e.g. wine, bananas), are seeking new production systems. Increase in farm size and area per worker, as well as the development of multiple enterprises in households and by the farmers themselves, call for production systems to be reorganised. Work is a key element in this reorganisation, source of competitiveness differentials with international competitors or a major constraint on the evolution of technical systems (Mak 2001; Madelrieux and Dedieu 2008). To ensure farm competitiveness and sustainability, innovation will be necessary in the matter of work organization, promoting flexible and responsive farming systems (Dedieu 2009; Astigarraga and Ingrand 2010), capable of adapting to instability in the prices of farm products or energy, and to increasing climatic risks (IPCC 2007). Finally, the development of financial agriculture, particularly in South America (Grosso and Albaladejo 2010), renews debates on the models of tomorrow’s farming, currently confined to the opposition between a capitalistic entrepreneurial agriculture and family farming, managing and handing down an inheritance. But behind all these models, the debate is really about relations with time (seeking short-term profits vs. stewardship over the longer term), with work (a resource to be optimized vs. a component of the family-farm relationship) and with investment (e.g. in technologies linked to precision agriculture) (Lémery 2000; Dedieu and Servière 2011).

An evolution of the place of agriculture in the territories

In a context in which the economic and social role of agriculture is becoming marginalized in numerous territories in Europe, farmers are no longer perceived as being just producers, but also as having the mission of managing space and natural resources. Depending on the characteristics of the territory, multi-functionality of agriculture raises three different questions (Meynard and Casabianca 2011):

- What agriculture in peri-urban areas, depending on the opportunities and constraints linked to the proximity of the town and the high density of non-agricultural population (Lamine et al. 2012, this book)?
• What cropping or livestock farming systems in high natural value and protected ecological areas, where the ‘production of nature’ can take priority over the production of food (Bellon and Hemptinne 2012, this book)?
• What combinations of activities in mountain farms, between e.g. food production, direct marketing, farm tourism, off-farm employment?

Farming activities must organise how they complement and coexist with other uses of space, with other rural activities and with the quality of life of residents and visitors. The transformation of farming systems is therefore of direct interest to non-farming players in the territory, with whom compromises, agreements or synergies must be sought (Etienne 2010). The construction of landscape mosaics, the management of eco-systemic services, the improved use of inherited resources (e.g. local breeds or know-how), or the establishment of new relations between producers and consumers; all these aspects refer back to the analysis of the resilience (Walker et al. 2002) and vulnerability (Janssen et al. 2007) of social-ecological systems, and to an effort to design innovative farming systems.

Transformations under tension

Behind these different drivers, radical changes to cropping and livestock farming systems are potentially emerging: the internalization of societal expectations regarding the environment could, in Western Europe, bring into question the fundamentals of present-day intensive agriculture. These fundamentals include the intensive use of pesticides and veterinary products, the growing integration of activities by downstream sectors, or the specialization of farms and territories.

A much greater differentiation than today could also be seen, for example, between (i) an agriculture in the peri-urban territories, marked by the constraints of cohabiting with residents, but also by the development of short food chains and direct marketing, (ii) an agriculture in areas of high-value natural heritage or of high recreational value, where the production of landscapes and the protection of biodiversity could take priority, and (iii) an agriculture in areas directed towards an export market, where priority would be given to competitiveness and productivity. Such differentiations in the types of agriculture would impose differentiation on farming systems, as well as on the evaluation criteria used to assess them.

Whether they are radical or more moderate, the changes in farming systems that will result from the combined effects of these drivers will not be made without tension:

• The classic tension between economic and environmental requirements, illustrated – in regions dominated by intensive arable crops – by the difficulties in developing environmentally-friendly practices, due of the additional workload they would cause (e.g. harrowing versus chemical weeding, stale seedbed, planting catch crops). There is also the tension between the necessity to minimize the use of pesticides and veterinary products, to limit their residues in food (and the environment,
see above); and the necessity to guarantee food safety, e.g. through the absence of toxins or pathogenic micro-organisms on food products.

- Tension between the individual logics of farms and territorial governance: for example, if the farmers in a region choose, all at the same time, to cultivate the most profitable species, or the ‘best’ variety of a given species, this creates genetically homogeneous areas, favourable to the development of pests to which these species or varieties are sensitive.

- Tension between supply chains in the same territory, associated with the coexistence of varieties of different uses (risks of genetic contaminations of crops/harvests, by pollen or by seeds), but also with competition for rare resources (fertile soils, flat lands, irrigation water, local breeds, see Le Bail 2000). In countries of the South, territorial competitions and complementarities between various types of livestock farms are organised around diversity of (i) animal production resources (rough pasture, tropical grassland, residues and agricultural by-products), (ii) mobility practices (nomadism, transhumance, sedentary), (iii) livestock farming functions (e.g. production, but also savings, manure, milking) (Duteurtre and Faye 2009; Dedieu et al. 2011).

**Thinking and acting in a systemic manner**

Resolving these tensions and reconciling contradictory demands requires either working out new compromises or the construction of new solutions that solve these contradictions. Although purely technical innovations of the ‘command and control’ type (e.g. pesticides, precision agriculture, modern livestock farming, decision-making tools) will certainly have an important role to play, they themselves cannot be the only solution. According to Darnhofer et al. (2009): “the attributes at the core of a ‘command and control approach’ are: efficiency, constancy and predictability. A problem is identified, and a technological solution developed. Implementing the solution aims at achieving a predictable outcome such as a specific yield level. This approach to farm management is based on an engineering mind-set. The goal is to design a crop or animal production system, so as to turn a variable, natural process into one which produces standardized commodities in a reliable, predictable and economically efficient way”. Such an approach, with no systemic vision, have shown its limits. It is unable to take into account the much wider range of objectives that is required to attain sustainability, and more often than not produce new undesirable risks and side-effects. The case of pesticides is a perfect example of this.

During the last decades of the twentieth century, the agricultural world lived with the illusion that agro-chemicals were going to control all the problems of pests, diseases and weeds. As the other techniques that were traditionally used to manage these bio-aggressors, they changed or disappeared: for example, rotations became shorter and specialised on the more profitable species, which increased parasite pressure and dependence on pesticides (Lamine et al. 2012, this book). To maximise the cereal yield, the sowing date was brought forward, the density increased, nitrogen fertiliser use
increased, and the most productive varieties chosen (often not very disease-resistant), all being developments favourable to diseases, aphids and weeds, and therefore to pesticide use (Lamine et al. 2011; Loyce et al. 2012). From technological innovations supposed to resolve precise problems, pesticides have thus become the pivots of production systems (Meynard and Girardin 1991). This pivotal role is reinforced by the extension system and the priorities of selection. The companies selling pesticides to farmers, with knowledge about their methods of use, have progressively become the main sources of technical advice. These companies are very efficient in sending out alerts about the presence of parasites in the region and do not always promote varieties that are disease-resistant. Plant breeders who have developed disease-resistant varieties have met with commercial failures, and the number of multiple disease-resistant varieties is still limited. A veritable socio-technical lock-in has become organised around pesticides, as shown by Vanloqueren and Baret (2008) or Lamine et al. (2011). The ecological and health limits of the immoderate use of pesticides are clearly visible today. To make significant reductions in their use, action should be taken on the whole of the socio-technical system, to reduce risks associated with bio-aggressors at field and landscape level, to dismantle the lock-in organised around pesticides, and to favour the diffusion of alternative solutions (such as disease-resistant varieties or the diversification of crops).

Generally speaking, the strong coherence which governs technical choices, as much as the complexities of agro-ecosystem regulations, invite us to think and act in a systemic way (Meynard and Casabianca 2011): to take into account the unintentional effects of technical choices, to reason by integrating several scales and time steps, to consider the interactions between techniques as such, and between techniques and their socio-institutional contexts of application. Agroecology, defined as the ecology of agro-food systems (Francis et al. 2003) constitutes a response to this need for a systemic approach. For example, it involves using telluric fauna to carry out certain soil tillage functions, and at the same time reducing the costs and time taken for this activity. It also implies controlling parasites by promoting their predators; it involves using the diversity of landscape mosaics as a source of resilience for the agro-ecosystem (Sabatier et al. 2010) and the fixing of nitrogen from legume crops as a way of supplying nitrogen to the other plants. The diversification of crops and productions can become compatible with farm specialisation, if the cohabitation, or even complementarity, between farms opting for different specialisations, is organised at territory level (Lemaire 2007). The global vision of the production-consumption relationship advocated by agroecology encourages us to explore agro-food systems associating consumption of local products, development of short distribution chains and diversification of production systems and landscape mosaics, as opposed to the dominant system, which associates long distribution chains, specialisation and uniformity of landscapes (Meynard 2010).

A redesign of farming systems is necessary (Hill and MacRae 1995; Lamine and Bellon 2009; Bos et al. 2012). Approaches centred on improving the efficiency of inputs or substituting one input for another will not be enough to resolve all the issues mentioned above. Agroecological redesign is still in the minority in the world of research and agronomic R&D; and if at the world level, as much investment had
been made in research into agroecological innovations as into innovations in pesticides or GMO, we would certainly be much more advanced in the redesign of farming systems (Vanloqueren and Baret 2009).

**Innovating to prepare for a diversity of futures**

Bos et al. (2009, 2012) stress the necessity of reflexivity for redesign, i.e. the systematic questioning of basic (and often unarticulated) frames (theories, values and assumptions) that guide our thinking and structure the way we act (Fig. 18.1). Important reasons for this prerequisite for redesign are:

- It requires simultaneous changes on several and very different dimensions of sustainability, that likely will conflict if interpreted at face value;
- It has to mobilise an increasing number of stakeholders and actors (including animals) with very different needs and value sets;
- The socio-technical system which presently dominates has resulted in a range of deeply entrenched beliefs, seemingly self-evident practices and goals, and material and institutional standards that will limit the range of solutions if left unquestioned.

As a consequence, the determining of precise (re)design objectives is much more complicated. At least two major difficulties can be identified:

- First of all, uncertainty about the future: beyond general trends such as the increasing importance given to the management of environmental resources, it is difficult to anticipate the evolution in 10 or 15 years’ time of the international economic context, of public policies, movements of opinion and the balance of power between pressure groups. Similarly, although the reality of climate change
happening now is generally admitted, its local repercussions are still uncertain. Design priorities between issues and criteria and evaluation criteria for the result, will favour one future over the other.

- A second difficulty is that the interests of stakeholders – from farmers to downstream operators, from advice bodies to public authorities, from agro-supply firms to mass distribution – do not necessarily align, at least not in the short term. Depending on the viewpoint, the same innovation can be considered as an advance or as a regression; what is relevant for one can be considered by the other to be ill-timed, or even harmful (Meynard and Casabianca 2011). Congruency of their long term interests may be possible, but will often require a redefinition of their identity.

The diversity of stakeholders, possible futures and local situations increases the need for innovation. Since sustainability itself can only be operationalized in context, universal ideal farming systems cannot exist. Redesign of farming systems thus has to:

- Prepare for a diversity of solutions, to leave the choice to farmers and other stakeholders, and prepare different futures;
- Above all help the farmers and other stakeholders to build their own systems, to adapt these systems to their own situation, and to build their own compromises, relying on their own knowledge and on scientific knowledge.

**How is the redesign of innovative farming systems to be organised?**

Innovative farming systems can have a variety of origins. Sometimes they come from the farmers, sometimes from research bodies, sometimes from development bodies, and most often from the combination of all their efforts. Innovation in agriculture, as in other sectors, is most often a collective and interactive process. It must not be seen as a linear process, in which there is a succession of stages of research, design, development, production and distribution, but as the result of comings and goings between these activities. Le Masson et al. (2006) show that the capacities for innovation of a structure or a collective are very much conditioned by the management of its design activities (the ‘moment’ when the innovation concept emerges and becomes defined), and the organisation of its relations with research and development. This part attempts to specify the modalities the design of innovative farming systems may use, relying on the acquisitions of agronomic sciences and the theoretical work in design sciences.

**Developing innovative design processes**

Le Masson et al. (2006) distinguished two ways of designing systems: rule-based design and innovative design. The most wide-spread approach to design is ‘rule-based design’. 
The aim of rule-based design is to gradually improve products or existing technologies. The design objectives do not change and can therefore be clearly defined in advance. The skills necessary to innovate and the validation processes (such as prototypes, trials, tests, indicators) do not need to be changed. This stability allows for the large-scale deployment of standardised methods, and favours a clear division of work between research and development. In the field of agriculture, rule-based design could be illustrated by the large majority of crop cultivar creations, by the refinement in adjusting nitrogen fertilisation to crop requirements, or the progressive improvement, over 30 years, in calculating feed rations from feed value tables and an estimate of animal requirements.

However, rule-based design is no longer suitable if the design frames themselves are called into question. The term ‘innovative design’ is used to indicate a process of exploration aimed at satisfying completely new expectations. As a consequence, it is not possible in advance to specify the required skills and the validation methods. Innovative design requires creativity, but during the design, as the concept of the innovation becomes defined, it also requires a great capacity to modify the desired objectives, as well as the fields of knowledge and the collaborations mobilised. The choice of the scale of approach (field, farm, landscape…) is not given in advance, and its definition is a result of the design process. The question of associating users in the design is central: If the users are mobilised very early on, they can contribute to the progressive determination of objectives and evaluation modalities. Innovative design, in a particularly cogent way, poses the question of integrating an anticipation of uses into the design (Cerf et al. 2012).

The development of future agricultural systems clearly calls for a considerable effort of innovative design (Meynard et al. 2006):

- **The introduction of new, additional objectives**, in particular the internalisation of environmental and social concerns in the design of agricultural systems, rather than the one-sided focus on economic considerations. Approaches at field and farm scales are no longer sufficient, because design involves steering processes that are expressed at higher system levels, like the landscape and the production chain. The need to incorporate a more heterogeneous set of values into the design, as new stakeholders and actors (like citizens, animal rights activists, animals) are included, makes setting objectives particularly complex.

- **A major change in the concepts and knowledge** to be mobilized: crop and animal scientists, classically in the front line for the design of innovative farming production systems, must take on the skills of ecologists, risk analysis specialists (to manage the obligation of results, emphasised in contracts centred on quality of the environment), of specialists in work and the evolution of jobs (ergonomists or sociologists). Adaptation to climate change calls into question the references of farmers and advisors, questioning the relevance of know-how acquired in the past: To rebuild their capacity to project themselves into the future, they must combine their own knowledge with knowledge on future trends gained from climatic and agro-ecological models.
A revision of evaluation methods and criteria for new systems: not only are increasing numbers of environmental and social (duration and conditions of work, social exclusion) criteria being added to classic economic criteria, but specific methods such as life cycle assessment or multi-criteria analysis must be deployed. The evaluation of the adaptive capacities of innovative systems in an uncertain environment is becoming essential: how do the systems keep some room for manoeuvre? How do they ensure the necessary connectivity between elements of the system? How do they reserve possibilities for adjustments in the management of production schedules? Methods of participatory evaluation, associating all of the stakeholders and mobilizing other criteria than those that the researchers judge to be important, are becoming indispensable (Le Gal et al. 2009).

A number of innovative design approaches practiced in the agronomic field are presented in the following sections.

**Improve what already exists or construct de novo?**

Redesign of farming systems cannot be confined within a standardised approach through which it would be an obligation to go. Meynard (2008) or Meynard and Casabianca (2011) find that design approaches for innovative farming systems can be distinguished into two major sets of approaches: the ‘*de novo*’ design and step-by-step design.

‘*De novo*’ design aims at designing cropping or farming systems that break away from existing systems. It involves opening the field of possibilities, without submitting to any restraint, either by realism (‘let it be immediately operational’), or by the conservatism that the step-by-step approaches are sometimes accused of (see below).

Model-based design is a very effective way of operating the *de novo* design: crop, livestock and farm models are used to give a dynamic simulation of the performances of crops, animals or farms subjected to various technical and economic choices (Le Gal et al. 2011). They enable a very wide exploration of technical combinations to be carried out, well beyond what the best experts know, and they inform the designer on their long-term impacts (for example Martel et al. 2008 in pig production), and on the probable effects of climate change. They make it possible to identify, within the multitude of possible combinations, the cropping and livestock farming systems that respect predefined requirements on criteria of production, costs, margins, work, or the environment (see for example De Wit et al. 1988; Chevalier-Gérard et al. 1994; Boote et al. 1996; Rossing et al. 1997; Keating and McCown 2001; Ingrand et al. 2002; Loyce et al. 2002; Duru and Hubert 2003; Bergez et al. 2010).

However, if model-based design is still the most frequently chosen approach, some researchers, since Vereijken (1997) have worked on prototyping without models (Lançon et al. 2008; Le Gal et al. 2011; Reau et al. 2012). In Reflexive Interactive
Design (RIO) new animal husbandry and chain concepts are developed by applying an interactive version of structured design (see Box 18.2; Groot Koerkamp and Bos 2008; Bos 2008; Bos et al. 2009, 2012). In RIO, the design process is as important as the resulting designs. They both aim at eliciting new ways of thinking and acting, rather than describing how sustainable animal husbandry should be done. From this perspective, the resulting designs are not meant as blueprints, but as visual change agendas and boundary objects to elicit new forms of collaboration, and open up the (perceived) solution space.

In step-by-step design, the aim is not to create a break, but to organise a progressive transition towards innovative systems. The design work begins with a diagnosis: in what way do the present farming systems satisfy new objectives? The diagnosis indicates the criteria that are not met satisfactorily, the agronomic and ecosystemic functions which are in question and technical actions which should be changed (Doré et al. 1997, 2008; Mischler et al. 2009). On the basis of this diagnosis, evolutions of the farming systems are designed, and implemented. Then a new diagnosis is made, new evolutions of the systems follow, etc. thus engaging in a true spiral of continuous improvement (Meynard et al. 2002) (Fig. 18.2). These actions benefit from progress made in recent years in systemic analysis methods in situ, which make it easy to carry out precise and reliable diagnoses (Box 18.1).

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1 See: http://www.duurzameveehouderij.wur.nl
Béguin (2007) proposes an analysis grid that enables us to better perceive the complementarities between the two design families:

- What has taken shape: what scientific or empirical knowledge is formalised?
  What is the status of the evaluation, the criteria and the indicators?
- Is there plasticity in the design, i.e. are several implementation options possible?
- How does the development of the innovation operate, i.e. are there exchanges and mutual learning between researchers and users during the process?

In step-by-step design, the exploration is more cautious, but has the advantage of adapting easily to the specific constraints of each farming situation. The farmer, often supported by a technician or by a collective of his fellow farmers, perfects his new system year by year. At the same time, he learns to control it, becomes convinced of its relevance, and gradually reorganizes his work and his means of production. Step-by-step design lends itself better to progressive mobilisation of the farmers, and therefore to development approaches.

*De novo* design opens the field of possibilities, giving free rein to inventiveness, and can in this way provide sources of inspiration to step-by-step design. The design...
workshops make good use of complementarities of knowledge, and innovation paths, associated with a variety of occupations or disciplines. Researchers display a pronounced taste for model-based design, which makes good use of scientific knowledge, synthesized by the models. However one may wonder if, for some researchers, \textit{de novo} model-based design does not serve to mask the fact that it is much more comfortable (even more rewarding at academic level) to do design without ‘being saddled’ with partners and confrontation with the real world. In fact, as underlined by Jeuffroy et al. (2008), many research models are still ill-adapted for use by grassroots players: input variables too complex to collect, opacity of the adopted formalisms, frequent dead ends concerning the effects of techniques on bio-aggressors, validity field ill-defined (Fig. 18.3). Researcher models are still difficult to use by others than their designers. So there is still a gulf between research, which concentrates considerable energy on modelling, and development which is not involved and does not feel concerned. To integrate the needs and constraints of their potential users into the models, associating in their construction farmers, advisors and R&D stakeholders, deserves to be more frequent than it is (Le Gal et al. 2009).

To encourage confidence in the design results, an experimental stage testing the innovative systems can be operated. ‘System experimentation’ thus aims at testing in the field the capacity of innovative farming systems to attain the objectives for which they were designed (Meynard et al. 1996). These experimentations can be
carried out in an experimental farm, in field networks or at whole farm level. System experimentations carried out in plant production have usually been carried out at field scale: as annual (e.g. Dejoux et al. 2003; Loyce et al. 2012) or pluriannual (e.g. Debaeke et al. 2009), most often to test crop management or cropping systems designed de novo. Experimentations carried out on livestock systems are often carried out at whole farm level. They usually come within de novo design approaches, and aim at checking how an inventive system designed from the combination of scientific and empirical knowledge functions at a pluriannual scale in situations of climatic and price uncertainties (see Dedieu et al. 2008; Benoit et al. 2009 for extensive and organic sheep systems). We are seeing the emergence of ‘system experimentation’ based on the principle of step-by-step design, for example when it involves the progressive and reflexive development of a system going towards increasing self-sufficiency (in mixed crop-livestock farming, see Coquil et al. 2009).

Step-by-step design and de novo design call partly on the same basic methodological resources: the agronomic models whose role is major in the de novo design, can also be mobilized for agronomic diagnosis (Doré et al. 2008) in step-by-step design. Agronomic diagnosis itself, the basis of step-by-step approaches, makes it possible to evaluate and improve the innovative systems undergoing experimentation (Dejoux et al. 2003), and can help to define the orientations of a design workshop (Lançon et al. 2008). Finally, agro-ecological indicators are used for the evaluation of candidate systems in de novo design, as well as for the step-by-step improving of real farm systems.

Organising the redesign of farming systems as a collective project

The design of farming systems has an indispensable partnership and collective dimension. It results from interactions between established knowledge and empirical knowledge, and is based on an organised exchange between various players (researchers, practitioners, development institutes, territorial players, private enterprises) with different natures, functions and interests. As stressed by Lançon et al. (2008), innovative design must mobilize a collective and distributed intelligence, more effectively, faster and less hazardously than individual approaches that are dependent on dominant discipline or local representations.

This collective character is all the more important because the situation in question is controversial. Methods have been developed in animal husbandry (Bos and Grin 2008; Bos 2008; Groot Koerkamp and Bos 2008; Bos and Groot Koerkamp 2009) to interactively design and realize system innovations in complex and often controversial contexts, in an effort to circumvent social and technical constraints for sustainable development. To fulfil these functions, design trajectories need to move from the strict research scene to co-conception with farmers, market chain, NGOs and other societal stakeholders, to have a material impact. Co-design and participatory approaches are part and parcel of the design process, to weld research-based universalistic knowledge, with local knowledge. As an example, to design an innovative poultry system, Bos et al. (2009) have proposed a specific methodology, Reflexive Interactive Design (RIO) (Box 18.2).
Box 18.2 Reflexive and Interactive Design (RIO)

The RIO approach is an attempt to integrate (social) system analysis, system innovation theory, with an engineering method called ‘Structured Design’ (SD) (Siers 2004), in an interactive, multi-stakeholder process (Fig. 18.4).

In SD, design of new machinery, buildings and constructions starts from an elaborate inventory of needs and requirements of the prospective users and environment. In RIO projects on redesigning animal husbandry systems, the basic needs of living actors (animals, farmers, the general public and consumers) are key starting points. For each, a Brief of Requirements (BoR) is formulated. Needs are to be differentiated from (short-term) interests, since they are the expression of fundamental preconditions for a good life, as perceived by the actor, or engrained in the actor’s biological make up. Short-term interests may be context dependent, and may change over time. RIO aims at the synthesis of the needs of these different actors, instead of weighing the pros and cons of the various interests. By taking needs as the central ‘currency’ for this design approach, actors – like animals and man – can be treated symmetrically.

(continued)
Reau et al. (2012), for their part, have formalized the organisation of workshops, for the collective de novo design of cropping systems. The design workshop brings together players with a variety of skills (e.g. advisors, researchers, farmers), on a shared redesign project according to innovative objectives (for example, large reduction in pesticide use, or self-sufficiency in energy). After agreement on the objectives, the group lists the techniques that can be mobilised, imagines ‘candidate systems’, both re-combining existing techniques and crops in the region and proposing the introduction of new techniques and crops. On the basis of the expertise of its members and agronomic models, the group estimates the agronomic and environmental performances of the ‘candidate systems’ and carries out the ex-ante evaluation of the systems, using multi-criteria analysis to select the most effective one regarding the chosen objectives. As a consequence, the agronomic models change their function: rather than producing ‘the solution’, they play the role of mediator between the worlds of research and development. To carry out this design work successfully, the group composition and the workshop setting are primordial. Five functions have been identified: the workshop leader, the expert in exploratory knowledge (often a researcher), the expert in localised knowledge (often a farmer or a grassroots technician), the leader of change (the one who encourages the others to take the plunge) and the evaluation operator.

In the case of the participatory design of decision-aid tools, Cerf et al. (2012) show the role played by the test of an innovation prototype by its future users. The analysis of the real uses of prototypes, and the exchanges between designers and users become a resource for starting a new design cycle. In step-by-step design, the exploration work carried out by each farmer is expanded within professional groups, where the farmers share their experience and enrich their learning (Goulet et al.
The diagnosis carried out on each farm is thus a source of collective learning, as much for the farmers as for the agronomists who are supporting them. This agrees with the observation by Chantre (2011), who stresses the role of collective experimentation within farmer networks as a lever to support learning dynamics. However, she underlines with regret, that ‘empowerment’, or “the way in which the collective experimentation then enables the farmers themselves to develop innovative processes (Röling and van de Fliert 1994), is not, to our knowledge, the subject of any particular work”.

Public authorities play a vital role in shaping the right conditions for redesigning projects. Innovative design can be helped by financial support, but they can also encourage innovation dynamics by scrutinizing existing regulations or specifically constructing new ones (Aggeri 2000). In most cases, existing regulations are structured around existing practices. There are often hurdles to overcome for innovative redesigns, because radically new practices are not accounted for in the existing regulations: any project with an innovative design ambition will have to induce innovation in regulation as well. A very common and basic obstacle is that regulations are often based on means, instead of ends, for example Good Agricultural Practices (GAP). Many environmental norms in agriculture are based on the standardisation of ‘sets of GAP’, sets of recommended and forbidden practices, according to the principle of the obligation of means. For an agronomist, imposing standardised practices is an absurdity, for several reasons:

- They tend to limit the capacity of farmers to adapt to the diversity of soils, climates and agricultural situations;
- The standards are specified at the level of the elementary technique whereas environmental performances often depend on interactions between several techniques; and
- They are often felt to be constraints: protection of the environment thus loses value in the farmers’ opinions.

In contrast, we suggest replacing the obligation of means by an obligation of result. In this way, the intervention by the public authorities should help farmers to make lucid appraisals of their situations and encourage the setting up of learning and virtuous improvement spirals, as illustrated in Box 18.3.

### Box 18.3 An example of obligation of results: agri-environmental measures aimed at safeguarding diversity in grasslands

In the Bauges country parc (French Alps), the sets of Good Agricultural Practices implemented until 2007 anticipated restrictions in the level of nitrogen fertilisation and delaying the date of the hay harvest. They were complex (for example, differences according to altitude and soil type), they were restrictive and were badly received by farmers. In 2007 this measure based on (continued)
an obligation of means was replaced by a measure with an obligation of result. A very simple indicator was thus used to evaluate both the ecological quality and the productive value of the meadows: at least 4 species present in the grassland out of a list of 24. The team, composed of farmers, advisors and researchers, who designed and evaluated this agri-environmental measure showed that the farmers consider that having grasslands that satisfy the biodiversity criterion gives them a professional prestige (and this creates competition). They then innovate in the way they use the grassland to respect this indicator. An institutional innovation gives rise to technical innovations! (Source: de Sainte Marie et al. 2012)

Conclusion

In the early 1990s, Meynard and Girardin (1991), in an article entitled ‘Producing in a different way’ put forward three ideas:

- The frantic rush to increase productivity led to intensive and specialised farming systems, highly dependent on the use of external inputs (e.g. pesticides in crop production), and with justification pointed at for their serious negative externalities on the environment;
- Alternative solutions are being studied, which refer to reorganising the farming system, and the spatial organisation of the cropping systems;
- Agronomists need to move forward in the design and evaluation methods of innovative farming systems, to take up the challenges which await us.

Twenty years later, what has changed? The intensive and specialised systems are still there, but they have corrected their most glaring errors. However we are seeing a profusion of local, national or international initiatives, aimed at inventing, testing and improving alternative systems of all sorts. Above all, immense methodological progress has been accomplished. International scientific journals have opened up to this work. International symposia on Farming Systems Design have been organised (Donatelli et al. 2007; Hatfield and Hanson 2009), which have made it possible to capitalise on the increasingly sophisticated and increasingly numerous methods of working.

However, the temporality of innovative design appears ill-adapted to the dynamic and the functioning method of short term projects of 3–5 years, such as those most frequently financed in public programmes of support to research and innovation. The specific features of innovative design mean that it is not possible to fix deliverables, it is not easy to define a priori the teams that will be involved, and it is impossible to fix milestones. Work on the organisation of innovative design in enterprises shows that although design must be closely linked to both research and development, it
must not be subservient to either of them (Le Masson et al. 2006). Two symmetrical obstacles can hold back innovative design (Meynard and Casabianca 2011):

- The reticence of many extension managers to see their agents expending their energies in systems that are not immediately profitable, in present technical and economic conditions, which curbs the exploration of potentially interesting systems;
- The idea – still shared by many researchers – that innovation flows naturally from the advance of knowledge, whilst the experience of innovative design, both in agriculture and in industry, shows that the design activity must, at least partially, steer the acquisition of knowledge.

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Chapter 19
Stimulating transitions towards sustainable farming systems

Boelie Elzen, Marc Barbier, Marianne Cerf, and John Grin

Abstract  How can the dynamics of the agro-food sector in the long run be addressed? We argue that sustainable agro-food systems cannot be developed through a simple improvement of existing systems, but will require a transition. Therefore, we focus on how transitions to sustainability could be initiated and supported, taking into account renewal initiatives at the farm level, organised projects, heterogeneous actors and differing interests. We argue that a transition will have to come from a range of novelties that initially have various misfits with an existing regime. To tackle these misfits will require a learning process that needs to be of a ‘reflexive’ nature which implies that various taken for granted characteristics of the regime and beliefs of stakeholders can be questioned. Another critical issue is that this learning not only takes place in a protected environment (or niche) but that new links with the existing regime need to be created. Only then can learning about novelties start a transformation process in the regime that may eventually lead to a transition.
The challenge

After the Second World War, a modernization of agriculture took place across Western Europe, which was supported by dedicated agricultural policies. Directly after the war, governments in various countries aimed to stimulate reconstruction, to foster economic growth and to prevent food shortages that had occurred in some countries. In the early EEC member states, agricultural policies focussed on producing affordable food in a situation of low incomes, and to free labour forces for industry, from which the badly needed economic growth during the reconstruction years was expected (Tracy 1989). Research, education and extension were supplemented with price and market policies, as well as measures in the fields of physical planning and water management.

Post-war policies were supported by societal consensus legitimizing and giving place to various forms of structural change, including social change in rural life, technical modernization and neo-corporatism. At the farm level, mechanization, pesticides, fertilizers, genetics and other novelties, based on advanced scientific understanding, became common and were aided by market and price policies, most notably product subsidies. Later, with the advent of the EC, this policy became part of a European Common Agricultural Policy, which gave an additional boost to the modernization of agriculture in a growing number of member states (Ackrill 2000).

From 1960 onward, this modernization pattern was followed across Europe albeit at a different pace for different regions and different sub-sectors. The general pattern was that farms increased in size, that livestock husbandry systems increased numbers of animals per unit of space and per farm and that numbers of farms and farmers dropped. This led to a large increase in the production of crops and animal products per unit of surface.

The increase of scale, more specifically the phenomenon that farms became larger while smaller farms had difficulties to remain economically viable, led to resistance from those attached to small-scale family-farming. Many European farmers were initially very reluctant to embark on their government’s modernization journey (Mendras 1971).

Against the trend, about one-third of the French family farms remained small scale which partly became possible through additional incomes from non-farm jobs. Another development (in France as well as in other European countries) was that of multi-functionality, i.e. providing other services on the farm (Knickel and Renting 2000; Laurent and Remy 2000; Renting et al. 2004). In the Netherlands the combination of a strong preference for family farming with opportunities for more modest modernization and scale enlargement led to farms that were larger in size but could still be run by a family, often with fewer family members active than before (Grin 2012). This was made possible through specialization: not only did mixed farming virtually disappear, also within crop farming or livestock production, there was increasing specialization on only one or a few crops or breeds (Bieleman 2000).

An important effect of the modernization process was that simple production-consumption chains developed into complex networks consisting of a variety of organizations with various specialized roles in food-processing. This coincided with
Stimulating transitions towards sustainable farming systems

the development of new consumption patterns stimulated by new technologies like refrigerators and new sales-formulae like supermarkets. As a result, food provision and consumption turned into a complex system of agricultural production, food processing, retailing and consumption practices (Marshall 2001).

In this process, food prices dropped considerably and international trade in food products rose, turning the agro sector into an important economic factor. Policies at the national and EU level which had sought to stimulate this were therefore quite successful.

This modernization programme, however, also had its downsides. We already mentioned the threat it posed to small-scale family-farming. A new concern was also the continuous pressure to invest in novelties emerging from the agricultural innovation system. This led to a growing dependence on banks to finance increasing investments brought about by mutually reinforcing combination of rationalization and scale enlargement. Furthermore in the 1960s, and rapidly after 1970, a variety of side effects became visible: overproduction, the dangers of chemical pest and weed control, emission of malodours from livestock units and mineral surpluses. In the livestock sector, impaired animal welfare became an issue with the BSE crisis that deeply impacted all of Europe in various ways (Barbier 2003) and reformed the scientific expertise system at the European level. This formatting crisis was deepened by other contagious and zoonotic animal diseases, especially after outbreaks of epidemic pests like classical swine fever, foot and mouth disease, and avian influenza which established food safety as a novel dimension in the landscape of agricultural policy and food provision systems. In the past decade, science-based criticism included the contribution of farming and livestock production to climate change and to excessive claims on natural resources of food production.

It is not difficult to see that these problems form the background of the particular nature of farming systems and their embedment as emerged during the first agricultural modernization (Beck 1992), with its emphasis on productivity (sacrificing proper attention to other issues), scale and intensity (more inputs and pollution per acre) and specialization (substance cycles were thus no longer closed on-farm, or at least within its neighbourhood). Governmental policies aimed to solve or mitigate the problems by stimulating research, subsidy programs and regulatory actions (Grin 2010; Grin and Marijnen 2011).

Thus, in terms of Beck’s modernization theory, the agricultural system that had emerged during the first modernization met the first attempts of reflexive modernization. The latter, however, also used various thoughts and approaches (hard and soft institutions) rooted in modernity. Thus, the actors involved on the one hand continued to increase production efficiency while, on the other, they tried to fine-tune inputs (of nutrients, agrochemicals, manure, etc.) to societal needs. Although protests had always been there, the limits of this approach became tangible when the BSE crisis and later the GMO controversy (Joly et al. 2000) delivered a strong signal that reflexive modernization was not only a question of environment but also of human health. What went on at the farm thus became a matter of trans-sectoral policy: consumption associations and environmental associations developed frame alignments on issues of food safety and environmental concerns.
Since the mid-1990s, the search for so-called ‘integral solutions’ gradually received attention in several countries as well as at the EU level. In the old thinking, the search was for a variety of ‘partial solutions’, i.e. one innovation addressing emissions of pollutants, another to improve animal welfare, etc. An integral solution seeks to address various challenges and aspects with the same solution. Integral solutions may also re-couple activities that had become separated through the specialization processes mentioned above.

Typically, such solutions not only focus on the farm level, but on the whole production-consumption chain and also consider the use of natural and cultural resources in a territory: what happens at the farm is closely intertwined with this chain and with the territory. As a result, changes at the farm, especially integral solutions that tend to be of a more radical nature, have implications for other parts of the chain and the territory as well.

These integral solutions often require a variety of changes: in policy regulations (spatial planning, price policies), in economic networks (from networks of highly specialized players toward webs that may produce integral solutions), in professional ethos of farmers facing prescriptions for changes (Lemery 2003; Lamine 2011), and changes in the innovation system from a primacy of scientific knowledge to a primacy of resolving problems in practice (Roep et al. 2003; Grin et al. 2004; Bertrand et al. 2005).

Such innovations, that typically consist of a combination of social, technical and institutional change, have been studied by many in the Farming System Research community, but not necessarily conceptualised in a more generic model across sectors and industries. Based on Science and Technology Studies and on Evolutionary Economics, the notion of transition has been proposed to describe this combination of various dimensions of change and the transition pathways that describe the interaction between the development of novelties and the transformation of an existing system (Elzen et al. 2004a, b).

A framework to stimulate transitions

An important question then becomes how transitions can be induced or stimulated. A first observation is that historical studies show that these processes are far too complicated and last far too long (in the order of decades) to be ‘steered’ or managed from a central point, e.g. by policies. The best we can do is to make clever use of an ongoing innovation dynamic and induce and stimulate smaller changes that in the longer term may have great effects. This puts an emphasis on learning and experimentation with a variety of innovations in a variety of projects which are to link up with institutional changes (LEARN 2000; Hoogma et al. 2002; Raven 2005).

In this section we will first present a conceptualization of transition processes, the multi-level perspective (MLP) that acknowledges the complexity of these processes. In this conceptualization a transition comes from radically different...
novelties that initially have misfits with the existing system. These novelties can either be developed in research projects or by farmers in their own practices. To address the misfits with the existing system, a learning process is needed that has to be of a reflexive nature. Finally, the learning in niches has to be linked to the regime (or existing system) to be able to start a transition process.

The dynamic of transitions

The traditional model sees innovation as a diffusion process: via innovators, early adopters, early majority, late majority and eventually laggards (Rogers 1962). Transitions have also been portrayed as a sort of diffusion process, distinguishing four phases: pre-development, take-off, acceleration and stabilization (Fig. 19.1). Although this curve resembles the typical S-curve of a diffusion process, the dynamic of translation and adoption is very complex and, most importantly, involves an interaction between novel practices and institutional changes that become mutually reinforcing until they reach some form of stabilization. Barbier (2008) nicely addresses the active process of mediation within a specific setting, including a voluntary scheme. This indeed resulted in such a curve in a water catchment area protection. Thus, adoption is not the cause of innovation; rather, innovation entails a performative socio-technical process of achieving transitions.

Although extensive later work has shown that these diffusion models are oversimplistic to account for the complexity of a transition process they are still widely held valid in policy arenas (policy makers who, directly upon a successful project, ask “And now, how do we scale up?”) and also in scientific circles (e.g. Gielen and Zaalmink 2003).
Increasing structuration of activities in local practices

![Diagram](https://example.com/diagram.png)

**Fig. 19.2** A dynamic multi-level perspective on system innovation. Regime developments are usually relatively stable. Under the influence of landscape and/or niche developments a period of transition may begin. Novelties emerging from niches may then gradually take the upper hand in the regime and lead to a new period of (dynamic) stability (Source: Geels and Schot 2007: 401, reprinted with permission from Elsevier)

To acknowledge the complexity of transitions and conceptualize system innovations\(^1\) in a more dynamic way, the so-called multi-level perspective (MLP) has been proposed (Rip and Kemp 1998; Schot 1998; Geels 2002, 2005). The core of the MLP is that system innovations are shaped by interactions between three levels: the socio-technical landscape, the socio-technical regimes and technological niches (Fig. 19.2).

\(^1\)Instead of the term ‘transition’, the term ‘system innovation’ is often used. The term *transition* highlights a difference between an earlier stage (e.g. horse-power based) and a latter stage (e.g. tractor-power based). The term *system innovation* highlights a process that takes place between these stages. *System innovation* is also used to distinguish these processes from more common, evolutionary patterns of innovation. Although various authors give somewhat different meanings to these terms, in general they are used interchangeably (e.g. Elzen et al. 2004a, b).
Socio-technical systems (e.g. the agro-food system) are located at the meso-level of socio-technical regimes. These regimes indicate a set of rules that guide and constrain the actors within a system in how they try to tackle various challenges they encounter, including factors like legislation, informal rules, economic factors, financing structures and dominant discourses. Change processes within a regime typically lead to evolutionary patterns of innovation. The socio-technical landscape is an exogenous environment of factors with a broader societal relevance like the need to reduce CO$_2$ emissions. Technological niches are the breeding ground for radical innovations that initially poorly fit the regime.

Novelties emerge in a local practice and become part of a niche when a network of actors is formed that share certain expectations about the future success of the novelty, and who are willing to fund and work on further development. Niches may emerge and develop partly in response to pressure and serious problems which can be either internal to the regime (such as animal welfare in industrial animal production) or come from the socio-technical landscape (e.g. the pressure to curb CO$_2$ emissions which affects more than just the agricultural regime). Supported by actors willing to invest in the new concept (industries, R&D organizations, government) and initially protected from competition at the market place (e.g. through subsidies), the novelty is developed further within the niche while broader networks are formed that support it, and more is learned about directions for improvement and how it can be made to work.

After some level of improvement of the novelty, and after learning more about its potential, it may find its way in specific market applications, often typical segments that exploit new functional characteristics of the technology and that focus less on cost (e.g. organic food). Through further improvement, increasing reliability, cumulated experiences and learning about functionalities and potential applications the novelty can spread to other market niches and/or trigger expansion of market niches. Institutional processes play an important role, such as the development of standards and regulations for the technology, and processes to reduce the mismatch of the emerging novelty with the rules of the dominant regime. As it starts to compete on or with main markets, the novelty may transform or substitute the existing regime and thus trigger a transition process.

This perspective allows for a very dynamic picture of innovation processes as its application to a variety of historical cases has shown. These studies, however, tend to focus on the vicissitudes of a specific alternative technology to an existing system (e.g. sailing ships replacing steamships in Geels 2002) although the new technology does not simply diffuse, but changes in the process (which S-curve do not display). This works fine for retrospective studies but it is problematic to use as a heuristic in a ‘learning strategy’ seeking to contribute to a transition. We do not know upfront which novelties will play a key role in the development towards sustainable agriculture. We need to acknowledge that ‘innovation in action’ is much messier than retrospective historical studies portray it (e.g. Elzen et al. forthcoming).
A reflexive stance to reconcile distributed agency and structural change

If we read the MLP from the perspective of structuration theory (see Grin 2006), transitions essentially become a matter of (1) redirecting the co-evolution of structure and agency; (2) going beyond the control-mode orientation characterizing ‘first’ or ‘simple’ modernity (Beck 1992); and (3) taking sustainable development as a normative orientation, amidst the turbulence of a variety of exogenous trends. Crucial in the process of re-orientation is reflexivity, understood as what Voß and Kemp (2006) have called ‘second order reflexivity.’ While ‘first order reflexivity’ captures the unconscious and unintended, ‘reflex-like’ consequences (side-effects and risks) of early modernization processes, second order reflexivity is about the self-critical and self-conscious reflection on processes of modernity. It evokes a sense of agency, intention and change. Here actors reflect on and confront not only the self-induced problems of modernity, but also the approaches, structures and systems that reproduce them (Grin et al. 2004; Stirling 2006). This has implications for learning from project experiences by R&D organizations and research institutes whose approaches are questioned by the critics of the effects of modernization processes in industrial agriculture (Barbier et al. 2005).

Since the late 1990s, these types of challenges have repeatedly been addressed in the IFSA community that has been involved in analysing and fostering learning at individual or collective levels in situations of change (Morris and Winter 2000; LEARN 2000). Many studies pointed out the need and the means to foster self-critical and self-conscious reflection in supporting farmers, advisors, local resources managers, rural communities in finding their way while tackling issues like catchment management, fire protection, multifunctional agriculture, co-design of decision support systems, etc. Such an emphasis on reflexivity turns the ambition to stimulate transitions into a form of reflexive governance (Voß et al. 2006) in which researchers should adopt a ‘dual vision’, alternating between a helicopter view that extends in time and space, and the perspectives of agents involved in the transition (Grin 2010: 315–319). A dual vision may help to promote reflexive learning, beyond the ‘taken for granted’: it can help mobilize ongoing, long term ‘landscape’ changes and existing pressures on the regime so as to open up new, conceivable modes of action (Grin 2010: 275–282). In the years to come, the way to carry out such reflexive learning needs to be further analysed and developed (Blackmore et al. 2012, this volume).

Dual track governance: key role of intermediaries

But how to coordinate such processes, or, more particularly, how may it be orchestrated in such a way that it is geared towards sustainable development? The answer is, obviously, not through any master, based on some master plan. Rather, we should
Stimulating transitions towards sustainable farming systems

expect this coordination to come from the distributed agency of the actors involved in structural change and innovative action. That is, it involves both a range of activities which focus on structural change, which then is explored in changed practices (top-down approaches); and activities focusing on developing and promoting these novel practices (‘experiments’ in niches), and from there change structure, i.e. change the existing regime (bottom-up approaches) (Fig. 19.3).

In the transition tradition, while top-down approaches are more central in transition management, (Rotmans et al. 2001; Loorbach 2007), the bottom-up ones are emphasized in the approach of strategic niche management (e.g. Hoogma et al. 2002; Raven 2005; Schot and Geels 2008; Elzen et al. 2004a, b). When these two ‘tracks’ of governance activities manage to strategically reach out to each other, they may actually start to reinforce each other. This we call ‘dual track governance’ (Grin 2006).

A crucial role in dual track governance may be played by intermediaries, positioned in between actors engaged in either track, and competent to do the job of

Fig. 19.3 A transition process requires the coordination of both top-down as well as bottom-up efforts. Also, the process needs to be orchestrated so as to be geared towards sustainable development. This orchestration is not achieved through some master plan, but through the distributed agency of the actors involved in the structural change.
‘translation’ between these tracks (Smith 2007). In many studies which have been carried out in the IFSA community, this role has been played, to a certain extent, by researchers involved in action research or participatory research (see Albaladejo and Casabianca 1997; Béguin and Cerf 2009). But many other professionals and organizations have also been recognized to act as intermediaries (Howells 2006; Ingram 2008; Klerkx and Leeuwis 2008). It is clear that we need to better understand their role and abilities and to identify which devices can support them in translating experiments into more structural change and vice versa. The notion of dual track governance, schematically depicted in Fig. 19.4, has been recently further elaborated (Grin 2010: 265–284).

Translation and mutual coordination requires learning as has already been shown in many studies focusing on the local level. The challenge is to address this at the different levels distinguished in the MLP, from niche to landscape. Actors engaged in experiments need tools that help them identify which regime barriers they encounter, and what ongoing regime changes and landscape developments may help to overcome them (Raven 2005; Bos and Grin 2008; Bos 2008). Learning how to ‘get the picture’ and to act in order to change their room to manoeuvre therefore seems crucial (Cerf et al. 2011). Actors who want to contribute to regime changes towards sustainability need tools that help them assess what changes may help to promote novel, sustainable practices (Rotmans et al. 2001; Grin 2006).
Learning how different levers are acting at the niche level is another critical issue. Actors that play an intermediary role need to understand how they can bring about connections between the two levels that they try to link (Smith 2007; Grin and van Staveren 2007). Actors at – and especially between – all relevant levels need to learn as part of their change strategies. This will require the development of methods such as the development and mid-way adaptation of visions and transition pathways in transition arenas (Loorbach 2007), socio-technical scenarios that anticipate conceivable pathways to realize them (Elzen et al. 2004a, b; Hofman and Elzen 2010), or methods which can foster second order reflexivity (ESP 2007). Such tools, for example, were developed for catchment management during the European SLIM Project (Steyaert and Jiggins 2007); others are known as ‘effective reformism’ (Roep et al. 2003) or reflexive design (Grin et al. 2004; Bos 2008).

The rather generic model of transition management needs to be adapted to agriculture in various situations, noticing that the effects of the landscape can be rather different for various national situations and regional ones. As a possible example, the LEARNing project was, to a certain extent, an attempt to start to link bottom-up processes and some more structural change in the building of a research agenda at European level for R&D issues in industrialized countries agricultures. To connect bottom-up and top-down processes, the researchers involved in the project chose to (LEARN 2000):

- develop reflexivity through change management in local situations, responding to the degree change was hampered or facilitated by local agency and structures in which the case studies took place; and
- get involved in a scaling-up process which was carried out by contrasting the different case studies at national and European level, as well as by inclusion, during this process, of local stakeholders, researchers and policy makers.

The outcome was a research agenda for R&D issues in industrialised countries’ agricultures, anchored in local situations and allowing to develop awareness for a reflexive governance (see also Hubert et al. 2012, this volume).

**Seeds of change: research-led and farming-led initiatives**

To develop more sustainable farming systems in various agricultural sectors and to foster transitions, two broad approaches have evolved: research-led and farming-led (Fig. 19.5). **Research-led approaches** often start with the formulation of visions of future agricultural production systems. These include, for instance, redesign of primary production, inclusion of new functions in primary production, vertical integration in the supply chain and combining functions of different agricultural activities in agro-production parks (Grin and van Staveren 2007). The underpinning of the sustainability claim of such visions varies from expert analysis only (LeMasson et al. 2010), results of extensive stakeholder consultation to deliberate co-design by scientific experts and stakeholders (Bos and Grin 2008; Prost et al. 2010).
At the same time, a variety of farmers are tinkering with a broad range of novelties. These farmers develop and try out new approaches to meet various challenges as they see them. Most of these farming-led initiatives are not guided by broad future visions and focus on specific aspects. They provide ample room for entrepreneurial initiative and use of local knowledge (e.g. Goulet 2008). Such initiatives are often not well known by the community involved in the research-led approaches, and therefore not necessarily reported and supported at the institutional level.

While much research has been done on research-led approaches like Strategic Niche Management (Hoogma et al. 2002; Schot and Geels 2008) and Transition Management (Rotmans 2003; Loorbach 2007) the farming-led processes have been under-addressed (Horlings 1996; Wolleswinkel et al. 2004). Partly as a consequence, the links between these two types of renewal processes have been, and still are, relatively weak. Yet documented experiences with either show the potential benefits of creating linkages between the two.

Early experiences with research-initiated projects have shown that in such projects it is not easy to mobilize the innovative potential and local knowledge of farmers and other directly involved stakeholders. A clear example of this is provided by P348, a Dutch participatory research programme (see Box 19.1).
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Programme 348 struggled hard to achieve its objectives, largely because farmers, societal organisations and researchers found it difficult to appreciate and adopt their presumed new roles (Grin et al. 2004: 131–134). As a response, it was decided to elaborate the rather abstract visions that had hitherto been developed into specific projects, to be proposed and led by at least one stakeholder and one researcher, and developed through additional course sessions. Nevertheless, also in these projects, various parties, due to the impact of the incumbent regime as well as the struggles it had been facing, found it difficult to take up their novel roles and mutual relations (Grin et al. 2004: 134–140).

Ironically, similar yet ‘mirror-image’ effects tend to occur in farmer-initiated projects. Horlings’ (1996: 307–319) evaluation of a range of joint, local farmers’ initiatives in the 1990s shows that such projects, while successfully mobilizing the energy, insight and innovative potential of farmers, often lack a clear view, adequate consideration on the ecological effects of their concepts, on the connections between their practices and other elements in the production chains, as well as to governmental policies and the innovation system. Similarly, a study of farmer-initiated innovations in the dairy sector showed that, while such innovations helped to resolve pressing problems and tended to trigger further innovations, they were often in need of better embedding in wider networks, novel knowledge and technologies, and support in bringing about more reflexivity (Wolleswinkel et al. 2004: 151–156).

Thus, research-led and farming-led initiatives both have strong points, but also weak points. This raises the question how strategies to stimulate transitions can make use of both of them.

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**Box 19.1 Programme 348**

In 1999, Programme 348 – New Husbandry Systems – was commissioned to DLO, a Dutch consortium of agricultural research institutes that had earned its reputation as a main pillar of agricultural modernization. The Ministry’s response to the 1997 classical swine fever outbreak, strongly emphasized that P348 intended to be an intensive, transdisciplinary cooperation that would lead to ‘something completely different’, changing societal conditions and appropriate for agricultural practice. The DLO programme leader thus decided to adopt a deliberative, interactive approach in combination with a method developed by the Interdepartmental Agency for Sustainable Development for designing sustainable systems (Weaver et al. 2000).
Learning for transitions

Need for reflexive learning

A system innovation or transition implies a re-assembly of the social, the technical, and the natural. As pointed out by Barbier (2010) this requires collective experiments where matters of concern and matters of fact (Latour 2004) are simultaneously at work in some specific ‘dispositif’ or ‘promising organizational arrangement’. Such experiments should have the following properties (Barbier et al. 2004):

- involve situations and practices of cooperative design between scientists, engineers and practitioners;
- involve a certain level of attention for the effects of re-framing positions and identities in systems of practice (farmers, land managers, R&D engineers, scientists, etc.) to smoothe the interactive process, but also for ethical reasons;
- allow a certain level of hybridity and openness for claims and concerns about producing ‘natural’ goods under a revision of the modern ontology of dividing nature and culture.

The re-assembly of the social, technical and natural should therefore include heterogeneous practices, a collective exploration of the potential of innovative design and will need to cross many of the organisational and institutional layers through newly emerging networks.

This will require reflexive learning in a process of reflexive modernization. Grin and Loeber (2007) brought back the notion of reflexive modernization from Beck (1992) and the structuration theory of Giddens (1991) to consider the re-structuration as the interrelated transformation of structure and action through structuration processes guided by the deliberate re-orientation of modernization. Reflexive learning implies that those involved not only learn how to do things in a new way, but also learn to do new things. This implies that various aspects are taken for granted, and the role of various stakeholders in a product chain can become matters of change. If such ‘radical’ changes can be made to work and are subsequently more widely used, they might eventually lead to a system innovation.

Dimensions of learning

To assess how reflexive learning may take place in practice, we need to discuss what is produced and learned in either research-led or farming-led initiatives, as well as which roles various participants play in these processes. We provide some suggestions based on the aforementioned LEARNing project that evaluated a variety of participatory research projects. The project distinguished two main dimensions which characterised the learning that took place in these projects, notably the primary expectations and the nature of agreement (see Table 19.1).
On primary expectations, a distinction is made between process performance and aim achievement concerning the learning and knowing which is at stake in the project or initiative. In some of the projects analysed in LEARNing the aims were of primary importance, according to the partners involved, while in others a high level of interaction, discussion and reflection based on sharing of knowledge was more crucial.

Concerning the nature of agreement a distinction is made between basing it on common values or on shared interests. In some of the projects, shared political or ethical values were important drivers for change. In other projects the participants relied more on sharing common aims or common understanding and identification of issues.

The LEARNing project distinguished some further dimensions of learning (Hubert et al. 2012, this book) that were used to analyse how learning was tackled by those involved in the reflexive and scaling-up work. Firstly, learning can be considered as an object, a matter of inquiry for scientific purpose (Table 19.2). In this perspective, the content of what is learnt is essential. In other cases, learning is intrinsically linked to acting, implying that learning is viewed as a process, which, as pointed out by Blackler (1995), has to be analysed as being mediated, situated, provisional, pragmatic and contested. Finally learning can be analysed according to its political content in the sense that it might result in changing the agency and the tangibility of the relation between power and knowledge.

### Role of researchers

Researchers can analyse and stimulate such learning processes through participatory research. This implies that the researchers engage in relationships with other project partners, e.g. promoters, lead-users, clients or other stakeholders, knowing that each of them is expected to have a direct or indirect effect on the research process itself. Here, the term participatory has a broad meaning, without ethical-political considerations about the nature of the relationships (and possible asymmetries) between researchers and others (Reason and Bradbury 2001). In practice, the nature of

### Table 19.1
Analysis of learning issues in various participatory research projects (LEARNing):

<table>
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<th>Nature of agreement</th>
<th>Process performance</th>
<th>Specific aims to be achieved</th>
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<tr>
<td>Based on common values, as well as on ethical and political commitment</td>
<td>Emerging ways of knowing</td>
<td>Adequate knowledge</td>
</tr>
<tr>
<td>Based on issues identification and shared interests</td>
<td>Methodological learning</td>
<td>Performance advice</td>
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partnership is often quite complex due to different agendas of partners, interest, goals, (personal) preferences, etc.

Some critical views on the potential of participatory research suggest that reciprocal partnership might work for public research, but that this would be very problematic for marketable research. Another criticism is that the embeddedness of researchers within the world of practitioners would limit their autonomy and independence. These claims and risks, however, rather than disqualify participatory research for these purposes, should be made a matter of enquiry to explore in detail what the potential of participatory research might be in various circumstances. This would lead to the following issues for further research:

- The nature and the effect of partnership settings on relations between actors;
- Comparing participation in the case of contractual research or public research;
- The practices of the embedded researcher: towards accountability.

In relation to this, we see a shift in literature: from a focus on methodological issues towards a focus on the practices in which the methods are being applied. This also brings to the surface the ‘politics’ involved in such practices: processes of power, legitimation and contestation. The research community will have to consider how to operate in such contexts.

### Agenda for (research on) learning

Research-led and farming-led initiatives have their starting points in two different types of knowledge, notably research-based knowledge and practice-based knowledge. Regarding research communities, we might expect some form of reflexive governance in attempts to build a research agenda on how to make a fruitful combination of the two. Although it is beyond the scope of this paper to provide a comprehensive

<table>
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<th>Type of learning</th>
<th>Dimensions</th>
<th>Important issues</th>
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<tr>
<td>Learning as object</td>
<td>The content of learning</td>
<td>Iterations between co-production of knowledge, norms and procedures</td>
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<td></td>
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<td>Change in relations, tools and skills</td>
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<td>Learning as action</td>
<td>The process of learning</td>
<td>Outcomes</td>
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<td>Monitoring</td>
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<td>Evaluation</td>
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<td></td>
<td></td>
<td>Phasing/steps/follow-up</td>
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<tr>
<td>Learning as politics</td>
<td>The performance of learning</td>
<td>How does the relation between power and knowledge operate?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What are the changes of identities and the re-distributions of relational-power?</td>
</tr>
</tbody>
</table>
analysis of how learning occurs and is supported in such processes, we will propose a set of main themes which should be addressed in order to support and analyse learning (Hubert et al. 2012, this book):

- Learning and knowing as a project, theory or ideology;
- Learning and knowing as a process;
- Evaluating and assessing processes relevant to learning and knowing;
- Institutionalising and organising in learning and knowing;
- Learning as a social and professional practice;
- Learning, knowing and building visions.

These themes are assumed to be of general relevance across many situations of change in Europe, although national priorities within this agenda may vary depending on history, local circumstances and stakeholders’ perspectives. Issues associated with each theme may also vary from country to country.

From learning to a transition

As has been mentioned above, system innovations take a long time to materialize (in the order of decades) because an existing system raises a variety of barriers for this to happen. While learning on novelties in niches is a crucial step in a system innovation process, this does not automatically lead to a transition. To stimulate this, a critical issue is how this learning can be made to affect developments in the regime.

New designs of (more) sustainable systems may have such effects, although not usually in a straightforward way. Box 19.2 gives an example of a project on the design of an animal friendly husbandry system for pigs by the name of ‘Comfort Class.’

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**Box 19.2 Comfort Class for Pigs**

In the Netherlands, a project on ‘animal centred design’ was started in the early 2000s. The Dierenbescherming (Animal Protection Society, APS) embraced the new concept and tried to convince others in public debates on the usefulness of the method. Researchers from DLO applied the approach to design new husbandry systems for pigs that fulfilled all their ethological needs. A popular, visualized depiction in glossy format of what was called ‘Comfort Class’ raised wide interest and appreciation. In June 2004, the Dutch Parliament urged the Minister of Agriculture to make Comfort Class the minimum standard in pig production and to stimulate similar developments in other sectors.

(continued)

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2 This air-traffic metaphor was chosen to depict the level of animal welfare (between Economy Class and First Class).
Pig farmers were explicitly invited to pick out specific ideas from the resulting design that they found useful for their own farms. Subsequently, both the concept of Comfort Class as well as specific novelties included have given rise to new experiments by farmers, including some that involved much more radical alterations to the initial designs (Bos and Grin 2010; Elzen et al. 2011).

The project subsequently triggered regime changes, including the ‘Beter Leven Kenmerk’ (BLK – Better Life Hallmark) issued by the Animal Protection Society (APS) to identify meat products from improved animal husbandry systems. The standards were inspired by Comfort Class experiences. At the time of writing, a wide range of retailers, butcheries and catering firms were listed on the APS website as selling BLK labelled meat. In December 2009, at the project’s closing festivity, the Minister of Agriculture made Pigs in Comfort Class the heart of her new policy on sustainable animal husbandry, which included fiscal advantages and subsidies for farmers investing in ‘better than regulatory required’ changes as well as a novel policy instrument, the so-called Small Business Innovation Research (SBIR)-tender to further develop such innovations. She also called upon retailers, catering firms and restaurants to address, together with pig farmers and the processing industry, the problem of higher costs of sustainable meat production.

The S-curve in Fig. 19.1 suggests that, after learning, a transition is a matter of ‘scaling-up’, but the example above shows that the dynamic is more complex. In an abstract sense, a sort of ‘scaling-up’ takes place, e.g. in terms of numbers of farmers adopting new pig husbandry systems, political and policy support for such systems, development of market instruments like the BLK. At a more concrete level, however, the novelty is not a fixed entity, nor is the way it is connected to a variety of other elements. At a closer look, ‘growth’ during a transition goes along with

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See: http://www.comfortclass.nl/

See: http://beterleven.dierenbescherming.nl/
continuous further development: of the novelty itself, leading to new varieties, of new types of users learning to work with it and thereby giving it meaning, of ‘supportive structures’ (BLK, SBIR), of regulation, and last, but not least, of ways to tackle resistance from various actors with stakes in the existing regime (Grin 2010, 2012). In terms of the preceding sections: learning never stops.

This is what Fig. 19.2 depicts in the area where niche developments affect regime developments: the variety of arrows indicates ongoing change of a variety of elements. Thus, the issue of niche developments affecting the regime is not a matter of mere ‘up-scaling’ but a matter of making a broad variety of connections between niche and regime.

In some recent studies the term (dynamic) anchoring has been used to describe processes of creating links between a niche and a regime (Loeber 2003; Grin and van Staveren 2007; Elzen et al. forthcoming). Using the notion of an anchor aptly describes that such connections initially are very fragile and may easily be broken again as is the case with an anchor: if forces go the right way, the anchor digs in deeper; if they go the other way the anchor lets go (Fig. 19.6).

Studies of processes of anchoring are still very rare and there is much more work to be done. We still know very little about which factors support or break up anchoring. What we do know is that anchors are not something constant but that this is subject to continuous change. Smith (2007) has used the term ‘translation’ to describe this. The example described above provides a clear example of this.

Still, the preceding discussions do give an indication of some important factors in relation to anchoring. First of all, learning in niches should not only involve niche actors. Some regime actors should also be involved as they are the ones that can start subsequent change in the regime. Another factor is that the dynamic of a system innovation is not a linear sequence of learning in niches and subsequently anchoring as a stepping stone towards scaling-up. As learning never stops, learning and anchoring are part of one and the same process. How they affect one another, therefore, should be an important issue for further research.
Anchoring only describes the initial stages in the change of a regime, which is intertwined with learning in niches. The result of anchoring is that a small part of the regime starts working with the novelty (a combination of new technologies and new practices) and that a small number of consumers buy their products. In economic terms this can be seen as an (emerging) niche market. A follow-on issue is how such niche markets may ‘grow’ to eventually lead to a transition of the regime (or a system innovation).

This is a rather complex process. Instead of presuming that a novelty is a ‘constant’ entity which tries to compete with an existing market with ‘constant’ products, we emphasize that both the novelty and the existing system are in continuous flux, because they are influenced by each other in this competitive process. We need further studies to analyse how this competition may develop in a situation of pressures for change on an incumbent regime (due to societal, political and market factors) and landscape trends.

A recent study (Elzen and Spoelstra 2010) proposes three key concepts to analyse how normative pressure on regimes can be increased; notably resource mobilization, (political) opportunity structures, and framing. Subsequently ongoing processes may create ‘opportunity’ structures that allow the pressure to be effective and stimulate novelties to break through. The study suggests four ‘streams’ that are relevant to determine this opportunity structure, notably a problem, regulatory/policy, technology and market stream. The conclusion is that normative pressures for change (part of the ‘problem’ stream) have their largest impact when the other streams become aligned at a certain point in time to create a ‘coherent package’.

This conceptualization can be a starting point to analyse in further detail how emerging, more sustainable novelties can eventually ‘break through’ to result in a transition. This should give us some clues about how a transition in a desirable, sustainable direction could be stimulated.

**Conclusion**

Although there is a lot we do not yet know on the latter stages in transitions (e.g. on ‘anchoring’ and on the subsequent ‘wider uptake’ of novelties) it is evident that the initial stage of learning on novelties in niches is critical as it sets the stage for these latter stages. Since we are not aiming for a simple improvement of existing systems, but for a transition or system innovation, the novelties need to be of a radical nature, implying that there will be various misfits with an existing regime. Since learning in niches will have to go along with anchoring processes to ensure that the changes have their impact at the regime level, a number of regime actors will have to be involved in these learning processes. But as the novelties have misfits with the regime this will never work if these regime actors take the regime characteristics for granted. The actors involved have to be prepared to question their own basic assumptions in relation to the regime. Only then will they be able to engage in a process of ‘reflexive learning’ which is critical in order to develop novelties further in such a way that they have an impact at the regime level.
The result of this reflexive learning is not only its content (e.g. new designs), but also the process by which new ‘social configurations’ are formed. These configurations include actors for whom the novelty has gained meaning and who continue working with it, either in the niche or the regime. Through them, anchoring takes place as a critical next step for the regime to change in the direction of sustainability.

In various countries a lot of learning already takes place on novelties, either in research-led projects or in farming-led initiatives. However, the connections between these two sources of learning are rather weak. One challenge for the future is to strengthen such connections since the research led-projects tend to emphasize sustainability aspects, while the farming-led initiatives tend to stress practical applicability. Both will be needed, however, en route towards sustainable agriculture. The reflexivity in all these projects is also a matter of concern. Although we have not explored this in detail, our conclusion from a variety of familiar projects is that reflexivity should get more attention than it currently receives.

To improve reflexive learning in research projects and farmer initiatives we first require a better understanding of how this can be stimulated and organized. This is an important challenge for transition research in the future. Furthermore, the successful governance of transitions requires a better understanding of processes of anchoring and of the wider uptake of novelties in a regime once anchoring becomes successful. Our understanding of these processes is still limited, and improving this is one crucial topic for transition research.

References


Stimulating transitions towards sustainable farming systems


Chapter 20

Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions

Laurens Klerkx, Barbara van Mierlo, and Cees Leeuwis

Abstract Over the years, there has been an evolution of systemic thinking in agricultural innovation studies, culminating in the agricultural innovation systems perspective. In an attempt to synthesize and organize the existing literature, this chapter reviews the literature on agricultural innovation, with the threefold goal of (1) sketching the evolution of systemic approaches to agricultural innovation and unravelling the different interpretations; (2) assessing key factors for innovation system performance and demonstrating the use of system thinking in the facilitation of processes of agricultural innovation by means of innovation brokers and reflexive process monitoring; and (3) formulating an agenda for future research. The main conclusion is that the agricultural innovation systems perspective provides a comprehensive view on actors and factors that co-determine innovation, and in this sense allows understanding the complexity of agricultural innovation. However, its holism is also a pitfall as it allows for many interpretations, which complicates a clear focus of this research field and the building of cumulative evidence. Hence, more work needs to be done conceptually and empirically.

Introduction

This chapter reviews the literature on agricultural innovation, with the threefold goal of (1) sketching the evolution of systemic approaches to agricultural innovation and unravelling the different interpretations; (2) assessing key factors for innovation...
Agricultural innovation for the purpose of this chapter is seen as a co-evolutionary process, i.e. combined technological, social, economic and institutional change. Therefore, production and exchange of (technical) knowledge are not the only prerequisites for innovation. Several additional factors play a key role, such as policy, legislation, infrastructure, funding, and market developments. Agricultural innovation is hence not just about adopting new technologies (Fig. 20.1); it also requires a balance amongst new technical practices and alternative ways of organizing. This concerns, for example, reorganizing markets, labour, land tenure and distribution of benefits (Leeuwis 2004; Röling 2009; Klerkx et al. 2010). Furthermore, agricultural innovation is not an inherently good and value free process, but normatively laden and driven by different worldviews and visions. Correspondingly, different development directions exist, each with its own winners and losers (Vanloqueren and Baret 2009; Thompson and Scoones 2009; Brooks and Loevinsohn 2011).

The above view on agricultural innovation has resulted from several in-depth studies of actual innovation processes, which discarded simplistic views on innovation as an invention (in the form of the results of scientific research, or the development of a technology) that is transferred to and adopted as such by the intended users. This broader view on agricultural innovation, seen as the result of multiple interactions between components of farming systems, supply chains and economic systems, policy environments, and societal systems, is reflected in the idea that system performance and demonstrating the use of system thinking in the facilitation of processes of agricultural innovation; and (3) formulating an agenda for future research.

Fig. 20.1 Innovation is not just technology, but is rather a comprehensive vision of what the future should look like and which requires changes in many ambits. Innovation is driven by people’s needs, ambitions and dreams, and requires that people at different positions in society change the way they work and live.
innovation is an outcome of ‘agricultural innovation systems’ (AIS). The thinking about agricultural innovation systems can be seen as the most recent in a family of systems approaches. The perspective is still in development, and—as we will show in this chapter—tends to be approached in different ways: it is looked upon as an infrastructure or as a process, has been located at different geographical scale levels, and includes different types of research, analysis and intervention (Pant and Hambly-Odame 2009; Spielman et al. 2009; Hall and Clark 2010; Brooks and Loevinsohn 2011). This chapter intends to shed more light on the development in thinking about the role of systems in agricultural innovation.

The chapter first gives a brief historical overview of approaches to agricultural innovation that have preceded and implicitly or explicitly contributed to the AIS concept. Then, different interpretations of AIS thinking are presented, followed by enablers and disablers of AIS functioning. After displaying research methodological approaches to AIS, implications of AIS thinking for the support of innovation processes are given, displaying some emergent approaches. The chapter concludes with an outlook on emergent research questions.

Evolution in thinking on systems approaches

Differences and similarities in subsequent perspectives to agricultural innovation

A wide range of approaches to agricultural innovation has emerged over the past 40 years (see Leeuwis 2004; Leeuwis and Aarts 2011). Some well-known examples are the Transfer of Technology approach (Jarrett 1985), Induced Innovation (Ruttan and Hayami 1984), Training and Visit System (Hulme 1992), Participatory Research and Participatory Technology Development (Farrington and Martin 1988; Neef and Neubert 2011), Farmer First (Chambers et al. 1989), and Agricultural Knowledge and Information Systems (AKIS) (Röling 2009). While agricultural innovation studies appear to have developed in relative isolation of ‘generic’ innovation studies which focus on industrial innovation, there has always been a degree of cross-fertilization. Generic systems studies have influenced systemic thinking in agricultural innovation studies, and vice versa. For example, the works of Checkland (1981) and Kline and Rosenberg (1986) have influenced AKIS thinking. Four main theoretical traditions with a cumulative degree of systemic thinking can be distinguished. Table 20.1 provides an overview based on several authors who have reviewed the major conceptual, organizational, and institutional features connected to these approaches.

It needs to be noted that the different approaches displayed in Table 20.1 are not necessarily mutually exclusive. Some approaches consecutively fed into each other. Others emerged in parallel: the AKIS and AIS approaches. Furthermore, different approaches co-exist: besides the emergent AIS thinking, there is still great adherence
Table 20.1  Shifts in theoretical perspectives on agricultural innovation (Adapted from Sanginga et al. 2009 and integrated with Hall et al. 2006; Vellema 2008; Pant and Hambly-Odame 2009). The theoretical perspectives on agricultural innovation have broadened over time in terms of the diversity of relevant actors; the recognition of innovation as a co-development process; innovation as being both technical, social, economic and institutional change; and as a complex, non-linear process

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Farming system fit Co-evolved technologies better fit to livelihood systems

Capacities to innovate, learn and change
The system concepts behind the different perspectives on agricultural innovation

The main difference in the system concepts appear to lie in how they consider the broader institutional and policy environment, and changes in these, as relevant to agricultural innovation, i.e. where they draw the system boundaries. The different system concepts are as follows:

- The system concept in adoption and diffusion theories, linked to perspectives such as Transfer of Technology and National Agricultural Research Systems, is entirely social. Innovations are said to spread via communication through social systems which are networks of close friends, relatives and neighbours. Mass media play a role in later stages of the diffusion process when large groups are motivated to adopt a new technology or product (Rogers 1995). The institutional and policy context is seen as an external factor that influences adoption by individual farmers.

- Farming Systems Research (FSR) emerged in response to the limitations and undesirable effects of the linear technology transfer approaches. From the start, a main principle of Farming Systems Research has been the need for partnerships between farmers and technical and social scientists to involve farmers in the design of technological solutions (Norman 2002; Pant and Hambly-Odame 2009). More recently, other stakeholders, such as extensionists and policy actors, are expected to participate in a collective design process as well. Over the years, the aim of Farming Systems Research has broadened from improving the yield of specific crops to sustainable livelihoods, i.e. improved productivity integrated with social equity and protection of natural resources. The units of analysis in Farming Systems Research are primarily farms and farmer groups within their direct biophysical and socioeconomic context: “The ‘farming system’ is understood as including all members of the farming family and all the biotechnical processes involved in farming.” (Dedieu et al. 2009: 109)

- The concept of Agricultural Knowledge and Information Systems (AKIS) also emerged as a critique towards linear models of innovation, but again draws broader boundaries. In an early definition AKIS is defined as “a set of agricultural organizations and/or persons, and the links and interactions between them, engaged in such processes as the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working synergistically to support decision making, problem solving and innovation in a given country’s agriculture or domain thereof” (Röling 1990: 1). As can be noted in this definition, AKIS were initially seen as having a clear (national or sectoral) boundary and a common purpose. This raised the critique
Systems approaches to agricultural innovation (see e.g. Leeuwis et al. 1990) that the perspective still adopted a mechanistic ‘hard systems’ view whereby it was assumed systems exist independently from the observer, and can be analysed, understood and ‘engineered’ towards an unambiguous goal – a view also recognizable in adoption-diffusion studies and some farming systems studies. Later on, Röling and others more consistently adopted a soft systems thinking (Checkland 1981) perspective, emphasizing that a system and its boundaries will be understood by actors in diverging ways given their different objectives and life worlds. Thus, the AKIS approach came to focus on the coordination among actors with different perspectives of who are part of a ‘human activity system’ (Röling 1992) with arbitrary boundaries. Here the systems concept became used merely as a strategy to make people think of themselves as being part of a system, with the view of enhancing coordination (see e.g. Engel 1995). However, organisations like FAO have continued to use concepts of AKIS that emphasize clearer boundaries and goals (Rivera et al. 2005).

- Agricultural Innovation Systems (AIS) thinking emerged parallel to AKIS (Assefa et al. 2009; Pant and Hambly-Odame 2009), influenced by ideas on ‘national systems of innovation’ as developed by Lundvall (1992) and pioneered by Andy Hall and colleagues (e.g. Hall et al. 2001, 2006) in the agricultural domain. AIS are defined as “a network of organisations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organisation into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge” (Hall et al. 2006: vi–vii).

The similarities between AKIS and AIS, according to Rivera et al. (2006: 587), can be explained by the fact that “AIS did not evolve as a further development of the AKIS framework, but rather as a parallel development which did not build upon the insights of the AKIS literature and the practical experience in applying this framework. One reason for this parallel rather than consecutive development may be due to the fact that, considering the background of the leading authors, AKIS evolved from the extension perspective, while AIS was developed from a research perspective.” While the definitions of AIS and AKS bear a clear resemblance, according to Hall et al. (2006) the main difference between AIS and AKIS lies in the greater and more explicit focus of AIS on the influence of institutions (seen as organisations like companies, public research institutes and governmental entities) and infrastructures on learning and innovation, and its explicit focus to include all relevant organizations beyond agricultural research and extension systems. Hall et al. (2006: 25), for example, see it as a weakness of AKIS that “the focus is restricted to actors and processes in the rural environment and the framework pays limited attention to the role of markets (especially input and output markets), the private sector, the enabling

1Recently, especially in context of European Union policy and research programs, the two concepts have more or less ‘merged’, because the acronym AKIS has been reinterpreted as ‘Agricultural Knowledge and Innovation Systems’ (Dockès et al. 2011).
policy environment, and other disciplines and sectors. The AKIS framework recognizes the importance of transferring information from farmers to research systems, but tends to suggest that most technologies will be transferred from researchers down to farmers.”

The main achievement of the AIS approach thus appears to be that it has further broadened the scope of analysts and interventionists on the complex interactions between a multitude of players and sub-systems that characterize innovation. For major societal challenges like the lack of food security, the increasing impoverishment of small farmers, the effects of global warming, animal diseases, depletion and pollution of natural resources, the increase in the level of systemic thinking can be considered a necessity (Röling 2009; Brooks and Loevinsohn 2011 – see also Elzen et al. 2012, this volume). A weakness when compared to the AKIS perspective (at least the soft systems variant) is that many AIS definitions still suggest that there is somehow a common goal or focus, which is related to enhancing innovation. Hence there tends to be little recognition that the goals, interests and perspectives of interdependent actors are likely to diverge and be conflictive.

Differences in conceptualization and operationalization of AIS

As becomes clear from its definition and as shows from Table 20.1, AIS are essentially about multi-actor interactions and structures (infrastructures, policies, institutions) that may serve to enhance innovation, with an understanding that innovation goes beyond technology development, but also often requires an improvement of parts of the innovation system itself to enable co-ordination of the relevant sub-systems. While there appears to be a shared understanding on elements within AIS conducive to innovation, different variants and strands of thinking continue to exist. As we will see below, these are associated with how the concept of a system is interpreted.

An infrastructural view of AIS

In a number of studies and analysis AIS tends to be approached as an ‘innovation support infrastructure’, sometimes biased towards the public sector (Vellema 2008). This goes along with studies that make a predominantly static analysis of the presence and interaction of actors (e.g. research institutes, financing organizations), and the infrastructures that govern the behaviour of actors in innovation processes (rules and regulation and physical infrastructures like transportation systems) and which exercise direct influence on innovation outcomes (e.g. intellectual property laws) present in countries. The main question is to what extent this system supports, or does not support and even constrain, agricultural innovation (e.g. Sorensen 2011). These system perspectives thus see innovation systems in terms of creating ‘fertile
soil’ for innovation to grow. Such studies interpret AIS both as a national innovation system (Temel 2004; Leitgeb et al. 2011; Sorensen 2011) and as a (sub-) sectoral innovation system (Blay-Palmer 2005; Gildemacher et al. 2009). This perspective on AIS correlates with a fairly static view on networks, in which embeddedness of an actor in the structure of a network, the existence of structural holes and weak ties in networks, co-determine the potential for innovation, as they give information on the available resource configurations (knowledge, finance, materials) and the potential for creative recombination of knowledge, technologies and practices (Spielman et al. 2009; Klerkx and Leeuwis 2009a). With its emphasis on clear boundaries and pre-assumed goals (i.e. the system exists to support innovation) the infrastructural view still has affinity with hard systems thinking.

A process view of AIS

Other authors tend to highlight the process side of AIS. This often results in a more dynamic analysis to assess the co-evolutionary process of interactive development of technology, practices, markets and institutions. This implies seeing innovation systems as self-organizing growing networks of actors connected to the development of a certain novelty, emerging from a dominant incumbent production system (characterized by certain technologies, practices) or value chain configuration and moving towards an alternative to the incumbent system or even replacing it (Ekboir 2003; Hall and Clark 2010; Klerkx et al. 2010). This implies seeing AIS as ‘systems in the making’. According to this view, there is a central focus on how an agency of innovators is embedded within and supported by a broader socio-institutional and technological environment, or conversely, the efforts of innovators to change their socio-institutional and technological environment. This way of looking at systems has affinity with complex adaptive systems thinking which emphasizes processes of self-organization, coincidence and non-linear dynamics (i.e. sudden shifts) (Ekboir 2003; Leeuwis and Aarts 2011). This view on agricultural innovation systems as self-organizing entities with increasingly systemic properties bears some resemblance to work which does not explicitly use an innovation systems approach, but rather a system innovation approach to study (radical) agricultural innovation (Roep et al. 2003; Knickel et al. 2009; Elzen et al. 2011; Lamine 2011; Elzen et al. 2012, this volume).

Niches in which newcomers experiment with a novelty in practice are seen as potential starting points for changing dominant, incumbent socio-technical systems that have adverse societal effects. The central dynamic is considered to be niche branching: a process in which niches arise and grow, while a specific new technology is applied in an increasing number of market segments. It is a co-evolutionary process in which changes in the knowledge of actors, preferences of users, informal rules, regulation and infrastructure occur together with consistent changes in technology. This happens if the niches align with, and are strengthened by, instability in the dominant system that is induced by pressure from external developments at
what is called the landscape level (such as an economic crisis, a natural disaster, or demographic change) (Geels and Schot 2007; Kemp et al. 1998; Elzen et al. 2012, this volume). This focus of innovation as a competition between novelties and incumbent rules and systems connects to socio-political and political economy studies on inequalities emerging from agricultural innovation (Thompson and Scoones 2009; Vanloqueren and Baret 2009). Niches may also compete among each other to become the new dominant technology or practice.

Some researchers link the two approaches (innovation systems and system innovation) (Markard and Truffer 2008; van Mierlo et al. 2010a). In this combined approach, niches are seen as ‘technological innovation systems’, i.e. as specific projects or as sets of projects connected to a similar novel technology or practice that may well cut across countries or sectors (Hekkert et al. 2007). Although the term suggests a narrow technology focus, technological innovation systems thinking does comprise accompanying social and institutional change. While the term technological innovation system is not actually used, this type of technology or practice focus has been applied frequently in the study of agricultural innovation using the AIS concept (see e.g. Hall and Clark 2010; Brooks and Loevinsohn 2011).

**A functionalist view of AIS**

*Functionalist approaches* to innovation systems (Hekkert et al. 2007) tend to focus on whether or not specific functions are fulfilled. In essence this kind of systems thinking draws upon a biological metaphor, whereby the whole (the organism) cannot function well if sub- and aspect-systems (e.g. organs and transport) are lacking or do not interact harmoniously. The functions of the innovation systems approach is linked to co-evolutionary approaches (equalling technological innovation systems to niches) as it intends to systematically map technological innovation system activities, providing insights into “the interaction of forces that determine the slow and difficult change of a merely locked-in system towards a new equilibrium” (Hekkert et al. 2007: 418). Seven functions have been identified, which should be present in well-functioning technological innovation systems, consecutively or simultaneously: (1) entrepreneurial activities, (2) knowledge development, (3) knowledge diffusion in networks, (4) guidance of the search, (5) market formation, (6) resource mobilization, (7) creation of legitimacy/overcoming resistance to change. Mapping the functions, and the interaction between them, are expected to inform policy by identifying ‘motors of innovation’, i.e. sets of functions that reinforce each other and accelerate developments, as well as lacking functions which hinder innovation. This approach has rarely been applied to the analysis of AIS, but has been mentioned as an interesting avenue for exploration (World Bank 2008).

As we can see above, there remain different academic strands of thinking about (agricultural) innovation systems. There continue to exist different views regarding boundaries (along geographical lines or along technology lines) and on the
system is (the support infrastructure of what is to change). Moreover, we see different implicit assumptions and conceptions about how change in systems comes about (through competition in a selection environment, through the provision of functionalities, through coincidence and self-organisation, etc.) and different orientations towards using the term system (as a descriptive or normative concept). Perhaps not all viewpoints are mutually exclusive, but there is certainly enough space for confusion and misunderstanding.

**Performance of AIS: key enablers and disablers**

In the previous sections we have seen that various views on agricultural innovation systems co-exist. It is interesting to note that most AIS perspectives use the term system in a normative rather than as a descriptive term. Innovation systems thinkers tend to be concerned primarily about how agricultural innovation systems should work (namely as systems that produce innovation) and with explaining why actors involved in networks do not collaborate, perform functions and/or work towards concerted action and do not show the system-like property of innovation. In fact, from a descriptive point of view one could argue that the use of the term system is a bit odd (see Leeuwis et al. 1990). Given these normative overtones in the AIS community it is not surprising that much has been written already on what are key enablers and disablers of innovation systems functioning. As demonstrated below, ideas and insights on this tend to coincide with the different conceptual viewpoints on AIS presented in the previous section.

**Key enablers for innovation systems performance**

Depending on the perspective of AIS that is used, different ideas exist as regards what is needed to enhance its performance. Taking the view on AIS as innovation support systems or as providing a fertile soil for innovation, it is often about the set of factors that determine networking for innovation and the formation of what have been called variously multi-stakeholder platforms (Röling 1994), innovation configurations (Engel 1995), innovation networks (Klerkx et al. 2010) or as public-private partnerships (PPPs) (Spielman and von Grebmer 2006). To enhance such ‘networking for innovation’, the AIS literature emphasises the need to arrive at shared visions, well-established linkages and information flows amongst different public and private actors, conducive incentives that enhance cooperation, adequate market, legislative and policy environments, and well-developed human capital (Hall et al. 2001; Spielman et al. 2008; Brooks and Loevinsohn 2011). While much of this AIS work has been carried out in developing countries, similar criteria for well-functioning have also been suggested for industrialized countries.
A well-functioning AIS is then characterised by (Spielman et al. 2008):

- Learning within and between firms and organisations in order to innovate
- Strengthening individual and collective capabilities to innovate
- Demand and supply-driven science and technology
- Innovation agents focusing on complex and dynamic interactions
- Network-based knowledge dissemination
- Both embedded and dis-embedded knowledge dissemination: in both tacit and codified forms
- Decentralized management of innovation processes

Taking the view on AIS as complex adaptive systems or as niches that interact with regimes to establish change, approaches such as strategic niche management (Kemp et al. 1998) advocate combinations of measures to stimulate niche development and protect and nurture niches from incumbent (regime) players. Central elements in this approach are: (1) The articulation of expectations and visions. Expectations are considered crucial for niche development because they provide direction to learning processes, attract attention, and legitimate (continuing) protection and nurturing; (2) The building of social networks. This process is important to create a constituency behind the new technology, facilitate interactions between relevant stakeholders, and provide the necessary resources (money, people, expertise); (3) Learning processes of multiple dimensions: (a) technical aspects and design specifications, (b) market and user preferences, (c) cultural and symbolic meaning, (d) infrastructure and maintenance networks, (e) industry and production networks, (f) regulations and government policy, (g) societal and environmental effects. This approach has been applied in methods like interactive reflexive design (Bos et al. 2009; Elzen et al. 2012, this volume).

Clearly, the functionalist approach sees as performance criteria the fulfilment of the functions mentioned in the previous section. All three views on innovation systems appear to discern similar enabling factors, with the main difference that the complexity/niche-regime perspective and the functionalist perspective appear to have a more central concern with regards to power struggles and negotiation between innovators (niches) and incumbents (regime).

**Key disablers of innovation systems performance**

Often innovation systems do not act as systems and display imperfections or system failures that hinder learning and innovation. Creating and fostering effective linkages amongst heterogeneous sets of actors (i.e. the formation of adequate innovation configurations, coalitions, PPPs) is often hindered by different technological, social, economic and cultural divides (Pant and Hambly-Odame 2006; Oreszczyń et al. 2010). Such divides may be caused, for example, by different incentive systems for public and private actors, differences between local indigenous knowledge
systems and formal scientific knowledge systems, social and cultural differences that cause exclusion of certain actors and ideological differences (Fig. 20.2).

Different categories of innovation system failures exist (Klein Woolthuis et al. 2005; van Mierlo et al. 2010a):

- **Infrastructural failures** concern (absence of) the physical infrastructure, such as railroads and telecom are constraints requiring major investments that cannot be made independently by the actors of the system. They also concern investments in knowledge infrastructure (R&D facilities) and financial infrastructure.

- **Hard institutional failure** refers to laws, regulations and any other formalised rules, or the lack of them, hampering innovation. For example, lack of IP regulation takes away incentives from innovators as they cannot protect their innovation. Absence of environmental regulation on radically different systems, having an institutional vacuum, may slow down certain developments.

- **Soft institutional failure** refers to unwritten rules, norms, values, culture, or ‘the way business is done’. They affect how actors interact, but also relate to their (in) ability to change their norms and values in order to enable innovation to take place.

- Related to institutional failures is **strong network failure**, which refers to actors locked into their relationship, which causes myopia and blocks new ideas from
outside and prohibits other potentially fruitful collaborations. *Weak network failure* refers to a situation where actors are not well connected and fruitful cycles of learning and innovation may be prevented because there is no creative recombination of knowledge and resources. These two failures indicate an apparent paradox in networking for innovation: a quest for a balance between openness and closure, informal or formalized interaction, trust relationships or contracts (Håkansson and Ford 2002).

- *Capabilities failure* points to the lack of technical and organizational capacity of the system to adapt to and manage new technology and organizational innovations, such as a certain level of entrepreneurship, adequately educated persons, time to dedicate to innovation, and networking skills.
- Finally, *market structure failures* refer to the positions of and relations between market parties. Such as a monopoly or the lack of transparency in the ever enlarging food chains, but also imperfections in the ‘knowledge market’ (Klerkx and Leeuwis 2009a).

To assess the enablers and disablers of AIS functioning, a number of methods have emerged or are suggested, as not all types of analysis have yet matured. We will discuss these in the next section.

### Methods for researching AIS

To analyse and assess innovation support systems (static view) and innovation systems in the making (dynamic view) a number of *innovation system analysis methods* have been applied and are proposed (see e.g. Spielman et al. 2009 for an overview):

- **Institutional analysis**, looking at the influence of institutional enablers and constraints in relation to innovation systems performance or of parts of it (Hall et al. 2001; Clark et al. 2003; Klerkx and Leeuwis 2008; Spielman et al. 2008). There are many studies that focus on such ‘soft institutional failures’ looking at projects and governance mechanisms such as R&D planning schemes (e.g. Hall et al. 2001; Klerkx and Leeuwis 2008). This kind of analysis can be approached from both an infrastructural and a process perspective.
- **Social network analysis** to map institutional linkages (Temel 2004; Spielman et al. 2011), visualizing relationships between actors, and assessing the position of actors within the system (in terms of centrality, number of ties, strength of ties). This type of research is generally used in a more infrastructural and static perspective.
- **Innovation histories** or **innovation journeys** (Douthwaite and Ashby 2005; Spielman et al. 2009; Klerkx et al. 2010). This is a way of recording innovation processes by means of timelines, focusing on important events and the relationships and activities which defined those events and influenced the outcome of the innovation process. Clearly, this type of research shows affinity with the process view of AIS.
• **Game-theory modelling.** According to Spielman et al. (2009) this is based on emerging work in evolutionary economics and offers insight into the value of the innovation systems framework, illustrating the spontaneous processes of social self-organization and the ways in which public policy and organizational structures can affect these processes. Again, this type of analysis tends to be process-oriented.

• **Benchmark analysis,** based on indicators such as patents, R&D expenditures, numbers of researchers, and input-output/spill-over analysis on R&D investment, returns on risk capital, etc. (Spielman et al. 2009). This type of research generally starts from an infrastructural and static perspective.

• **Innovation system analysis,** using the different categories of system failures cross-tabulated against actor groups to identify failures and underlying motives in the innovation system as well as to identify windows of opportunity, for both infrastructural (Gildemacher et al. 2009), and process-oriented analysis (Klein Woolthuis et al. 2005; van Mierlo et al. 2010a).

• **Functions of innovation systems approach:** are all functions properly performed? (Hekkert et al. 2007). This type of analysis has been mostly executed in a process-oriented fashion.

Since AIS thinking has been around for a while, the AIS approach has proved its value as a comprehensive framework for analysing strengths and weaknesses in agricultural innovation systems in different contexts. However, it has been less applied as an operational concept with policy options and targeted interventions in innovation processes (Spielman 2006). In the next section we will discuss some emergent interventions which take a specific innovation systems perspective.

**Stimulating AIS: Interventions at different levels**

Recently, some methods and toolkits for AIS interventions have been developed (World Bank 2008; van Mierlo et al. 2010b, c). Roughly two types of interventions can be discerned, which are obviously closely linked to each other:

• **Innovation support system**-level interventions aimed at making structural changes in the innovation support system (research, extension, education, funding, etc.) and the enabling policy environment to optimize AIS functioning.

• **Innovation network**-level interventions connected to stimulating the formation of innovation networks (called variously innovation projects, platforms, coalitions, public/private partnerships) which are usually below the niche level (niches consist of several networks working on similar topics) and supporting their role and functioning, e.g. in forming linkages, fostering partnership, stimulating learning, and helping them to exercise agency to bring about broader institutional change.
As regards support system-level interventions, this often deals with changing or creating policies and institutional arrangements conducive to innovation (World Bank 2008). For example, Spielman et al. (2008) generate several recommendations for this type of interventions from a structural analysis in Sub-Saharan Africa. They typically deal with overall policies affecting funding, incentives, accountability mechanisms and interaction patterns (Fig. 20.3). To strengthen the education systems the authors have the following suggestions among others:

- Realign visions and mandates: get a common focus on development objectives of all AIS players.
- Develop the human capital base by enhancing innovative capabilities: investments in training.
- Facilitate the flow of information and technology: i.e. change extension systems, develop systemic intermediaries.
- Induce change in organisational cultures, behaviours, and practices: e.g. change the orientation of research systems towards demand-driven modes of working.
- Create a conducive and appropriate policy environment: reduce the capriciousness of policies, increase influence of the sector on policies.

As existent innovation systems in terms of policies and instruments may not be optimal for supporting radically different developments but rather support incremental change and optimization of existing production systems, several authors (Bos et al. 2009; Klerkx et al. 2010; van Mierlo et al. 2010a, b), discuss the importance of structurally changing, for example, existent legislation and funding instruments, as these may favour incumbent systems but hinder innovative development. This deals, for example, with environmental regulations that do not accommodate new technologies and lack of risk capital facilities.
Innovation support system interventions are expected to create either a generic or a novelty-specific innovation enabling context in which innovation networks or partnerships develop and become productive as the chance on innovation increases. However, at the local level of these networks a conducive context is needed as well, and ideally, network level interventions and broader system level interventions feed into each other. In the next section we describe two specific, recently developed types of interventions aimed at stimulating innovation networks with a broader systemic perspective: (1) via researchers and extensionists/advisors acting as innovation brokers and (2) with the aid of reflexive monitoring.

**Interventions aimed at innovation network performance:**
**Dedicated innovation brokers as systemic intermediaries**

Currently, the emergence of new organizational forms for stimulating agricultural innovation is evident, appearing under a variety of banners such as transdisciplinary research projects, network approaches, system innovation programs, and public-private partnerships. Although there are many operational differences they all somehow facilitate a collective process in which new social and technical solutions, or at least their contours, are designed, agreed, and/or acted upon. Interventions that aim at fostering innovation network thus often deal with improving communication between innovating actors. Despite the existence of a broad literature on the facilitation of interactive processes and social learning in agriculture (see e.g. Leeuwis and Pyburn 2002; Cristóvão et al. 2012, this volume), the literature on embedding this facilitation role as a specialised function in AIS is still limited. Although mentioned as a solution to innovation system fragmentation and underperformance (Spielman and von Grebmer 2006; World Bank 2008; Oreszczyn et al. 2010), the topic appears to have been less systematically investigated in the agricultural sector. Nonetheless, there is an emerging experience of actors that explicitly dedicate themselves and position themselves as a systemic intermediary and a systemic facilitator, an in-between in a many-to-many relationship (Howells 2006; Leeuwis and Aarts 2011). These systemic intermediaries act as *innovation brokers*, whose main purpose is to build linkages in AIS and facilitate multi-actor interaction in innovation (Klerkx et al. 2009; Klerkx and Leeuwis 2009a). In some countries, such as the Netherlands, these innovation brokers have emerged as specialized actors (Klerkx and Leeuwis 2009a), but in other countries several types of organizations (e.g. research organizations, NGOs) have taken up this role (Klerkx et al. 2009).

However, embedding such an innovation broker role as an additional role to, for example, ‘classical’ research and extension is challenging. As the World Bank (2008) argues, research organizations should focus beyond the connection with farmers (through participatory research) on the interface with private sector actors in the value chain (traders, processors) and broader civil society, and must change their governance systems towards partnerships. The latter also includes rewarding
alternative forms of research (such as action research – see Hocdé et al. 2008; Van Paassen et al. 2011; Schut et al. 2011) and cooperation of different actors, instead of focusing on publications.

However, beyond changing the incentives for the research organizations and their roles, this also requires changing perspectives. Research funding organizations need to take an innovation systems view and adapt their funding mechanisms in such a way that research agenda setting and funding processes enable this kind of multi-actor partnerships (Klerkx and Leeuwis 2009b). For example, a clear challenge is to balance long-term and short-term perspectives in research through multi-actor partnerships, to ensure all partners are satisfied in their needs and remain motivated (Klerkx and Leeuwis 2009b).

As regards the role of extension organisations, or more broadly, advisory service providers, who as a rule have acted as intermediaries in the translation and exchange of knowledge for problem solving and innovation, the shift to such a systemic intermediary and systemic facilitator role is still challenging (Leeuwis 2004; Rivera and Sulaiman 2009).

Leeuwis and Aarts have summarized (see Table 20.2) what the changes towards such an innovation broker or systemic facilitator role imply for communication professionals such as extension and advisors, but they also apply to researchers who intend to foster partnerships, e.g. action researchers. This connects to three main functions important for fostering networks and partnerships (Klerkx et al. 2009; Leeuwis and Aarts 2011):

- **Demand articulation**: articulating innovation needs and visions and corresponding demands in terms of technology, knowledge, funding and policy, achieved through problem diagnosis and foresight exercises.
- **Network composition**: facilitation of linkages amongst relevant actors, i.e. scanning, scoping, filtering and matchmaking of possible cooperation partners.
- **Innovation process management**: enhancing alignment in heterogeneous networks constituted by actors with different institutional reference frames related to norms, values, incentive and reward systems. It includes a host of facilitation tasks which ensure that networks are sustained and become productive, e.g. through the building of trust, establishing working procedures, fostering learning, managing conflict and intellectual property management.

**Enhancing the reflexivity of innovation networks**

Innovation networks meet specific challenges like the inherent unpredictability of the outcome of their actions, the many uncertainties they need to deal with, the social ambiguity and the need to be and remain flexible and ready to embark on new paths. To support them in meeting these challenges reflexive monitoring has been developed. This type of monitoring and evaluation encourages participants of an innovation network to keep reflecting on the relationships between the key items: the long term goals of an innovation endeavour, normalized practices, plus the
Table 20.2 Roles of systemic facilitators/innovation brokers (Adapted from Leeuwis and Aarts 2011), which consist of three main roles: demand articulation, network composition and innovation process management

<table>
<thead>
<tr>
<th>Demand articulation</th>
<th>Network composition</th>
<th>Innovation process management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate and visualise interdependencies among stakeholder practices</td>
<td>Make an inventory of existing initiatives, complemented with stakeholder analysis</td>
<td>Identify and propose process facilitators who are credible and trusted by the stakeholders involved</td>
</tr>
<tr>
<td>Explore and exchange stakeholder perspectives (values, problems, aspirations, context etc.)</td>
<td>Build on existing initiatives for change and the networks around these</td>
<td>Work towards process agreements, including dealing with media, mandates etc.</td>
</tr>
<tr>
<td>Through discussion, role playing, dramatization, visits, filmed interviews, informality, humour, fun etc.</td>
<td>Arrange contact between disconnected networks who may have compatible interests</td>
<td>Probe to explicate the interests and fears that underlie mobilised arguments and counter-arguments</td>
</tr>
<tr>
<td>Visualise invisible bio-physical processes with the help of discovery learning tools or simulation</td>
<td>Work towards ‘coalitions of the willing’ and exclude actors who do not feel interdependent</td>
<td>Steer collaborative research activities to questions relevant to less resourceful stakeholders</td>
</tr>
<tr>
<td>Explore past and current trends and likely futures if nothing changes</td>
<td>Mobilise pressures from outside (carrots and sticks) to enhance feelings of interdependence</td>
<td>Make stakeholders talk in terms of proposals and counter-proposals</td>
</tr>
<tr>
<td>Use visioning tools and scenario analysis to imagine (and find common ground on) possible futures</td>
<td>Forge/broker contact between existing networks and outsiders and/or outside expertise</td>
<td>Ensure regular communication with constituents to take them along in the process</td>
</tr>
<tr>
<td>Discuss institutional and other influences that reinforce existing patterns/problems</td>
<td></td>
<td>Translate agreed upon problems and solutions into storylines and symbols that are likely to resonate in society</td>
</tr>
<tr>
<td>Organise contact with others who have encountered and managed similar problems</td>
<td></td>
<td>Use media and lobby tactics to influence societal agenda’s and advocate solutions (with the help of storylines/symbols)</td>
</tr>
<tr>
<td>Elicit uncertainties that hinder change, and design collaborative investigation and experimentation to develop common starting points</td>
<td></td>
<td>Use practical actions and experiments as source of reflection and learning, rather than organising discussion and reflection only</td>
</tr>
<tr>
<td></td>
<td>Make an inventory of existing initiatives, complemented with stakeholder analysis</td>
<td>Organise regular reflection on process dynamics and satisfaction with outcomes</td>
</tr>
<tr>
<td></td>
<td>Build on existing initiatives for change and the networks around these</td>
<td></td>
</tr>
</tbody>
</table>
developments in the systems surrounding them, that offer not only barriers, but also opportunities for agricultural innovation.

The central aim of this type of monitoring is to increase reflexivity; this is the case when the network develops new coordinated ways of acting while the institutional context is changing too (and partly as a result of this). The latter is important, since innovation networks bring together actors who are part and parcel of problematic institutional contexts that are seen to demand innovation (van Mierlo et al. 2010a, b).

There are essential differences between reflexive monitoring and other more familiar forms of monitoring and evaluation (see Table 20.3 for a comparison of different forms of evaluation). The future simply does not develop as predicted, finances are often uncertain, there are often conflicts of interest and people have a tendency to keep plodding along the same old path. Consequently, strategies tend to be developed in an iterative fashion rather than at the start and the objectives often change during the course of an innovation trajectory. Moreover, results often only become visible after a long time. It is therefore not very realistic to have an expert collect data for subsequent evaluation using pre-defined objectives with a result-oriented approach. The Logical Framework approach is commonly used in the agricultural domain (IFAD 2006).

Participatory types of monitoring and evaluation in which the actors have their say can help ensure that participants learn, and learn together. A world famous example is fourth-generation evaluation (Guba and Lincoln 1989). In agriculture the MSC method (most significant change) is a well-known example of fourth generation evaluation (Davies and Dart 2005). Reflexive monitoring takes it a step further, though. Learning is not the end in itself. It is about learning to tackle the challenges that are encountered in innovation trajectories, by developing possible solutions jointly. Participatory methods base their monitoring on the current

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**Table 20.3** Key characteristics of forms of monitoring and evaluation (Adapted from: van Mierlo et al. 2010c). Purposes shift from monitoring and evaluation for accountability purposes with low stakeholder participation, to monitoring and evaluation for learning purposes with high stakeholder participation

<table>
<thead>
<tr>
<th>Ambition to reach institutional change</th>
<th>Extent of participation</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Result-oriented evaluation (e.g. Logical Framework)</td>
<td>Participatory monitoring and evaluation (e.g. most significant change)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Evaluation of system developments at the system level</td>
<td>Reflexive monitoring</td>
<td></td>
</tr>
</tbody>
</table>

---

2 These concern qualitative and anthropological models of evaluation, which emphasize the importance of observation, the need to retain the phenomenological quality of the evaluation context, and the value of subjective human interpretation in the evaluation process.
perspectives and the goals of the people involved, which are often at odds with the need to put the institutional preconditions up for discussion and to develop other, radically different realities. After all, it is precisely these existing perspectives that may be part of the problem.

The emphasis of *reflexive monitoring* is on flexibility, rather than on a strictly structured methodology or a rigid sequence of steps. This type of monitoring is customized work: the challenges of the moment hindering innovation determine the monitoring activities. Hence, the monitor is not only an observer but also –primarily – a facilitator who intervenes for example if new insights are not resulting in actions. He or she encourages participants to reflect upon the relationships between the project and its context, between project activities, and between short-term objectives and long-term ambitions. This allows them to break away from the old patterns of thinking and acting, and away from the undesirable effects that were associated with them. The monitor can add impetus to this change by holding discussions with participants, asking questions about implicit assumptions, giving advice about the composition of the network or the purpose and program of a meeting, drawing attention to problems and external developments, emphasizing the progress within the project, and so forth. At times, special tools are used. One such tool is the collective system analysis in which the Innovation System framework developed by Klein Woolthuis et al. (2005). It is used to collectively analyse institutional barriers as well as windows of opportunity for an envisioned innovation that emerges in the slipstream of external developments. Hence, reflexive monitoring is expected to support the emergent design of joint directions of solutions aiming for long term ambitions.

The first experiences with reflexive monitoring show that it can help participants go a step further than making plans with no obligations, and genuinely get involved with an innovation initiative (Regeer et al. 2009; van Mierlo et al. 2010b). It has encouraged researchers to tackle questions more creatively instead of getting stuck in more of the same type of studies. Additionally, it has encouraged all kinds of actors involved to look at their networking activities from a broader perspective on institutional barriers within society, and to recalibrate those activities. The collective system analysis has been shown to support system thinking in innovation networks. It did indeed have the potential to enhance reflexivity if carried out collectively. However, regular patterns of thinking and acting within projects have been found to interfere in subtle ways with the new knowledge generated and to limit the transformation of the reflexive feedback and insights into action.

**Outlook and research agenda**

In this chapter we provided an overview of the different ways agricultural innovation systems have been conceptualized, operationalized, researched and how interventions have been shaped under the influence of these perspectives. The AIS perspective
provides a comprehensive view of actors and factors that co-determine innovation, and in this sense facilitates an understanding of the complexity of agricultural innovation. However, its holism is also a pitfall as it allows for many interpretations, which complicates a clear focus of this research field and the building of cumulative evidence. As a result, more work needs to be done conceptually and empirically. Some suggestions for further research are given below.

(a) More systematic analysis of similarities and differences between different innovation system and system innovation perspectives in a similar vein as some authors (Coenen and Díaz López 2010; Markard and Truffer 2008) did in their comparison of theoretical frameworks used for studying industrial innovation. The aim would be to explore opportunities for cross-fertilization without losing the richness of their paradigmatic differences and their respective value for research questions which cannot be studied from other paradigms. This includes linking the scientific discussions on agricultural innovation to those in industrial innovation studies, e.g. on how to prevent the inherently dynamic conceptualization of innovation systems to become static in the actual analyses of these systems.

(b) Articulate and be transparent about the perceived system boundaries of the AIS that is being studied (sector, country, region, technology, value chain), and the extent to which we speak about a functioning system or a network which is a ‘system in the making’. It is also about recognizing diversity of subsystems within a system, and getting a clearer view of how different system boundaries cut across each other (see e.g. Hekkert et al. 2007). This is also about recognizing that actors in AIS cater for different, sometimes very divergent, development directions (e.g. a research institute supporting simultaneously both transgenic crops, organic agriculture, and multifunctional agriculture), and may both have enabling and constraining roles (e.g. government funding research and innovation, but also maintaining legislation favouring incumbents). This calls for a more careful description of the multiple identities of actors in AIS, and recognizing that innovation systems simultaneously enable and constrain innovation (Hung and Whittington 2011). This includes acknowledging that while gaining complete knowledge of a system is impossible, defining the boundaries of the innovation system to be analysed in itself a value-driven act, marginalising what lies outside the system. A systematic reflection on the choices made, e.g. as in critical system heuristics (Werner and Reynolds 2010) may help AIS researchers to welcome and deal with the different perspectives of actors involved in systems and thus to return to soft systems thinking.

(c) More systematically reflect on the implicit and explicit theories of change that underlie different modes of systems thinking. In the early 1990s the emergence of the AKIS perspective led to intensive debates on whether systems should be looked at from a hard systems, soft systems or critical systems perspective, and since then the array of systems perspectives has only expanded (e.g. with autopoietic systems thinking and complex systems thinking) (see Leeuwis 2004: 295–301 for overviews). Each of these perspectives goes along with different assumptions about reality, fundamental processes and theories of change. It seems
high time to pick-up that debate again, to compare systematically perspectives and to formulate a coherent conceptual perspective that can inform AIS practice.

(d) Develop a better understanding of how actions and agency at the level of innovation projects or specific socio-technological trajectories (niches, technological innovation systems) influence broader system change (niche, regime, structural change in national or sectoral innovation systems). Now often studies remain concentrated either on the innovation project management or technology design and development level; or take a rough, long term transition perspective, or focus mainly on a structural analysis of innovation support system conditions. In the spirit of the concept of the ‘duality of structure’ (Giddens 1984), concepts such as ‘effective reformism’ (Klerkx et al. 2010; Roep et al. 2003) ‘anchoring of innovations’ (Elzen et al. 2012, this volume) or ‘institutional entrepreneurship’ (Hung and Whittington 2011) aim to bridge this gap between different levels in innovation systems (i.e. innovation networks, niches, innovation support structure, regime) and how they link and influence each other.

(e) Develop research methods that – in addition to the analysis of structures and their changes and ‘hard’ innovation system performance criteria such as patents, numbers of researchers, monetary investments in research and innovation – allow for analysis of the many intangible effects of interventions in processes of learning and innovation. For example: network formation and synergic effects of networking, the role of visions as guiding devices in innovation, emergent and synergic effects of different separate innovation systems interventions, i.e. what have been dubbed ‘soft’ evaluation criteria (Oughton et al. 2002). This also includes developing research methodologies that are part and parcel of the innovation process. AIS research would then be a form of action research that stimulates not only reflection but also reflexivity and researchers would then also be innovation brokers.

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