# Participatory and Holistic Approaches with Grassland Farmers and Development of Policies

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**ABSTRACT**

The world is changing rapidly. Grassland farmers and ruminant livestock breeders will have to adapt to these changing environmental, social and economic conditions. Research can help them at the condition that linear 'top-down' technology transfer methods are abandoned for the benefit of participatory and holistic approaches. These approaches classified in the generic term of 'Farming System Research' consider farmers as real research partners, and they merge farmer's and scientist's ideas with those of other stakeholder types. They combine scientist's and farmer's knowledge for creating fast innovations, easily adopted by farmers since farmers themselves contribute to their design and their development. Innovations can then be disseminated by these farmers towards more important group of farmers. This process of innovation dissemination is very efficient because there is nothing more convincing for a farmer than listening and looking to what a similar farmer has achieved for improving its system and its income. These approaches proved to be successful in many parts of the world but it has still to be developed in many other regions. This will require a paradigm change in research, extension, teaching and production methods. It will also require a strong political will. The adoption of a holistic view is a prerequisite for developing an agriculture that conserves resources, maintains rural employment and minimizes external costs, while achieving high productions. Holistic livestock breeding is grassland-based. It minimizes the use of external inputs. It could maintain or restore biodiversity. Holistic livestock breeding is thus based on the principles of agroecology.

***Keywords*:** Agroecology, farming system research, holistic, livestock, participatory, policy, technology transfer.

## Introduction

In Europe, grassland farmers are facing many challenges (Peeters, 2015). In the dominant livestock production system, huge investments were made in land, buildings, machinery, and cattle, while production costs for fertilizers, animal feed and veterinary costs increased a lot. The milk quotas that ensured a stable market between 1984 and the early 2000s are now totally suppressed. As a consequence, milk prices became much more unstable and do not always cover production costs of dairy farmers. Meat prices are also often below profitability level. The livestock sector is largely dependent on subsidies. Because of these important loans and costs, and the lack of good economic perspectives, the dominant livestock production system is questioned. On the other hand, expectations from the society are increasing. Farmers should decrease their negative impacts on the environment and improve product quality. In response to that, many farmers started to develop alternative paths, towards more 'autonomous' and sustainable farming systems. The situation in other OECD countries is similar for at least some aspects. These alternative farming systems can be organic, agro-ecological or sometimes called by farmers themselves, the 'new peasantry' model. Their development will require many innovations, locally adapted, less dependent from up-streams and down-streams industries and banks, less dependent from fossil fuels and more based on local resources and the ecosystem services provided by biodiversity.

In lower income countries, the prevailing conditions are very different (Steinfeld *et al.*, 2006). Livestock systems are more determined by biophysical and socio-cultural environments. The use of external inputs is often low or nil. Grassland-based systems are though very variable within and between regions. The following challenges are, however, frequent in many tropical areas. The reduction of the grassland area because of demographic explosion and conversion of pasture into arable land generates conflicts between semi-nomadic or transhumant specialized livestock breeders on one hand and arable and mixed farmers on the other hand. Climate change frequently provokes major disturbance in the production environments, for instance by inducing severe droughts and pasture degradation. Soils of many regions are deteriorating because of climate change and overstocking. Poor soil quality combined with climate limitations are often an obstacle for increasing production. Animal diseases are not yet sufficiently controlled. Economic and income growth induces the emergence of a middle class, especially in Asia that influence ways of life and meat consumption. More mono-gastric meat is consumed which applies a pressure on ruminant production systems and grassland areas. Intensification of ruminant livestock systems is one of the responses to these challenges. It is mainly possible in emerging economy countries. All grassland-based systems will have to adapt under the pressure of environmental, social and economic conditions. Here also, this process will require locally adapted innovations for increasing resilience, income and sustainability in general.

In all parts of the world, it is urgent to help farmers to adapt to the fast changing situation. This paper explores the best ways to do it. It is rather clear that the traditional linear 'top-down' technology transfer from research to extension and farmers can no more be considered as a credible solution. Only holistic and participatory approaches have the ability to provide relevant answers. These approaches are described and discussed after having introduced general concepts.

## Conceptual framework

***System*:** The word 'system' derives from an ancient Greek word that means 'organized set'. Although Aristotle (- 350) did not initiate system research, he formulated one of the essential attributes of a system: '*the whole is more than the sum of its parts*'. Morin (1992) insisted on the fact that the whole is also sometimes 'less' that the sum of its parts. von Bertalanffy defined a system as '*a complex of components in interaction*' (1967) or '*a set of items in mutual interactions*' (1968). de Rosnay (1979) defines it as '*a set of elements in dynamic interaction, organized according to one goal*'. The modern concept of system appeared in the United States in the 1930s at the instigation of precursors such as Ludwig von Bertalanffy, Norbert Wiener, Claude Elwood Shannon, Warren Weaver and Jay Wright Forrester.

## Farmers typically view their farm as a system

***Holistic or system approach versus reductionist or analytical approach*:** The reductionist or analytical approach consists in 'dissecting' the complexity of nature in 'pieces', in the simplest possible particles so that they are understandable and analysable by human mind. It was formalized by Descartes in its

'*Discourse on the Method of Rightly Conducting One's Reason and of Seeking Truth in the Sciences*' published in 1637.

The knowledge produced by the 'reductionist' method is considered as non-ambiguous, precise and neutral from the point of view of the values *i.e.* 'objective'. This method is distinguished from common sense considered as 'subjective'. It is based on a rigorous, controllable, reproducible approach. It uses protocols that typically make the factors varying one by one, '*all else remaining equal*'. It takes primarily an interest in linear causal relations. It practises a continuous reassessment of results, laws and theories, to come to the knowledge nearest possible to the truth by successive approximations. It claims to produce knowledge of universal value. The adoption of this method allowed fast and considerable progress in science and technology, particularly since the 19th century. It had success precisely because initially it took an interest in simple problems like the discovery of atoms, binary chemical reactions, photosynthesis, or the effect of nitrogen fertilization on grassland yield. Fortified by these extraordinary knowledge advances, it seemed to be the scientific reference method, at least in the so-called 'exact' sciences.

However, since the beginning of the 20th century, it appeared that it was also advisable to deal with complexity, to consider nature as a complex system and not like a sum of well-circumscribed realities isolated from the whole. This approach consists in considering larger units, more complex problems, representative of the real world, without isolating them from their environment. von Bertalanffy clearly expressed this concern: '*The tendency to study systems as an entity rather than as a conglomeration of parts is consistent with the tendency in contemporary science no longer to isolate phenomena in narrowly confined contexts, but rather to open interactions for examination and to examine larger and larger slices of nature*' (Ackoff, 1959 cited in von Bertalanffy, 1968). It is the base of the holistic or system approach.

If reductionist research is very effective for solving relatively simple problems, it is not at all adapted to solve complex problems. However, the current world is more and more globalized and complex. The economic, social and even ecological contexts evolve very quickly. The truths of yesterday can be obsolete tomorrow. Only the system approach can adapt to this kind of context.

The reductionist researcher goes into his disciplinary knowledge in depth like a shovel man digs a well. In the 19th century, a researcher could still apprehend rather easily the disciplines of his colleagues; he had a sight on the research horizon in the other disciplines. In the 21st century, a researcher is very often isolated in the bottom of his well of knowledge. If there are certainly laudable initiatives encouraged by funding agencies to dig passages between sciences, these initiatives, despite everything, come more often under multidisciplinarity than interdisciplinarity and even less transdisciplinarity.

The total unbalance in budget and research effort between reductionist and holistic approaches, at the benefit of reductionist research, is one of the factors explaining a low contribution of science to the design and development of solutions to the many challenges that society and grassland-based systems are facing.

***Farm and farming systems*****:** A **farm system** is defined at the farm level as a set of resources, resource flows and interactions between biophysical, socio-economic and human elements (Dillon *et al.*, 1978; Norman *et al.*, 1982; Shaner *et al.*, 1982; Dixon *et al.*, 2001). A farm system is characterized by a resource management strategy to meet the diverse requirements of a farm household. These requirements are not all related with income. The decision centre is the farmer and his/her family (Fig. 1). Economic, socio-cultural, ecological, institution, policy, scientific and technical environments influence farmer's and farmer's family decisions. In mixed livestock/ cropping systems, decisions are taken for designing, implementing and managing cropping, forage, livestock feeding, livestock husbandry and marketing systems. In other farm systems such as specialized livestock systems, some components may be lacking. Variable parts of the crop and animal productions can be consumed by the family (self-sufficiency), another part can be marketed as an output in the economic environment. This economic environment provides also external inputs that farmers can buy or exchange for a part of their own production. A farm system is thus a decision-making unit including a household, a territory, and management systems that use and transform land into products that can be consumed or sold. It uses and can generate capital and labour. Farm system components are interrelated. The end product or waste of one component may be used as inputs in others (= internal input). The waste of the livestock system such as FYM is an input in the cropping system. The forage and straw obtained from the cropping system may be used as fodder for cattle.

A **cropping system** is implemented on a plot or a group of plots. It includes one or several crops, possibly in association, crop rotations, and all related techniques and practices. Cropping systems include leys (temporary grasslands) and other forage crops (Allen *et al.,* 2011). A **livestock breeding system** is characterized by the management of one or several herds or flocks. It includes herd composition (e.g. breed and other genetic characteristics, population pyramid, sex ratio), feed nutritional characteristics, grazing type, reproduction and health care management. It may consist in several activities such as dairying, piggery, poultry, fishery, bee-keeping, etc.

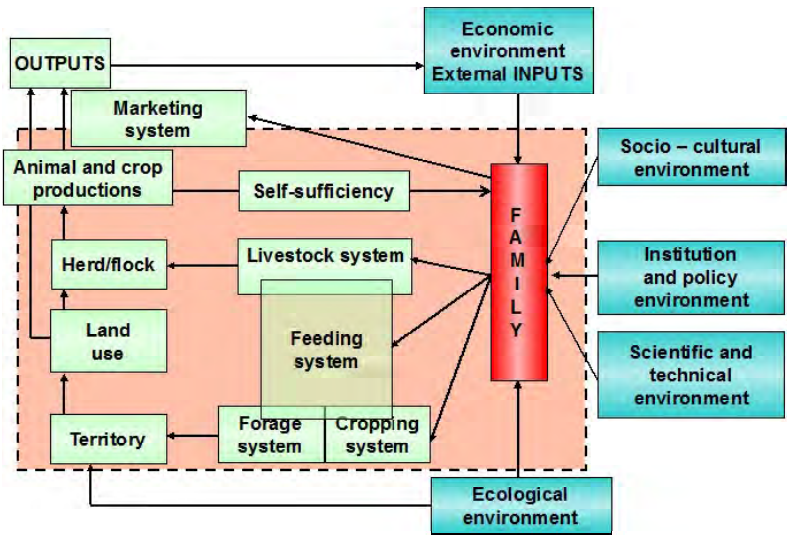


**Fig. 1.** A farm system (delimited by the dotted line) and its environments.

A **farming system** is a wider concept than a farm system. Dixon *et al.* (2001) defined a farming system as a '*population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. Depending on the scale of the analysis, a farming system can encompass a few dozen or many millions of households*'. Farming systems include the 'horizontal' (*i.e.* territorial) integration of farming as well as its 'vertical' (*i.e.* market) integration (Dedieu *et al.*, 2009).

Seré and Steinfeld (1996) identified eleven broad categories of livestock production systems by combining three criteria: integration with crops, relation to land and agro-ecological zone. They defined grassland-based systems as livestock systems in which more than 10% of the dry matter fed to animals is farm produced and in which annual average stocking rates are less than ten livestock units per hectare of agricultural land.

It appears clearly on Fig. 1 that changing a single part of the system only cannot be done without considering the effects of this change on the other parts or sub-systems. Any innovation has to be coherent with the whole system. Actually, in a development process, all components of the system have to be changed at the same time and in the right proportion.

## Origin and history of Farming System Research

Farming System Research (FSR) is still a young science. Its history started in the 1970s in Lower Income Countries (LIC) when it appeared that the techniques of the Green Revolution were not adopted by farmers especially resource-poor farmers located in less-favoured environments (Petheram and Clark, 1998; Collinson, 2000; Norman, 2002; Sajeev *et al.*, 2010; Kruger and Gilles, 2014). It was especially the case in most of Sub-Saharan Africa and in certain parts of Latin America and Asia. In these regions, smallholder farmers were not adopting the technical recommendations derived from disciplinary, commodity-oriented research. Agricultural economists then started to try understanding the way small farmers make decisions. Some important conclusions were identified. Farmers are often continuously experimenting new solutions and are not against innovations in general. Production environments are heterogeneous. Farmer's take advantage from this heterogeneity to develop complementary land uses and practices that increase the resilience of their system. Isolated techniques and even technological packages promoted by advisory services often do not fit with this heterogeneity. Site-specific solutions are needed. Innovations have to be designed for specific contexts. Techniques developed in small plots in experimental farms cannot easily be transferred to the 'real world' in farms because characteristics of experimental farms are largely unrepresentative of conditions prevailing on the majority of small farms. An innovation has to be coherent with the rationale of a farming system and its complexity. It cannot be airdropped from the sky as a disembodied truth. Discipline-oriented research can rarely propose valid answers to complex systems and their solutions can even lead to environment degradation and resource exhaustion. Objectives and determinants for action of many farmers cannot be reduced to profit maximisation.

It was then realized in the 1980s that, in Europe also, family farms, especially those in less favoured areas, were also not adopting the discipline-oriented innovations recommended by the top-down research-extension framework (Sajeev *et al.*, 2010).

## Description of Farming System Research (FSR)

Compared to reductionist approaches, the originality of farming systems approaches is to '*(1) address the complexity of 'real-world' phenomena (instead of using disciplinary simplifications) and (2) to work on problems that are relevant to farmers (instead of focusing on issues that are primarily of academic interest)*' (Sajeev *et al.*, 2010).

Research on farming systems includes some elements that frequently characterize them (Sajeev *et al.*, 2010):

- interdisciplinarity: combination of natural and social sciences, for example grassland science, livestock breeding, ecology, economics, anthropology, sociology;
- the attitude to look at farmer's family as a decision centre in a dynamic and evolving context (continuous changes in public policies, market prices and local opportunities);
- the comprehensive study of the farm and the family as a system.

In the implementation of farming systems approaches, it can be justified at a certain stage to focus on specific elements, certain subsystems or certain interactions. The contribution to reductionist research to solve some specific problems can thus be necessary.

Participation of farmers is regarded as essential in many farming system research. The participation of farmers is considered to be important for:

- understanding the objectives of farmers and the coherence of their farming practices;
- making sure that innovations are adapted and acceptable by farmers. Farmers are the most qualified to assess the probability of success or failure of an innovation proposition;
- producing tools which help farmers on the ways of change such as indicators, softwares, quality assessment methods of soils or grasslands.

Many Farming System Research projects are 'action research' and closely associate not only farmers and scientists but also other stakeholder types in participatory approaches.

## Technology transfer and participatory approaches

Experimental Development tries to apply specialized knowledge produced by Fundamental or Applied Research (see definitions in Frascati Manual (2002) of OECD). Knowledge transfer is then typically considered in a 'top-down' approach (Fig. 2). The term 'transfer' is explicit by itself. There are those who 'know' and those who 'receive' knowledge. Agronomic research results are transferred to agricultural advisory services that are responsible for translating them into terms comprehensible by producers. However, information occasionally goes up from production and advisory services to research and enables to define and guide part of new research. Technology transfer is based on the assumption that, when innovations are broadcasted, they are proposed in a rather homogeneous social environment and ecological context where people cope with the same kinds of challenges, share values, objectives and interests, and that innovations can thus be easily spread among potential users. However, potential recipients of innovations often have different values, objectives and interests. They have varied powers in their society and variable access to resources. These reasons explain why the

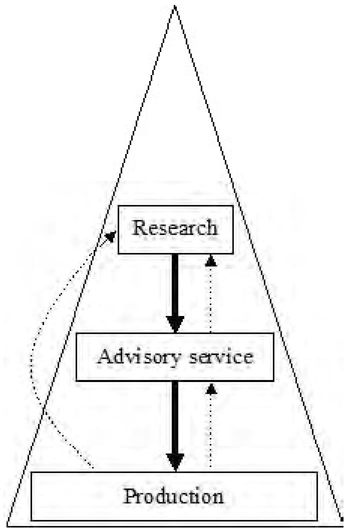


**Fig. 2.** Vertical diagram of the 'top-down' transfer of research results to the production (full line: main information flows; dotted line: subsidiary and occasional information flows).

diffusion of a particular innovation is often slow and weak, even worthless.

Rather than developing innovations for solving problems which they perceive with their disciplinary scientific knowledge and techniques which often provide them a fragmentary vision of the reality, scientists can change the paradigm of their research by working either 'for' or 'on behalf' of farmers but 'with' them. This paradigm change is the basis of the participatory approach in research. From the scientist's point of view, farmers can indeed be regarded as real research partners (Fig. 3). They have their own knowledge which can usefully complement scientist's knowledge. Moreover, farmers have values and objectives that are not necessarily the same ones as those of scientists. While interacting at the beginning of research on these objectives and also on farmer's constraints whose scientists are not always aware, scientists avoid engaging in dead ends which lead to develop solutions that are finally rejected by farmers. This research partnership with beneficiary farmers is characterized by a result-oriented research strategy, a real implementation of interdisciplinarity, a challenge of the 'top-down' continuum of the research-development operation and a use of participatory research where farmers can be associated to knowledge production and scientists can learn a lot from local knowledge. Moreover, research topics and products derive from a working method rather than from a predefined research orientation. Research protocols are not defined in advance, only the holistic and participatory research method is. Analytical trials are thus not systematically organised.

Actually, farmers innovate permanently. Agricultural tools, machinery and techniques were of course developed by farmers only since the origins of agriculture until the recent appearance of agronomic research. In the 21st century, farmers very often continue to develop

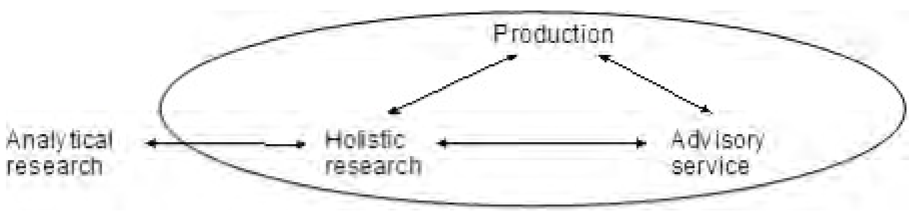


**Fig. 3.** Horizontal diagram of the participatory and holistic approach (in the ellipse) (full line: information flows). Holistic scientists, advisory services and farmers work together, on an egalitarian basis, for developing innovations within the framework of production systems. They are in touch with analytical researchers. That enables solving specific problems which appear during system approach activities.

innovations without the support of scientists, at least in a first phase of technological development. It is understandable that it is people who are constantly in contact with the ground reality and confronted with technical difficulties who find solutions rather than scientists working in laboratory and whose main aim is to publish scientific papers in high impact factor international journals. It is thus not exaggerated to consider that farmers are researchers. It is however interesting for them to work with other researchers, scientists, who have complementary knowledge which can for example enable to generalize solutions developed locally by farmers or to improve innovations initially developed in farm.

The crossing of ideas of farmers and holistic scientists is all the more fertile as it is supplemented by the contributions of reductionist scientists who may bring certain knowledge and carry out specific experiments for solving problems in the context of holistic and participatory approaches (Fig. 3). The backward and forward process between holistic and reductionist approaches should be largely adopted by research teams. It appears clearly that, in this process, it is the system approach which leads the innovation process and that reductionist research comes in support and not the reverse. Holistic scientists can be used in this partnership as intermediary between reductionist scientists and farmers. Each partner is winning in this collaboration. It would however be necessary to develop a specific assessment system of scientists who commit themselves in holistic and participatory approach otherwise they would be completely disadvantaged compared to their reductionist colleagues.

The farmer–scientist partnership is usefully supplemented by the participation of other stakeholders. Farmer's advisers can make durable the diffusion of knowledge after the end of a research program. Other actors like decision-makers, representatives of environmental NGOs, entrepreneurs of the agri-food sector and retailers can also play a key function. These other actors should ideally be associated very early in the innovation development process in order that an important social and commercial movement would support this process.

When this farmer's and scientist's knowledge is combined, conditions are created for the emergence of fast innovations, easily adopted by farmers since farmers themselves contributed to their design and their development. Innovations can then be disseminated by these farmers towards more important group of farmers. This process of innovation dissemination is very efficient because there is nothing more convincing for a farmer than listening and looking to what a similar farmer has achieved for improving its system and its income.

## A diversity of methods

Biggs (1989) proposed a classification of participatory approaches in agricultural research into four categories:

- Contractual: researchers contract with farmers to obtain land and services;
- Consultative: researchers consult farmers about their problems and then develop solutions for them;
- Collaborative: researchers and farmers collaborate as partners in the research process;
- Collegiate: researchers work to strengthen farmers' informal research and development systems, and farmers are given scope to apply their initiative and specialised knowledge throughout the research process.

Real participatory approaches are collaborative or collegiate. They emerged in the middle of the 1980s and were named '**Farmers First**' approaches (Probst and Hagmann, 2003). A large range of approaches and processes has developed primarily through North-South partnerships. They all focus on farmer's participation in technology production, testing and evaluation for increasing farmer's productivity and income within the framework of a sustainable agricultural production. The innovation process is regarded as a complex, multi-agents system. They include methodologies such as (Kruger and Gilles, 2014):

- Farmer-back-to-Farmer (Rhoades and Booth, 1982);
- Farmer First and Last (Chambers and Ghildyal, 1985);
- Participatory Action Research (PAR) (Farrington and Martin, 1987; Okali *et al.*, 1994) and Participatory Rural Appraisal/ Participatory Learning and Action (PRA/ PLA);
- Farmer Participatory Research (FPR) and Farming Systems Research and Extension (FSRandE);
- Participatory Technology Development (PTD) (ILEIA, 1989; Gonsalves *et al.*, 2005a, 2005b, 2005c) and Participatory Innovation Development (PID);
- Community Based Natural Resource Management (CBNRM);
- Sustainable Livelihoods Analysis (SLA) and other gender and stakeholder analysis methods such as Agricultural Knowledge Information Systems (AKIS) and Rapid Appraisal of Agricultural Knowledge Systems (RAAKS).

All these participatory methods were developed in the framework of Farming System Research.

## Example of a holistic and participatory approach

In Europe, a holistic and participatory research methodology has been developed in the framework of the 'Working group on Integrated and Ecological Arable Farming Systems (I/EAFS) for EC- and associated countries' (Vereijken, 1997 and 1999). Scientists and farmers were associated, as partners, for the design, development and the dissemination of 'prototypes of farms'. This kind of method has been adopted for example by Vereijken (1997 and 1999), Peeters and Van Bol (2000), Lambert *et al.* (2002), Sterk *et al.* (2007). The methodology has been successfully applied in several European Union (EU) countries and in one tropical country (Sterk *et al.*, 2007). It proved to be very effective. The methodology of research-action is based on the choice of 'pilot-farms' clustered in groups of about 10 farms. The number of farms must not be too important for allowing close and dynamic interactions between farmers and scientists.

Pilot-farms are laboratories of new agricultural systems. They are centres of active innovation and dissemination. Improvements are introduced step-by-step in these pilot-farms according to pre-defined objectives by using multifunctional management methods. Objectives are translated into an indicator system that is used for checking if systems are evolving in the right direction after the use of management methods. When farms are considered sufficiently improved, the principles of their optimised functioning can be described and schematised by farm type. The details of the functioning of pilot-farms cannot be adopted as such by other farms but the principles of their functioning can. This set of functioning principles is summarized in a concept called 'farm prototype'. The method does not only associate farmers and scientists within a participatory approach, it bring also together decision makers, farmer's advisers, scientists specialised in certain disciplines, agricultural teachers, consumers, environmentalists and nature conservationists. This approach guarantees the continuation of the project after the end of the research activities. In this methodology of research-action, the research protocol is not defined in detail in advance, as for analytical researches, since it is developed in consultation with farmers and other stakeholders.

The **first steps of the project** consist in selecting pilot farmers, the signature of a contract with them, selecting the other stakeholders of the research and implementing farm groups.

- Selection of pilot farmers: A call is launched for instance in agricultural media and to farmer's Union for identifying volunteers to be partners of the research. Candidates should be very motivated by the project, skilled, respected in the agricultural world and able to collaborate with others. Their system should be representative of a farm type and of the regional diversity of farms. They should be considered as leaders and acknowledged as efficient and open to innovations.
- Signature of a contract with pilot farmers. A contract is signed with the selected farmers. Farmers commit themselves for all duration of the research to collaborate with scientists; to use all their skills and experience for developing innovative solutions for reaching the project objectives; and to participate to the meetings. The research team commits itself to use its expertise for developing innovative systems; to contribute to improving farmer's income; to ensure the confidentiality of the results; to collect data on farms; to inform farmers of the results; to compensate farmers for specific research activities and for some other activities not linked with production and decided in common.
- Selection of the other stakeholders associated to the research. Stakeholders mentioned above are invited to take part in meetings and in the follow-up committee. They will be able to give their opinion on the objectives, on the working methods and on solutions. Some of them will be involved in result dissemination.
- Implementation of farm groups. A first meeting is organised with all farmers, scientists and other stakeholders in order to start the group dynamic, to introduce partners, to explain the project objectives, methodology and activities. Each member of the research project introduces himself and describes his expectations from the project. Each member is also invited to express his 'dreams'. In particular, farmers are invited to define their personal goals, their vision on their farm and their projects for the future. This process avoids later misunderstanding and disappointments. The specific objectives of the project are decided at this occasion. Decisions are taken on indicators and management methods.

**The core of holistic and participatory method includes 5 steps** for the design, development and dissemination of the 'farm prototype' (Fig. 4).

## Step 1 – Definition of the hierarchy of objectives.

A general objective of the research is defined with farmers and other stakeholders. Specific objectives are more concrete than the general objective. They are specified by consensus. Priorities between specific objectives are also defined. The hierarchy of specific objectives of the system is defined for correcting shortcomings and insufficiencies of the farming system (e.g. important input expenses, exclusive marketing of products through main agro-food channels). Example of a general objective: Development of an agro-ecological livestock breeding system. Examples of specific objectives: Increasing forage self-sufficiency; Reducing or suppressing external chemical inputs (fertilizers, pesticides, drugs); Optimizing nutrient cycles, etc.

## Step 2 – Multifunctional indicators and management methods.

Major objectives are translated into **multifunctional indicators**. These indicators should check that the system is getting closer to the objectives and to what extent. They show the changes of conditions of farm systems. They should as far as possible measure several specific objectives. That is the reason why they are multifunctional. Their number must be as small as possible but the set of indicators should provide a sufficiently precise picture of the system of each farm. They should be easily, quickly measured and at a low cost. Examples of indicators: Amount of purchased concentrate feeding per cow; Amount of purchased chemical input par ha; Grassland quality index; Proportion of legume in grassland sward in the middle of the grazing season, etc.

A **reference value is determined for each indicator**. When data are collected, farm indicators are interpreted in comparison with other farms (pilot group or sectorial average) or with previous values of the same farm (time trend) or with target or threshold values (Maljean *et al.,* 2005). Reference values are thus needed. These reference values describe the desirable values of indicators. They represent the objective to reach for each indicator in each farm. Each year, indicator and reference values are represented on a bar chart for each farm and for the average of the group. These data are also represented on 'spider web' diagrams.

Each pilot-farm is also described by the research team for *i.a.* soil characteristics, crop, forage and livestock productions, grassland sward quality, and bookkeeping. Plot maps are drawn for each farm. The status of each parameter is represented by a colour code. This 'helicopter view' of each farm is a useful tool for stimulating discussions with farmers.

Subsequently, **Multifunctional Management Methods** are developed for reaching the specific objectives. These methods could be: Multifunctional Crop Rotation Method; Ecological Nutrient Management; Integrated Crop Protection Method; Integrated Livestock Feeding; Integrated Livestock Health Protection Method; Multifunctional Grassland Management; Development of an Ecological Infrastructure; Farm Structure Optimisation; Food Processing and Marketing Method. The Crop Rotation Management Method for instance is multifunctional because it aims *i.a.* at producing food and feed, fixing nitrogen by legumes in soils, increasing soil organic matter and soil life, and controlling weeds, pests and diseases. These methods are designed and tested on the basis of a strong involvement of farmers. Those accept to take the risk to implement these new methods on their farm. They should thus believe in their efficiency. After improvement of the agricultural system by management methods, indicators are used for checking the effect of these methods for reaching the objectives. Each method should be designed, developed and tested by answering to the following questions: 'Is it acceptable by farmers?' 'Is it manageable?' 'Is it efficient?' 'Is it ready to use?'. Qualified answers to these questions reveal the need for further improvement or the rejection of the method. This improvement is iterative during all the duration of the project.

### Step 3 – Follow-up and annual assessment of the pilot farms.

A **follow-up of farms** is carried out by individual meetings 'on the kitchen table' during farm and field visits, every second week, between a farmer and the research team in the period of plant growth. At these occasions, recent activities, future activities and possible problems of the farm are discussed. Solutions for solving problems are designed if necessary. Samples and data are collected in order to measure **indicators**.

An **annual assessment of pilot-farm progress** is carried out by the research team on the basis of indicator values. It is then discussed in group in the winter period during 4 to 6 annual meetings during which farmers, scientists and other stakeholders get together. Decisions are taken on future activities of the project, on the improvement of multifunctional management methods and on annual progress objectives of pilot-farms. Progress objectives are precisely defined for each aspect that needs an improvement in each farm in the following year. Actions to undertake are decided in common agreement between farmers and scientists.

### Step 4 – Design of the theoretical prototype.

The **theoretical prototype is progressively designed** by regular meetings between scientists and individual farmers. Conflicts can appear between objectives and between methods. These conflicts are solved by identifying trade-off and by further designing methods. The result of the process is a coherent set that can be described by a text and a chart, the 'concept of prototype-farm'. This concept of prototype-farm includes innovations, improved methods and compromises that lead to the achievement of the specific objectives.

### Step 5 – Dissemination of the prototype concept.

When pilot farms are sufficiently improved and close to the objectives, the prototype can be disseminated to other farms at a region or country level. Pilot farmers are supported in this task by scientists, farmer's advisers, decision-makers and all other types of stakeholders mentioned above. Didactic material is for instance produced and provided to farmers. Pilot farmers are remunerated for the time they spend for this dissemination activity.

**The method is iterative**: steps 2, 3 and 4 are repeated each year up to the moment where the objectives of pilot farms are reached. Ideally, the iterative process of steps 1 to 5 should last 3 to 4 years. Dissemination should then start for 3 to 5 year duration.

## Development of policies

Several countries have a strong tradition of holistic and participatory approaches. Australia, South Africa, many lower income countries as well as many international research organizations are used to work with these methods. This is though not the case in other regions of the world such as Europe where these approaches are underrepresented in agricultural research. In this case, a total

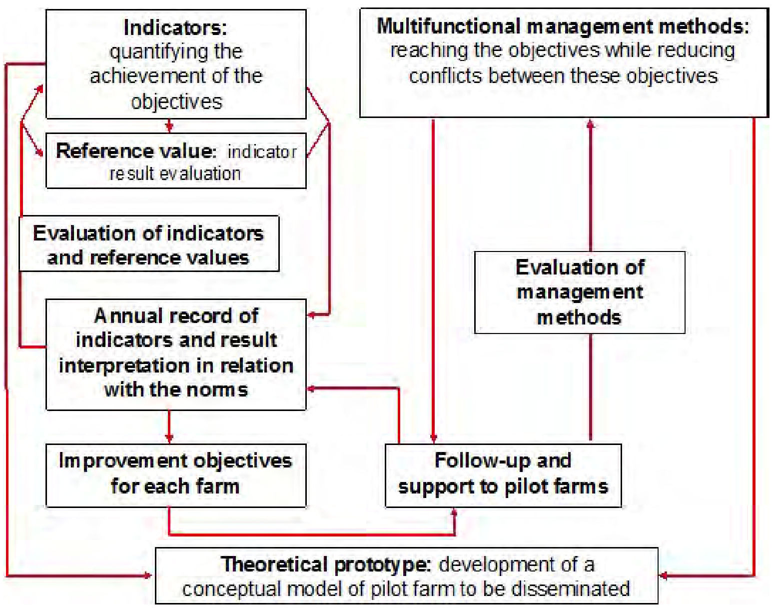


**Fig. 4.** Flow chart of the holistic and participatory research method after the definition of general and specific objectives.

nature conservationists, decision makers);

- a technological Revolution for designing and developing holistic methods and systems in livestock farms, adapting them locally, disseminating them, supporting farmers in their transition period;
- the integration of biodiversity enhancement in methods and practices for developing an agriculture based on biodiversity;
- developing the market for grassland-based products by giving priority to these products in school and administration cafeterias (canteens).

change of paradigm and new policy orientations are needed. These policies will require in priority:

- a fundamental reform of the training of future farmers, technicians and farmer's advisers in technical schools;
- a reform of the specialization training (master) of agricultural scientists in higher education institutions;
- a restructuration of agricultural research that will define new priorities. The dominance of reductionist research should be inverted at the benefit of holistic and participatory researches. Groups of pilot farmers should be created per farm types in many regions. They should associate different types of stakeholders (ex.: holistic researchers, reductionist researchers, farmer's advisers, technical and higher education schools, consumers,

Changes in agricultural policies are also necessary for integrating holistic and participatory approaches in rural development policies. The initiative of the European Union to launch the 'European Innovation Partnership for Agricultural Productivity and Sustainability' is a good step in this direction. It aims to promote bottom-up approaches by linking farmers, researchers, advisers, businesses and other stakeholders into groups charged with finding concrete solutions. Governments are invited to spend a proportion of their rural development funds on supporting so-called 'operational groups' that are quite close to pilot farmer groups described above. A well-defined holistic and participatory method, such as those mentioned above, should however be adopted for ensuring success.

## Discussion and conclusions

Grassland farmers are facing important challenges all over the world. They will have to adapt quickly to changing ecological, social and economic environments. This will not be easy. Locally adapted innovations developed in a coherent system will be needed. Only holistic and participatory approaches will be able to achieve this goal, with the support of reductionist approaches for specific topics. Farming system research should be much more adopted as a thinking framework for policy design, development, research and teaching. This will require a paradigm change. All Western culture, the whole functioning of Western society and consequently modern science are based on a reductionist view of nature and human activities. The scope of this change should thus not be underestimated.

A holistic view of farming systems will also lead to considerable changes in practices. Many chemical inputs could be replaced by ecosystem services provided by biodiversity. Two examples can be cited. Nitrogen fertilizers could be largely replaced in grasslands by biological nitrogen fixation performed by forage legumes whether they are annual or perennial herbaceous species, or woody species. Trees could produce tannins that could control internal parasites of ruminants, provide better animal welfare, reduce calf mortality and increase growth of young animal by creating shelter towards extreme weather conditions. That would mainly reduce production costs of intensive farmers and increase production of more extensive farmers. The adoption of a holistic view is a prerequisite for developing an agriculture that conserves resources, maintains rural employment and minimizes external costs, while achieving high productions. It could also improve the opinion of citizens and decision-makers on livestock breeding impacts on the environment. Holistic livestock breeding is grassland-based. It minimizes the use of grains in ruminant feeding and in doing so stores carbon in grassland soils and reduce $CO_2$ emissions from tilled arable soils. It spares the destruction of tropical rain forest and other species-rich ecosystems like the Pampa for producing soybean that is used for feeding factory farming monogastrics. It could manage high nature value grasslands and maintain or restore biodiversity. Holistic livestock breeding is thus based on the principles of agroecology.

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