ISSUES IN INTEGRATIVE STUDIES
No. 12, pp. 93-138

Interdisciplinary Research for Integrated Rural Development in Developing Countries: The Role of Social Sciences

by
Dirk van Dusseldorp and Seerp Wigboldus

Wageningen Agricultural University

Abstract: This article is based on the experiences of various interdisciplinary research and planning teams at Wageningen Agricultural University. After giving a typology of interdisciplinary research, the authors examine the role of social sciences in interdisciplinary research in various fields of importance for rural development in developing countries. The type of interdisciplinary research discussed is the so-called "broad" interdisciplinary research in which participating disciplines have very different paradigms. The article closes with an overview of the potentials and constraints in broad interdisciplinary research and some general observations. Finally, systematic evaluations of interdisciplinary research programs will contribute to its progress.

THE PROBLEMS policy makers and planners are facing are becoming more and more complicated. Seldom is there a course of action that does not require the input of various ministries or departments. This also means, automatically, that the knowledge of several disciplines is needed to lay the foundation for sound policies and their implementation. As a result, interest in interdisciplinary research has increased in the last decades.

Hereafter the concept of interdisciplinary research pertains to the so-called "broad" interdisciplinary research. This means among others that a wide range of disciplines is involved, from technical to social disciplines.

A note of caution is in order right at the beginning. However important interdisciplinary research may be, there are many situations in which sound monodisciplinary research is not only effective but also more efficient. As will be shown hereafter, interdisciplinary research is a difficult type of research, with many pitfalls and possibilities for breakdowns. Consequently, there must be very compelling reasons before cumbersome interdisciplinary research is selected as the best approach for obtaining insight into the processes to be influenced in order to solve problems of a society or community.

The problems in interdisciplinary research are partly due to misunderstandings surrounding it. Therefore, there must be a clear understanding of what policy or action-oriented interdisciplinary research means, how it should be conducted, and what its potentials and limitations are.

From recent literature (Wigboldus, 1991), it is clear that even though the discussion of interdisciplinary research is on-going, there is a certain stagnation in development of new theoretical concepts. Since the overview articles of Lekanne (1976) and Kockelmans (1987), few new ideas have come forward. Russell's edited publication (1982) contributed some interesting practical ideas. Chubin, *et al*.'s book (1986) consists, for the major part, of reprints of articles and chapters of books, but gives scarcely any new insights. For those interested in the present state of the art Klein's (1990) *Interdisciplinarity: History, Theory & Practice* can be useful.

Despite the avalanche of literature on this subject, the outcome of "broad" interdisciplinary research is still not very impressive. Partly due to ignorance of what interdisciplinary research should comprise, research proposals are often poorly designed. Futhermore, the outcomes of policy/action-oriented interdisciplinary research are in most cases not very highly appreciated by the scientific community. Outstanding scientists are often more interested in monodisciplinary research. This tendency occurs in many universities, and it affects the quality of interdisciplinary research. So a vicious circle is entered.

In the following, a typology of interdisciplinary research is drawn first, followed by a description of various approaches, that can be used in interdisciplinary research for rural development in the fields of regional (integrated) rural development, fanning systems research, and in agricultural research using plant growth models. Finally, we can conclude with an overview of the potential and constraints of interdisciplinary research, ending with some general observations.

Types of Interdisciplinary Research

It is possible to distinguish between several types of interdisciplinary research. This distinction is useful because there are considerable differences in the constraints one encounters during the preparation and implementation of the different types of interdisciplinary research. Figure 1 gives an overview of "Types of Interdisciplinarity."

Interdisciplinary research projects differ for the following reasons:

1) The interdisciplinary team has representatives of disciplines using more or less the same paradigms and methods; for instance agronomists, soil scientists and climatologists; or biologists, chemists and physicists. In such situations communication is relatively easy — illustrating an example of narrow interdisciplinarity. However, when an interdisciplinary team consists of agronomists, soil scientists, economists and social scientists who have different paradigms and use different methods — illustrating an example of broad interdisciplinarity — the chances that there will be problems in the communication between the team members increase considerably.
2) In small interdisciplinary teams the communication problem will be less than in large teams where, naturally, in most cases, a larger number of disciplines will be represented.
3) When the members of an interdisciplinary team are coming from different institutes, communication and organizational problems will be bigger than when they come from the same institute. Different organizations often have developed different organizational cultures which determine how to cooperate and communicate with each other.
4) Finally, members of an interdisciplinary team can come from different national cultures. This gives an additional complication in the communication between members of a team.

To summarize, starting from a team consisting of a small number of members with closely related disciplines of the same organization and the same culture, problems of communication and organization will continuously increase and will culminate in large interdisciplinary teams with representatives of disciplines which have little in common and with a different organizational and cultural background. In interdisciplinary research for integrated rural development, in which external donors are involved, the most

FIGURE 1: Types of Interdisciplinarity

A) NARROW INTERDISCIPLINARITY	B) BROAD INTERDISCIPLINARITY
1) Interaction Between Disciplines with —Same Paradigms —Same Methods *Disciplinary outputs can be easily integrated*	Interaction Between Disciplines with: —Different Paradigms —Different Methods Disciplinary outputs are difficult to integrate
2) Few Disciplines Involved *Simplifies communication*	Many Disciplines Involved *Complicates communication*
3) Representatives of Disciplines Located in Same Organization *Simplifies communication and organization*	Representatives of Disciplines Located in Different Organizations *Complicates communication and organization*
4) Representatives of Disciplines from the Same Culture *Simplifies communication*	Representatives of Disciplines from Different Cultures *Complicates communication*

complicated mode of interdisciplinary research always applies. Because in this case broad interdisciplinarity is required, a rather large team is needed, and researchers and their counterparts come from different organizations and cultures. This means that preparation of this type of interdisciplinary research requires more attention than simpler forms of interdisciplinary research.

Interdisciplinary Research for Regional Planning and Integrated Rural Development

Historical Background

Several decades ago it became clear that the project approach often failed because it was planned and implemented in isolation. Irrigation schemes were not used or not used optimally, because school and health facilities were not available. The successful introduction of new production technologies bogged down because neither the market system, nor the physical infrastructure (roads, storage facilities) could cope with the increasing volume of produce. During this period, the concept of regional planning, at least in developing countries, became popular. But most of the regional plans presented, often in several volumes, were seldom implemented, because they were too complex for the administrations of most developing countries. The fashion of regional planning was soon followed by the concept of integrated rural development projects (lRDP's). In this concept the ideas of bottom-up participation and programmatic approach were combined in one way or another. Taking into account the manpower and funding absorbed by this type of project, most of them cannot boast good track records for efficiency, effectiveness, or impact.

Interestingly, integrated analyses of regional plans, are still being used. However, in most IRDP's a sound general analysis of the area in which they are operating is missing. Sound analysis based on interdisciplinary research should not only be the basis of but is even crucial for the success of any regional plan or integrated rural development project.

The research process described hereafter is based on experiences of interdisciplinary teams commissioned with the formulation of regional plans. Before going into the process of interdisciplinary research, it is important to emphasize that the final outcome of interdisciplinary research is integration of outcomes of monodisciplinary research. A common misconception is that interdisciplinary research means all disciplines are merged: agronomists must involve themselves with economists, and sociologists should have as much to say about soil classification as soil scientists. Yet, this effort to arrive at a unified science is doomed to fail in broad policy/action-oriented interdisciplinary research, and will lead to shallow, if any, results. The integration of the disciplines themselves should not take place in interdisciplinary research, Rather, interdisciplinary research is characterized by:

1) An integrated research design, made and agreed upon by all disciplines involved.
2) A period during which monodisciplinary field research takes place, with an intensive exchange of information that can influence the direction of monodisciplinary research.
3) An integrated analysis of the problem under study.

Figure 2 illustrates the stages through which a policy/action-oriented interdisciplinary research project can and should go. Hereafter the interdisciplinary research process for integrated rural development will be described. The numbers between square brackets ([ ]) of the various stages cor-

FIGURE 2. Stages in Policy-Oriented Interdisciplinary Research

Preparation	[1]	Problem Formulation by Policy Makers
	[2]	Translation of Policy Problem into Research Problem(s)
	[3]	Operationalization of Research Problems and Preparation of Work Program per Discipline
	[4]	Integration of Disciplinary Research Program into an Interdisciplinary Research Project
Field Work	[5]	General Orientation in the Field (Rapid Rural Appraisal [SONDEO])
	[6]	Adjustment of Research problems and Work Program
	[7]	Monodisciplinary Research, with Regular Consultations and Exchange of Tentative Findings and, When Necessary, Adjustments of Disciplinary Research Problems and Work Programs
Synthesis	[8]	Presentation of Disciplinary Findings
	[9]	Integration of Findings via Regular Meetings
	[10]	Team Members' Following of the Way Their Inputs Are Used During the Integration Process
	[11]	Final Synthesis
Reporting		

respond with the numbers indicated in Figure 2. Note that it is not a linear but an iterative process.

Preparation of the Research Proposal

[1] The important difference between action-oriented research and scientific research is that the problem, for which the research project should provide information and lead to tentative solutions, is formulated by policy makers and not by researchers.

[21 This difference does not mean that the scientists do not have an important task in the stage of problem formulation. Often problems formulated by the policymakers have to be redefined for the following reasons:

a) The policy problem has to be translated into a research problem.
b) The policy problem identified is not the real cause of the undesirable situation the policy maker wants to solve. For instance, lack of ac-

ceptance of a new production technology is seen as the result of poor functioning of the extension service. However, in reality it is caused by poor performance of the market system. In such a situation hierarchies of explanatory variables that could have created the problem must be constructed (Birgegard, 1980). As mentioned earlier, translation of the policy problem into a researchable problem (or problems) is a rather crucial stage in policy-oriented research process for the following reason. At this stage the views of scientists and policy makers may already diverge. Therefore, during this stage there must be regular consultation between researchers and the commissioner of the research (Lohuizen, 1983; Majchrzak. 1984).

[2] + [3] + [4] There are also reasons, internal to the research process, that make these stages crucial. Firstly, representatives of the various disciplines have to reach agreement on the general research problems.

Often the policy problem is caused by several processes that have to be looked into by different disciplines. As a result the general research problems have to be dissected in several research problems. The singling out of particular processes for further research because they are deemed the most important (the principia media of Mannheim, 1960), is a crucial and at the same time very difficult decision. This is often an arbitrary decision strongly influenced by the world view of participating scientists. The disaggregation of general research problems into research problems for the various disciplines has to be done in a way that enables integration of the outcome of various monodisciplinary research sub-projects in the final synthesis. At this moment the framework for integration of monodisciplinary research results should he created. If this is not done at this stage, considerable problems can be expected in the synthesizing stage. There are also other important aspects that have to be taken into account in the preparation of the research proposal:

a) The results of the various disciplines must be comparable. In a regional analysis, for instance, the data can be compared on a geographical basis.
b) The outcomes of monodisciplinary research and analysis must be made available in such a way that they can be understood and used by other disciplines.
c) The level of information should be more or less the same. The integrated analysis will be biased when one discipline has far more information than the others.

d) Collecting too much data is a problem to avoid. In the final analysis often only a fraction of collected data are usually used. Sometimes abundance of data actually creates more confusion, instead of enabling transparent analysis of the potentials and constraints for development of an area or region. This very problem occurred in a research project in Benin (Danne, 1990). Granted, in the beginning it is not always easy to know exactly which data or information are needed. Careful advance consideration of the reasons data have to be collected, how they are processed, and who on the interdisciplinary team is going to use them, and for what purpose lengthens the preparation period. At the same time, this kind of attention to process shortens the overall period needed for data collection, and consequently diminishes the costs of data collection, the most expensive part of the research process.

e) The area or region under study is always part of a larger entity, be it a river basin, a higher administrative unit, or a market system (Weintraub and Marguiles, 1986). For that reason some disciplines have to collect information outside the area or region. This step must also be discussed and coordinated in preparation of fieldwork. If this step is not taken misunderstanding may occur, especially when scarce resources such as transport facilities are required.

All these aspects have to be discussed in detail among the various disciplines involved. If this discussion is not handled properly big problems can be expected during implementation of fieldwork and certainly during the synthesis of the outcomes of various monodisciplinary research efforts.

On the basis of the framework of problems indicated above, the disciplines have to operationalize their research problem(s) and make a tentative work program. On most occasions there is only a limited amount of time or resources available. Consequently there are limitations to the depth of research, a situation that will have consequences for choice of methods. Limited time and resources necessitate careful coordination. On the basis of the work programs presented by the disciplines, a general work program for the team is prepared, designating what time each discipline is collecting what kind of data and, if possible, where collection will occur. Furthermore, the time when a discipline will deliver specific data to another discipline should be mentioned. If agronomists do not receive timely information from climatologists and soil scientists, they are not in a position to indicate the physical agricultural production potential of a region. Figure 3 is a model for visualizing the working program. It gives an overview of data collecting ac-

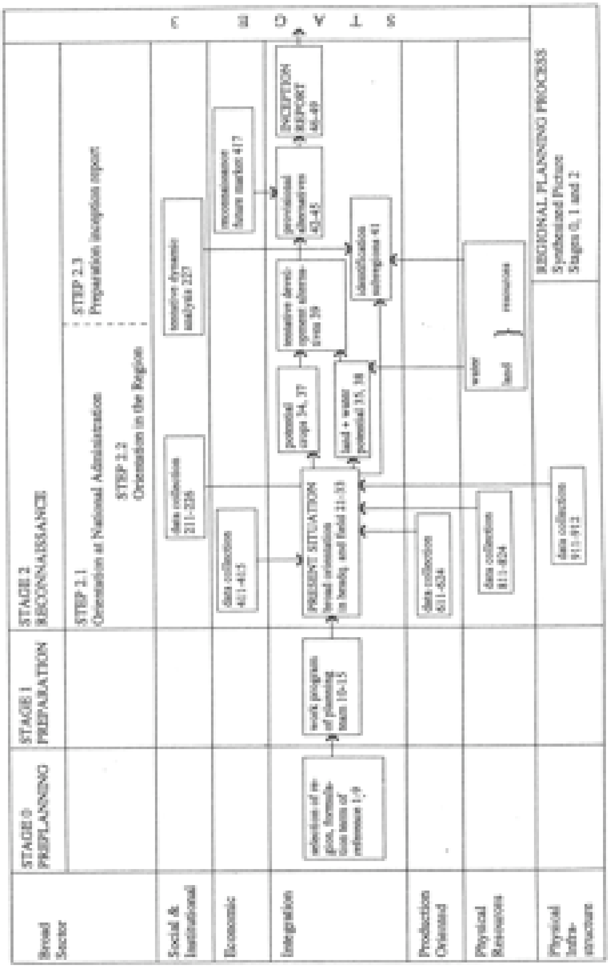
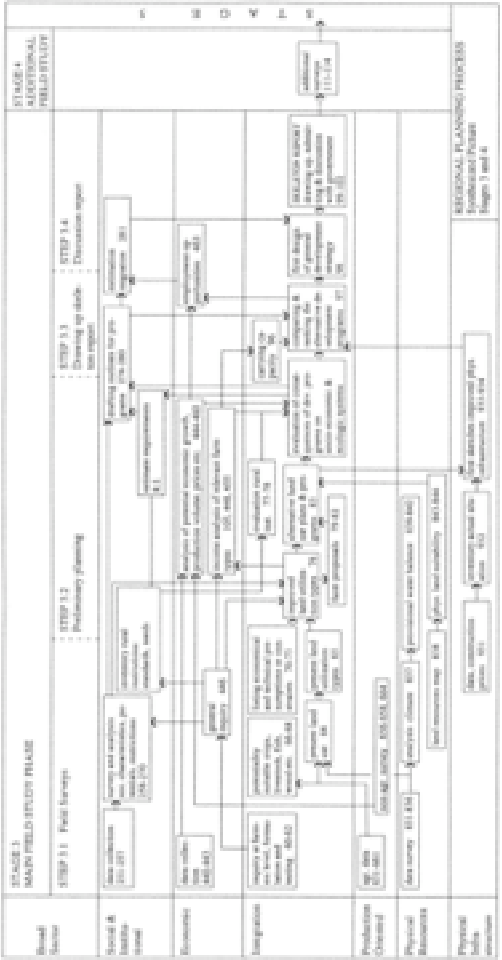
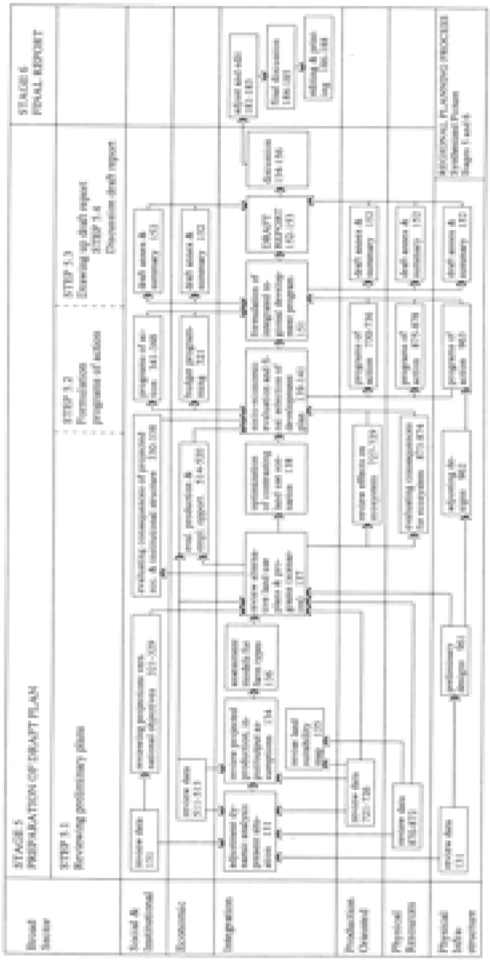


FIGURE 3 An example of the work program of an interdisciplinary team.





tivities and exchange of information, thereby picturing the communication process that should take place within the team. More detailed charts for work programs for interdisciplinary research in regional planning appear in van Staveren and van Dusseldorp (1980).

Finally, a budget has to be made. For sizable teams that have to operate in large regions, special attention must be given to logistical aspects, such as transport, lodging, etc.

The work program has to be discussed and accepted by both the interdisciplinary team and its director or principal. Though every team member retains responsibility for the quality of outcomes of monodisciplinary research, the other members must still be able to ask critical questions that can influence operationalization of the research problem and final work program. At the same time, team members must respect each others' expertise. From the very beginning, there should be intensive communication among all disciplines. When the final research proposal is accepted by all team members, and the principal has agreed to fund the research proposal, fieldwork can begin.

Fieldwork

[5] After collecting and analyzing the available secondary data upon which already tentative hypotheses can be formulated, general orientation in the field follows. This orientation can be accomplished via the Sondeo method (Hildebrandt, 1981), which can be a part of rapid rural appraisal approach (Beebe, 1985). Sondeo method is a simple procedure whereby team members go two by two into the field to observe and discuss potentials and constraints for development of an area, with the people in the field and among each other. Every day the couples are changed, so that all members of participating disciplines have had an opportunity to observe in combination the same area, albeit but from their different scientific angles. This arrangement facilitates an important basis for future communication during the period, in which each discipline goes, at least for sometime, its own way.

[6] On the basis of the reconnaissance survey, an adjustment of research problems and work programs may possibly be necessary.

[7] In the next step representatives of the various disciplines start their own research. During this period of monodisciplinary research, there should be regular consultations between team members. Exchange of tentative data and information make it possible that mutual influence of the actual problem formulation as well as work program of participating dis-

ciplines occurs. The views and information presented by one team member can influence the perception of other team members. In response, they can focus on other issues or areas than those originally mentioned in their work program.

The type of data that has to be collected by various disciplines depends on the nature of the region. For the social disciplines, van Staveren and van Dusseldorp (1980) provide checklists for disciplines frequently involved in research for regional planning.

In research projects that are part of a regional planning exercise for predominantly rural areas, some disciplines have to contribute their information at an early stage: for instance with climatology, hydrology, geology, and soil science. On the basis of their input other disciplines then focus their own research and planning activities, such as agronomy and animal husbandry, that in turn provide information for sociology and economy (see Figure 3). Some of the team members will have left the field already, because their research activities have finished by that stage. When they are stationed nearby, it is still possible to have them at team meetings, but often they have taken up other duties and their involvement would be expensive. In such a situation the disciplines leaving the team should have presented their reports in time, so these can be discussed in detail with other team members.

Synthesis

[8] In this stage the findings of various monodisciplinary research efforts have to be made available to all team members.

[9] When larger teams are involved, sometimes a nucleus team is given the first responsibility to combine information provided by participating disciplines into an integrated and dynamic analysis. However, all team members should have opportunities to make suggestions about how integration should take place.

[10] More important, team members follow closely how the results of their disciplines are being used in the integration process. This means that all team members should be available if possible. In addition, part of the integration can, and sometimes should, take place during fieldwork.

[11] To reiterate, the outcome of interdisciplinary research, as presented in the final synthesis, is based on contributions of the separate disciplines, even when these contributions cannot be recognized. But the quality of such an integrated analysis is determined by the contributions of the disciplines. The building stones, which are the basis for analysis, have to be mentioned in the final report in appendices. If the building stones are not

clear it will be difficult, if not impossible, to judge the quality of the integrated analysis, and to falsify it. From a scientific point of view this would be a poor performance.

An excellent integration of disciplinary contributions of poor or heterogenous quality delivers a poor product and can create havoc during the preparation and implementation of action programs, especially in policy and action-oriented research. In such cases multidisciplinary study of good quality is preferable.

Reporting

In policy-oriented research it is important to pay special attention to presentation of the report. It should be understandable for policymakers and laypeople alike.

The Role of Social Scientists in Interdisciplinary Cooperation in Farming System Research (FSR)

Historical background and main characteristics of FSR

Agricultural research has provided important inputs for rapid increase of agricultural production in Western as well as in developing countries. However, the farmers have been the primary beneficiaries, or those living in areas favored with good soils, climate, or infrastructure (e.g. irrigation systems). The development of innovations, such as high yielding varieties was mainly done in isolation from research stations. Little attention was paid to available indigenous knowledge (Brokensha *et al.*, 1980), or to the farmers' positions and their environments. Farmers were supposed to adapt themselves to the innovations developed by researchers. As a result, many of the innovations were not accepted, or only partly introduced. It may also take a long time before small farmers, by far the majority in developing countries, can profit from the outcomes of agricultural research.

In the last decades, appreciation of the knowledge of farmers, especially in less favored areas, has increased considerably. Obviously the detailed knowledge farmers have of their own environments is considerably larger than the knowledge of agricultural researchers. Box (1988) found in the Dominican Republic that farmers were aware of far more varieties of cassava than researchers. Many of these varieties previously unknown to the research station, were crucial for their survival. This realization has led to a new approach towards agricultural research in the sense that more attention is paid to farmers' knowledge; moreover, a part of the experimentation takes place at the farm, in so-called farming systems research.

The main characteristics of farming systems research (FSR), according to Shaner *et al*. (1981:19-20), are the following:

1) *Farmer based*. It starts with farmers and their households, their knowledge of their farms and the (physical, biological economic, and social) environments in which they have to operate.
2) *Problem solving*. FSR tends to focus on short-term objectives. The approach identifies farmers' constraints that are beyond their control. From this starting point, an assessment is made of whether actual cultivation practices can be improved or whether innovations still unknown to farmers can be fitted into their farming systems.
3) *Comprehensive*. FSR studies the whole farm setting in order to identify problems and opportunities, notes their interrelationships, sets research priorities responsive to farmers' and society's goals, carries out experiments, proposes changes in the light of these comprehensive perspectives, measures results in terms of their impact on farmers and society, observes farmer acceptance of change, and transfers acceptable results to implementing organizations. This means that not only farming practices are of importance. Attention must also be paid to non- and off-farm activities because in many developing countries an important part of the income of households comes from outside the farm. This outside income is often on a working-hour basis and is higher than the farm income.
4) *Interdisciplinary*. The comprehensive approach requires an interdisciplinary effort. That is, different disciplines have to work in close contact with each other. Because women perform many, if not most, of the activities on the farm (in Africa), female researchers should be included on the FSR team.
5) *Complementary*. FSR replaces neither commodity nor disciplinary research nor extension. However important farmers' knowledge may be, there is still a considerable amount of knowledge beyond their horizon. But there should not be a one-way flow of information. Farmers' practices can open new avenues for agricultural research in the sense that specific problems are identified for research. Additionally, the ways farmers cope with their environment can create new insights for agricultural researchers. FSR can build bridges between the farmers, agricultural researchers, and extension workers. For improving cooperation with agricultural research stations, it is particularly important that the social sciences are included. The various roles they can fulfill there — go-

between and translator, monitor, assessor of social impact, analyzer of indigenous knowledge, accommodator, or scout — have been elaborated by van Dusseldorp and Box (1990).

6) *Iterative and dynamic.* It is iterative because in a process that starts with partial information, insight is gained through studies and experimentation, leading in turn to modifications of actions. FSR is dynamic in the sense that objectives and approaches for future work can be adjusted in the light of accomplishments.

7) *Responsible to society.* FSR operates from the farmers' and society's viewpoint. For instance, it is not sufficient to look only at maximal income of farmers in the short run. Sustainability also has to be taken into account. Farmers' practices that lead to accelerated erosion should be modified.

Recently, there have been indications that the heyday of FSR is over. Some of the criticism heard in developing countries indicates FSR is a very expensive research approach that can only be used if there are rich donors willing to fund it for a considerable time. Furthermore, some of the disciplines required are scarce, not employed in agricultural research stations, or not available at all, as is the case with social scientists. Finally replicability is not always easy. The recommendation domains (the areas in which the farmers can use the outcome of FSR) are often limited.

Sociological Theories That Can Be Used

In research that leads to recommendations for development and improvement of farming systems and rural development, adaptation of farmers' behavior is necessary. In other words, the farmers and members of their households have to decide to perform certain activities in a different way, to introduce new activities, or to eliminate activities performed in the past. In such cases, the sociologist has to indicate what these changes are and whether the farmers and their families are willing and able to adjust their behavior, taking into account their environment. The same holds true for farming systems research, in which knowledge of the farmer plays a central role.

It is crucial that sociologists make the theories they use explicit. In FSR research descriptive theories are first formulated and tested. On the basis of these descriptive theories, prescriptive theories can be developed, forming the intellectual basis for any action program that is to be designed. The action program, in turn, will indicate how to change or adapt the existing farming systems to new situations or innovations developed by participating disciplines on the FSR team.

In order to provide the information mentioned above, the sociologist has to focus attention on two main concepts: behavior and determinants that can influence behavior. The decision pattern of members of farmers' households is closely related to behavior.

Human behavior is "The acquired manner in which a human being acts in a given situation as a result of his previous human association" (Fairchild, 1955:21). Kunkel (1970) offers a behavioral model (theory) for explaining how human behavior is created and how it can be changed. This model has limitations, because it is a considerable reduction of reality. However, its simplicity and practical application possibilities are fruitful. It is also possible to use other theories, including existing decision theories. However, if other theories are selected, other data and information have to be collected.

In Kunkel's vision (1970:26-61) human behavior is shaped by stimuli. He distinguishes **reinforcing stimuli** (rewards) and **aversive stimuli** (punishments). On the basis of previous experiences, human actors know which type of activity was rewarded, or looked upon less favorably by the social environment. When activities are rewarded in a constant and consistent way, this activity will most likely be repeated in the future. When an activity will constantly be condemned (punished), very likely it will not be repeated. The main question is: what is an actor seeing as reinforcing stimuli and as aversive stimuli? The judgment depends on **state variables**. The state variables of actors are determined by the ideal values of their societies and their translation of these values into operating norms. These norms are changing over time, because actors are in constant dialogue with the value pattern of their society (Giddens, 1979). What is seen as immoral behavior in the immediate moment may be seen as acceptable behavior in the near future.

State variables present conditions of deprivation or satisfaction. For example, after a couple of hours working in the field, actors will be very thirsty. Their level of deprivation will be high. They will experience a glass of water as a great reward. However, after three glasses of water their level of deprivation will go down, a state of satisfaction (saturation) having been reached. At that moment water is no longer a reward. It can even become an aversive stimulus, if they are forced to drink more water. This holds true for all types of reward. The more specific a reward is the bigger the chance that a state of satisfaction will be reached quickly. When an effort is made to influence the behavior of the actors via rewards one has to know what their level of deprivation is and for what specifically. Reinforcing stimuli must be found that can satisfy many demands. Obviously, money is such a **generalized reinforcing stimulus**.

Many activities are "rewarded" and "punished" at the same time. Earning a lot of money at the costs of others can be rewarding, but it can at the same time lead to a loss of social status, because the actors will be seen by their social environments as greedy and unkind people. This means that the actors have to make a cost/benefit assessment. Clearly, the human being is a cost benefit optimizer (van Dusseldorp, 1992).

In addition, the schedule of reinforcement must be considered. "Whether reinforcers are presented continuously or intermittently, on a ratio or interval schedule, on a fixed or variable basis, is largely a function of the social context, such as customary payment for work or periodic festivals" (Kunkel, 1970: 43). For instance when work is necessary to prevent erosion that in the long run can affect the very existence of a farm, it is questionable whether a farmer is willing to bear the punishment of this moment (costs in labor or other scarce resources needed for implementation of anti-erosion works), because the rewards in most cases can be expected only after many years. It is easy to point out to farmers in India that by continuing the present type of farming, they will destroy their farms, and they will be of no use for their children. Most likely, their answer will be that if they are not producing as they are now, there is little chance their children will survive. So, what will be the benefits?

The sociologist has to find out what actors are experiencing as rewards and punishments of their activities. The most simple way is to investigate why farmers have decided to start an activity in the past and what kind of cost/benefit assessments they have made. When these decisions were made long ago, this is not a simple affair. Some kind of rationalization will automatically take place. But there is another reason actors will have difficulty explaining why they have decided to start a specific activity, especially when it comes to activities that take place regularly and do not require a substantive amount of scarce resources. In such a situation the decision process often is made in a **pre-attentive way**. A "...pre-attentive process refers to any information processing, that is outside of a decision maker's ordinary attention and awareness" (Gladwin and Murtaugh in Barlett, 1980:117).

As mentioned earlier, the behavioral theory has limitations. It is a rather mechanistic view of human actors. In reality things are far more complicated. Due to changes in operating norms, it is difficult to predict, at least for a long period, the reinforcing stimuli by which behavior can be influenced.

Even so, human behavior is shaped to a considerable extent by rewards and punishment. Unless there are suddenly considerable changes in the environment, operating norms will change only gradually. Therefore, for the short term some prediction is possible, albeit with prudence.

Position of the Social Scientist in the FSR Team

Before discussing the research activities of the sociologist, two positions the social scientist can have in an interdisciplinary FSR team, and in agricultural research in general, have to be mentioned.

a) In the **steering approach** (Van Dusseldorp, 1977; Van Dusseldorp and Box, 1990) sociologists, on the basis of their knowledge of the farmers' actual behavior, indicate what technical innovations can and should be introduced in order to improve the farming system. For instance, on the basis of the existing labor film the sociologists can indicate that the farmers' position could be improved if crops or animals are introduced. (The labor film is a graphic presentation of the hour of labor used for various activities over time.) They would require time and attention in periods when farmers have a surplus of labor, time and attention that cannot be used for other activities and are not needed for religious or other ceremonial obligations. With them, the farmer can obtain a higher income with available resources.

   Dewalt calls this the "social science of agriculture." He explains: "the study of the interaction of the natural environment, socio-cultural patterns, market conditions, government policy, and technological systems in order to identify agricultural research and/or extension priorities, to determine appropriate institutional structures and responsibilities for research and extension, to predict the consequences of agricultural change, and to identify government, agency, and institutional policies that will facilitate the development of more just and equitable social systems" (Dewalt in McCorkle, 1989:43).

   There are several reasons why sociologists should be careful not to overstress their steering function. Firstly, the predictive power of sociology is rather limited, especially when it comes to predictions that cover five or more years. This is typically the period required to develop, via breeding, new varieties with required characteristics. Secondly, in most cases people and their society adapt more easily to new circumstances than to their physical and biological environment. Thirdly, technical scientists do not appreciate having social scientists, including economists, tell them what direction their research should take. This was clearly demonstrated in the Centro Internacional de Agricultura (CIAT) in Colombia, where economists tried to determine policy over technical scientists and came, at least for some time, into great difficulties.

b) The **accommodation approach**. Here the first move is made by the technical disciplines, which indicate what kind of technical innovations are possible in the given physical environment. On the basis of their information the economist can make an assessment of expected benefits. The sociologist is then able to make an assessment of the social acceptability by comparing the present and desired future behavioral pattern, taking into account reinforcing and aversive stimuli that are available. The advantage for sociologists in this approach is knowing on which type of activities in the farming system research efforts should concentrate.

Categories of Information that Have to be Provided by Technical Disciplines, When the Accommodation Approach is Followed

In actual practice the FSR team follows a mixture of the steering and accommodation approaches. Thus, whenever sociologists have, in the beginning of the research process, important information that can influence the direction of research of other disciplines they will make this information available. Hereafter special attention will be paid to the accommodation approach and the type of information that has to be exchanged between technical and social disciplines.

The sociologists have to find out what kind of behavior is required before the new innovation, or mix of innovations in the case of the so-called package approach, can yield expected benefits. Through intensive discussions, the technical disciplines have to indicate what farmers must do exactly, in order to obtain maximum results of the new (available or potential) innovation(s), and what the consequences are if the pattern of activities is not or only partly followed. When a new crop or a new variety of an existing crop is introduced with different properties then the following items have to be discussed:

a) *The time factor* is often of great importance. Therefore the agronomist must indicate in great detail what has to be done at which particular moment: for instance, when the land preparation must be ready and how much time is involved; when seed beds have to be prepared, at what time this has to be done, and how much time is required. In the case of transplanting or sowing, the period when it has to be done and time required for these activities must be indicated. In addition, farmers must know what to do once the crop is established: for instance, weeding or the observance and combating of diseases; knowing when the harvest should take place and what kind of activities have to be performed, as well as the duration and which kind of activities are needed in storage and processing, when they have to take place, and their duration. In this way it is possible to make the labor film, which indicates what has to be done, when, and the number of human labor hours needed. By comparing this labor film with the existing labor film, a first assessment of the acceptability of the innovation for farmers and their households can be made. One question to consider is whether women have extra time available if household tasks remain the same.

b) *Time consciousness*. There is another aspect of time. Some crops or animals are very susceptible to certain diseases. When the occurrence of a disease is not recognized in time, this can have considerable consequences for production, or even lead to the death of crops and animals. In irrigation projects, farmers have to prepare their land in specific moments. Often great accuracy in timing is required during irrigation activities when water is scarce. Members of the farmer's household must have the ability to take the issue of timely action seriously. This circumstance can create problems in the first period of introduction, because many traditional crops do not require such a time-specific approach in observing diseases or infections and application of insecticides or medicines.

c) *Ergonometric and cultural aspects of labor*. Attention must also be paid to ergonometric aspects of the various activities. Does the activity require the power of a full grown man or can it also be performed by women and children? Here only physical aspects of the required labor are considered. But sociologists also have to determine whether labor that physically can be performed by women is also acceptable in a certain socio-cultural environment. Attention must also be paid to what kind of position in which activities have to be performed. Do they require bowing, kneeling or can they be done standing, etc.? Certain positions are sometimes perceived as socially demeaning. This cultural dimension requires special attention when new equipment is introduced. For instance, Amhara farmers in the Awash valley in Ethiopia refused, at least in the beginning, to bow, a position required in the harvesting of cotton.

d) *Knowledge and skills*. What kind of knowledge and skills are required to perform the various activities needed for a successful introduction of an innovation? In the case of diseases farmers must be able to identify the symptoms of a certain disease and distinguish it from other diseases with more or less the same symptoms. Sometimes this requires that farmers be able to recognize new causalities. If they believe that certain diseases are caused by supernatural powers, they will either feel themselves in no position to do something or refer to magic. These responses do not mean that their behavior before was irrational. Within their worldview, taking belief in supernatural powers as an example, it was logical and rational to perform activities they did before (e.g. to sacrifice an animal to appease the spirits). When animals are new in the farming system, farmers have to know how to handle them and the same holds true for tractors or pumps, etc.

e) *Inputs*. What kind of inputs are required? Are these inputs available? Is the farmer familiar with these inputs? The use of insecticides or new mechanical equipment is not always easy and without danger.

f) *Benefits*. What are the extra benefits (reinforcing stimuli) for the farmers' household when the proposed innovation (or mix of innovations) is correctly introduced? It is important to know not only that production will increase, but also the economic benefits. Here the economist has a major role in providing the information.

g) *Risk*. Another aspect that needs attention is the risk factor. New varieties or a new breed of animals are often more susceptible to the vagaries of the environment. They may not be able to withstand drought or flooding very well, or are not immune against certain diseases. In other words, is it possible for technical disciplines to indicate clearly, and in a quantified way, the extra risks involved when an innovation is introduced and accepted? Especially for small farmers, even "small" risks should be avoided whenever possible, because these farmers have little or no risk absorption capacity. Researchers must be sensitive to the issue, because in most cases, they have a wealth bias. As a result, they are inclined to think (very) small risks are acceptable.

h) *Consequences of partial change in behavior*. Finally, technical disciplines must indicate what the consequences are if a certain activity is not performed in the proper way, or at exactly the right time. For instance, what will be the loss in production, in percentages or quantities, when the farmers are two days late in observing a disease or in applying an insecticide?

When this information is made available by soil scientists, agronomists, irrigation specialists and economists, sociologists have clearer insight into the behavior pattern required, as well as the benefits (incentives, reinforcing stimuli) and the costs and risks (aversive stimuli) that can be expected. This information is essential for discussions with farmers that must occur in order to find out what their opinion is regarding the new crops, animals, or production techniques which are already available or could be developed via research at agricultural research stations.

A Relational Model of the Farming System

In the foregoing section attention was focused on the behavior required from farmers in order to ensure the success of a specific innovation. Whether the farmer will accept an innovation is determined not only by the benefits of that specific innovation, but even more important, how the innovation fits into the farming system as a whole. Necessarily, then, the FSR team needs clear insight into all components of the farming system under investigation, and the interrelationships among these components. This insight can be achieved by making a model.

There are three types of models. In the **conceptual model** all components of a system are indicated, but no attention is given to relations among these components. The **relational model** indicates not only the components of a system but also their interrelationships. Finally, there is the **mathematical model**, in which relationships can be expressed in mathematical formulae. This type of model will be discussed later on.

A relational model is depicted in Figure 4. The lines indicate relations that exist between components. An essential part of the farming system is the work necessary for maintaining farm buildings, the repair or construction farm equipment, and the time women need for looking after small children, cleaning the house, collecting water and/or firewood, cooking, and washing, repairing and making clothes for members of the household, etc. These activities are mentioned under the heading “reproduction activities.” Another important component consists of activities outside the farming system, the so-called **off-farm** and **non-farm activities**. In many households in developing countries, these activities can provide 50% or more of total household income. It is necessary therefore to investigate the household as a whole of which the farm is a sub-system.

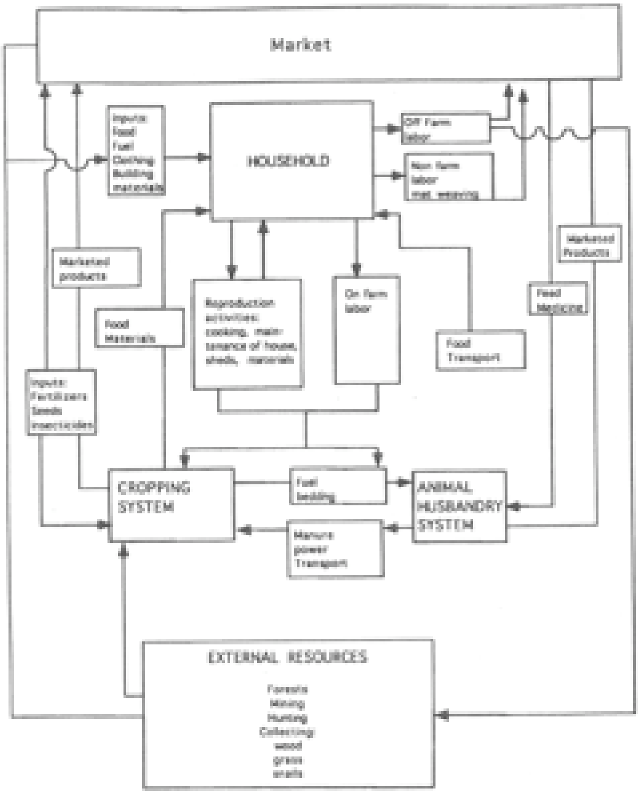


Figure 4: The household/farm system

As soon as possible the FSR team should make a relational model of the farming systems they are investigating. After making a conceptual model, construction of the relational model follows. It is not enough to indicate relationships by lines only, as indicated in Figure 4. When considering labor, it is necessary to find out how much labor is involved for the activities mentioned, both in the components and their interrelationships. For instance, it is not enough to know that firewood is collected from the forest. The amount of time this takes and who is involved in this activity should be indicated. Similarly, the volume of crops used as food for the household, fed to the animals, or sold at market should be known.

A relational model of the farming system can be an important tool for coordination of the activities of members of a FSR team. Such a model provides insight into the relative position of components, the various disciplines involved and the potential relationship they might have with other disciplines.

Three Periods in the History of the Household and the Farm

In the accommodation approach, sociologists try to determine, in cooperation with their colleagues, what the future behavior pattern should be. This determination must occur before the introduction of certain innovations can be successful. The next step is to analyze the actual behavior pattern of members of farmers' households. In addition sociologists must obtain insights into reinforcing and aversive stimuli that have determined behavior. Present behavior is a result of events that have taken place in the past. It is necessary therefore to construct a history of the household and its farm. Dividing this history into three periods can be helpful:

a) *The formative years of the farmer and his wife*. This should include the background of their parents, composition of the families they came from, their education, and their activities before they started their own household and farm.
b) *The period from the start of the farm until the start of the FSR*. In this period an overview of important events that took place should be made, plus the various decisions that were made. The information obtained from this period has some weaknesses. Firstly, respondents may not remember exactly what took place in the past, because most of the events took place long ago. Secondly, members of farmers' households very likely will rationalize their reasons and arguments on the basis of which decisions were made. Hence, this information cannot be accepted at face value. It requires regular checking.

c) *The period of implementation of the FSR*. In most FST a considerable amount of information is collected by technical and economic disciplines indicating exactly what farmers did and what decisions they made. This information must be made available to sociologists, as soon as possible and be included in the schedule of the history of the farm (see Figure 5).

Past Events and Decisions to Investigate

Some events and decisions worthy of investigation follow. They can provide insight into the functioning of the household, and the reasons decisions were made, thereby helping to explain the present situation of the farm. In order to have a complete history of the household and farm, investigation should begin when the household and farm were founded. Because a long time may have passed, problems with memory of the respondents can be expected. For that reason, special attention should be given to major decisions made in the last five years.

A very detailed analysis must be made of decisions that have been registered during the FSR period. Because these decisions will have been made only a couple of weeks ago, the reasons will very likely be easily remembered. The main focus should be on the types of assessments actors have made on costs and benefits related to the decision under scrutiny, in addition to finding out whether other alternatives have been taken into consideration, and for what reasons they were discarded. Preferably attention should be paid to decisions which do not take place regularly and in which a considerable amount of scarce resources were involved. Otherwise the problem of pre-attentive decision making may occur. The respondent may not always be willing to provide this information. Informants have to be all the relevant household members, not only the head of household.

a) *Development of the household* is determined by the birth, death, adoption, and marriage of children, plus the moment that they leave the family. This information, combined with the information obtained from their formative years, can be graphically presented in a family tree. Such a tool provides insight into that part of the farmers' networks, as far as they are based on kinship. This kinship network, though, can be quite large and may not be the source of the most useful members of a network. When it comes to adoption of children into or departure of children out of the household it is important to find out the reasons.

TIME	THE HOUSEHOLDS	THE FARM				BUILDINGS			OFF/NON-FARM ACTIVITIES	CREDIT	MARKETING
		LAND	CROPS	LIVESTOCK	EQUIPMENT	INPUTS	HOUSE	STABLE, ETC			
PERIOD 1 THE FORMATIVE YEARS			RICE/MAIZE/CASSAVE								RICE ONLY
PERIOD 2 START OF THE FARM UNTIL FSR											
YEAR 1		7 ACRES INHERITED	START PEPPER	+1 COW							RICE
2		+2 ACRES	STOP MAIZE	+3 GOATS						+10,000 RS	RICE AND PEPPER
3		-1 ACRE	STOP PEPPER	-2 COWS				BUILT A STABLE FOR GOATS		-7,000 RS	RICE
N							BUILT A NEW HOUSE				
PERIOD 3 PERIOD OF FSR WEEK 1 2 3 N	M	O	R	E		D	E	T	A	I	L

+ = BOUGHT OR DEBIT
– = SOLD OR CREDIT

FIGURE 5

b) *History of the land.* What was the size of the farm at the start? Was it inherited, bought, rented, share-cropped, etc.? Was new land bought, rented, share-cropped, or was land sold, rented, or shared with other persons? What was the price of purchased land, and what were the conditions when land was rented or shared? What were the locations of plots? Also to whom was land given, or sold, from whom was it obtained and for what reasons?

c) *Crops*. What crops were grown when the farm was started? Were new crops introduced and when? For what reasons and from where was information about these crops obtained and from where did seeds or seedlings come? Were crops eliminated from the farming system and for what reasons? Have farmers observed changes in yields or disease occurrence? What kind of explanation do they give for these changes?

From the crops presently grown the sociologist, together with agronomist, has to find out, in great detail, how these are cultivated and for what reasons the various cultivation practices are performed and by whom.

d) *Livestock*. When the farm was started were there livestock and of what type? Were new types of livestock introduced into the farm system and for what reasons? From whom was information obtained about new types of livestock? Was livestock sold, bought, or rented? Under what conditions, from whom and for what reasons? What was the purchase price of cattle? Did farmers or their families observe changes in productivity of animals or disease occurrence? What kind of explanation do they have for these changes?

e) *Inputs*. What kind of inputs did the farm household use — e.g. manure, fertilizer, or insecticides — when it started the farm? Were new inputs introduced, when and for what reasons? From whom was information about these inputs obtained? How did farmers get access to these inputs and under what conditions?

f) *Equipment*. What type of equipment did farmers have when they started their farms? Was new equipment introduced, when and for what reasons? From where did they obtain information about new equipment, such as a new type of plough, a small tractor, or spraying equipment? How did they obtain this equipment and under what conditions: for instance buying with or without credit, renting, borrowing or shared use? Did they make their own equipment?

g) *Buildings*. First the history of household dwellings should be pursued. In what kind of house did the household first dwell? Was it owned, rented or provided free? Were any improvements made? A new house built at the same location or at another plot? What materials were used in building and/or for improvement of the house? How and from whom were these obtained and under what conditions? What were the costs involved? The same questions mentioned above can also be asked for stables, sheds, or storage facilities on the farm.

h) *Off- and non-farm activities*. What kind of off- and non-farm activities were performed by various members of the household? When was the first time these types of activities were performed by various members of the household? When was the first time these types of activities were initiated? What were the reasons these activities were performed, and what was the remuneration per invested hour of labor? According to the opinion of the various respondents, what was the social status of this type of work? Were opportunities to do off- or non-farm activities not taken into consideration and for what reasons?

i) *Credit*. It is important to find out whether farmers and their households have taken credit (lending of money on whatever conditions), and at what moments in the history of the farm, for what reasons, from whom, and under what conditions? Did the farmers observe changes in the credit system or conditions under which credit is provided? What explanation do they give for these changes?

j) *Marketing*. What kind of products did the farmers' households sell? When, where, to and by whom were these products sold? When did the marketing of various products take place for the first time and for what reasons? What were the prices for various products? Have the farmers and their household members observed any changes in the marketing system and prices? What explanation do they have for these changes?

All of the important events and the related decisions made by farmers and their households can be brought together in a schedule of the history of the farm, as indicated in Figure 5.

The social and economic environment

The members of a farm household are not operating in a vacuum. They are embedded in the cultural, social, and economic environment of their villages and regions. It is necessary therefore to gain insight into the value patterns and social structure of the society in which they are living, as well as the relations they have with various individuals, groups, and institutions.

On the basis of information farmers have been given — e.g., with whom they had contacts, whether in obtaining information or credit, or selling products, renting or selling of land — a **social network** diagram can be

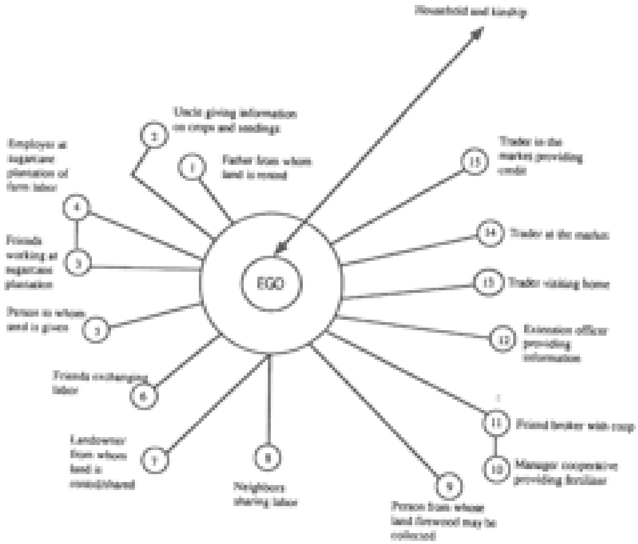


FIGURE 6 A social network diagram of a farmer

made. Such diagrams are useful, because they give insight into the systematic interaction of people engaged in activities that can alter institutions in which they are participating. They also have a definitive structure that influences the behavior and attitudes of the respondent in the center of the network (ego). This information can be of importance in a later stage of the FSR, when recommendations have to be made regarding how and via whom farmers can best be approached when introducing proposed innovations. Figure 6 is an example of such a network diagram.

It must be realized that the social network of farmers is larger, in the sense that they may also have relations not directly concerning the farm or household. They can be involved in other organizations such as religious groups, village councils, cooperatives, etc., from which they obtain assistance and many kinds of information. Moreover, insight into the networks of farmers' wives and the older children is significant.

Research techniques to be used

Obviously the information sociologists want to obtain from their respondents may be sensitive. Not everybody is willing to give in great detail the reasons for specific decisions. Researchers have to be aware that if respondents are willing to answer questions, the answers are not always correct. They can have implicit objectives they do not like to reveal, because they are at the margin of the norm and value pattern of their societies. For instance, the main reason they bought a piece of land might not be that they wanted, in the first place to extend their farms, but they tried to prevent their neighbors, with whom they had quarreled, from getting a bigger farm. In order to obtain this type of information, researchers have to put considerable efforts into building up good relationships with their respondents.

In obtaining the data and information indicated above, researchers can use the diagnostic case study approach (Doorman, 1991). This approach relies on techniques of observation, as well as open and structured interviews. Once obtained, information must be put into field notes which can be analyzed at a later stage.

Researchers must realize that this type of intensive discussion with farmers can influence their future behavior. For example, it is possible that during a discussion with farmers on the various types of credit that are available, farmers start to realize that they can substitute the credit they take from middlemen by credit from other sources like NGO's. This will affect their future decision making. The researcher, however, will only have information on decision making in the past.

Presentation of data and information

Data and information can be presented as follows:

a) *The report*. Sociologists can write a report on the basis of their field notes. When it comes to the rather voluminous description of case studies, this must be done as detailed as possible in the draft report. In the final report only those events relevant for the line of argument have to be included. However, there is some danger that only that information will be used which supports the line of argument. Obviously this must be avoided.
b) *Schedule of the farm history and social network diagram.* The draft report, and even the final case study, may be too bulky and too technical for team members to read. Yet the findings of the diagnostic case studies must be discussed intensively with technical disciplines.

Therefore, the findings of each farm in schedules should be presented as indicated in Figures 5 and 6.

How to arrive at recommendations

On the basis of the schedule of decision making in the past and present (Figure 5) it is possible to initiate a discussion with the other team members. The following issues are important.

a) Are there any activities or events that the sociologist has not observed or was not informed of, but other team members are aware of and consider important? If so, this information should be brought into the schedule.
b) Are there crucial decisions, according to the technical and economic disciplines, that require more in-depth information?

On the basis of these discussions, sociologists can revisit farmers in order to complete their information.

Now the sociologists have a clear insight into:

a) The past and actual behavior pattern of informants in a household, and the way they make cost/benefit assessments arriving at specific decisions, and;
b) The desired behavior pattern needed for successful introduction of a specific innovation.

By comparing the two sets of behavioral patterns the sociologist can make an assessment of the changes that have to be made in the behavior and decision patterns of the household.

On the basis of what the farmer and his household members experience as reinforcing and aversive stimuli, and expected reinforcing and aversive stimuli connected with the proposed innovation or mix of innovations, sociologists can:

a) Make an assessment of the likeliness that the innovation will be accepted;
b) Indicate, in case the chances of acceptance are low, how innovations should be adjusted, as far as technically and economically feasible, in order to obtain a higher rate of acceptance;
c) Mention what kind of other innovations would be acceptable to farmers' households;

d) Outline the kind of measures advisable, necessary, or recommendable to speed up the acceptance;
e) Indicate on the basis of the social network diagrams by which channels members of the household can best be approached.

Understandably these kinds of observations and recommendations can only be made **after intensive discussions with farmers** and their household members. Group discussions are preferable, though women and children may not participate in these intensive discussions. The opinions of farmers are crucial. They are the ones who must make the final decisions and have to take the risks.

The Interface Between Simulation Models and the Social Sciences

The use of mathematical models is penetrating agricultural research stations where crop simulation models have become popular. The interesting aspect of crop simulating models is that they are giving a specific framework for interdisciplinary cooperation between physiologists, agronomists, soil scientists and entymologists.

Recently, efforts have begun to interface these models with linear programming models of economists and with mathematical models for land evaluation models. There are indications that, via interfacing of various mathematical models, a framework for policy-oriented interdisciplinary research can be developed. This interesting development has to be followed closely by social scientists, not so much because they have to try to obtain their place in these models, but to see at what moments and in what ways they can contribute to the agricultural research process as it is developing presently. If this interfacing does not occur the social sciences will become isolated in the field of interdisciplinary research for agricultural and regional development. In a recent (March 1992) workshop in Wageningen of modellers of agricultural development, sociologists were absent. The main comment of the other disciplines was: we continue with our work and the sociologists can write the instruction leaflet once we have decided what has to be done.

It is important to emphasize that experienced modellers are well aware that simulation models are tools and instruments which can facilitate agricultural research, nothing more nor less than that. They are a type of metamethod, indicated by Heckhausen (1972), and do not lead to transdisciplinarity. Nor can the output of these models be accepted at face value. Experiments in the field are necessary to test these outputs.

Penning de Vries, *et al*. (1989) explain these models as follows:

> A crop model is a simple representation of a crop. It is used to study crop growth and to compute growth responses to the environment. Crop models in common use can be distinguished as descriptive and explanatory model[s].

Descriptive models

A **descriptive model** defines the behavior of a system in a simple manner. The model reflects little or none of the mechanisms that cause the behavior. Creating and using this type of model is relatively straightforward. Descriptive models often consist of one or more mathematical equations.

Explanatory models

An **explanatory model** consists of a quantitive description of the mechanisms and processes that cause the behavior of a system. These descriptions are explicit statements of scientific theory and hypotheses. To create an explanatory model, the system is analyzed and its processes and mechanisms quantified separately. The model is built by integrating these descriptions for the entire system. An explanatory crop growth model contains descriptions of distinct processes such as photosynthesis, leaf area expansion, and tiller induction.

In such a model:

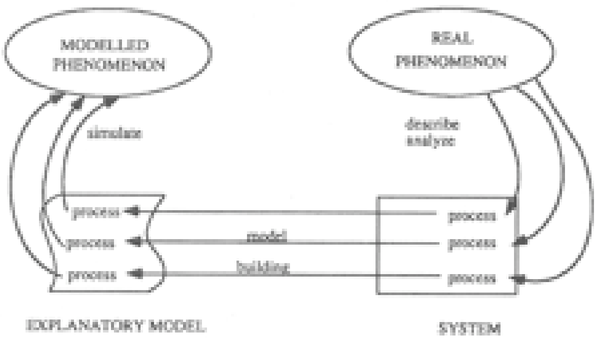
Each process must be quantified in relation to environmental factors, such as radiation and temperature; and in relation to the crop status, including leaf area, development stage and nitrogen content. Growth rates can then be computed for any stage of the growing season, depending on the actual crop status, the soil and the weather. All important factors can be accounted for in this way, provided there is sufficient theory and data to quantify them.

It is possible, with these explanatory models, to perform simulations, which lead to explanatory simulation models, in order to be able to perform simulations on effects of alternative developments.

Simulation models are relatively simple representations of the systems in the world around us. A system is defined here as well as delineated parts of the real world. The user identifies a system on the basis of objectives and on the intrinsic structure of the world as measured and observed. For an agronomist, a system may be a rice crop; its elements, plant organs (such as leaf stem and root) and processes (such as growth and transpiration) interact strongly. Weather is a driving variable because it exerts an important driving or regulating effect on the crop. The crop, on the other hand, has virtually no impact on the weather. In general, driving variables influence the system and its behavior, but the reverse is not true.

The essence of the foregoing citations is that theoretical agronomists are able, via reduction, to create a crop growth simulation model through which it becomes possible to experiment by computer with a specific crop. This prospect does not automatically mean that results of such simulation exercises reflect what will happen in reality. Not all processes are taken into account in the model. Therefore, field trials are necessary to test the results. Figure 7 shows how explanatory models can be constructed. Figure 8 is a simplified overview of the work program for an interdisciplinary research team.

The foregoing also indicates that such simulation models are of little value for the social sciences. First of all, their research objects (farmers) are reactive in the sense that they can and will change their behavior, either when there are changes or when they expect changes in the environment. This condition will have its effects on the environment. It is also close to impossible to test the outcome of simulation models introduced in social sciences.



Source: Penning de Vries et al. (1989). Simulation of ecophysiological processes in several annual crops.

FIGURE 7 A scheme to indicate how real world observations are analyzed and integrated into an explanatory model to simulate behavior of the system.

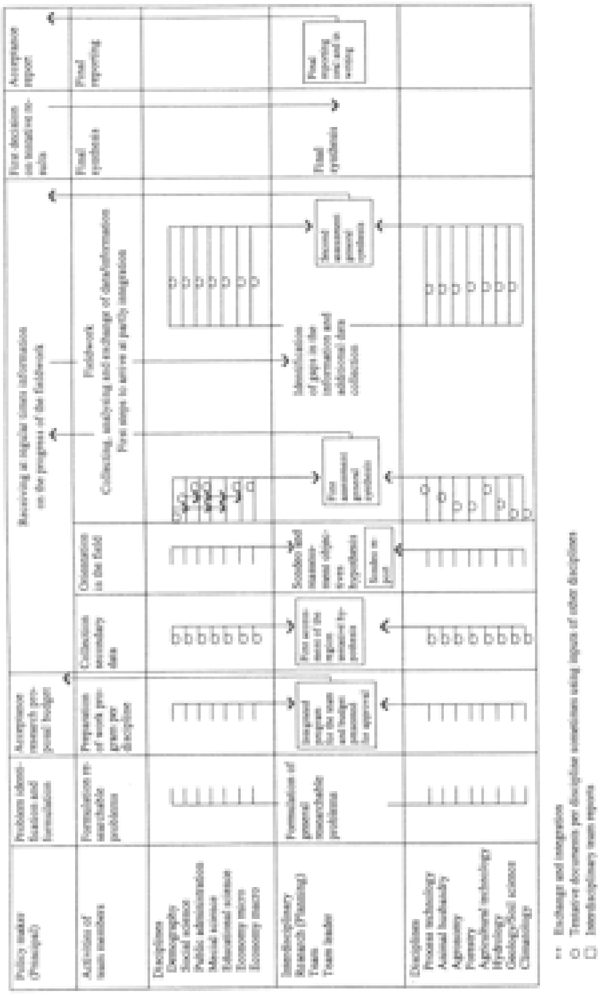


FIGURE 8 Simplified bar chart visualizing the work program for an interdisciplinary research team.

To sum up, the advantages of crop growth simulation models in agricultural research are as follows:

a) The simulation model claims to give a framework that facilitates interdisciplinary research. It facilitates indication of precisely what is expected of each discipline in a specific research project.
b) The model makes it easier to indicate relations between applied and fundamental research. For instance, a rice crop does not absorb nitrogen from the soil after flowering. However, during the period of maturation a process takes place within the rice plants that leads to replacement of nitrogen. This process is far more important than was thought before. At present, insight into how this process works is missing, suggesting an important lead for further fundamental research.
c) The simulation model makes it possible to design more specific field experiments. A crop growth simulation model better facilitates knowledge of what exactly has to be tested.
d) Finally, the model enables obtaining the same results with fewer field experiments. By conducting experiments using the computer it is possible to find out which trials will give poor or no results. These trials can then be eliminated. Because field trials are a very expensive part of agricultural research, efficiency can be improved considerably.

Some of these advantages have been clearly observed in the field (McWilliam, Collison, van Dusseldorp, 1990). Simulation models can strengthen the interdisciplinary research efforts in agricultural research stations once they have been introduced. Whether use of simulation models will increase efficiency depends, however, on a sociological variable. A large area, covered by field trials, is an important status symbol from which directors of agricultural research stations are not always willing to part.

At the moment efforts are underway to interface results of simulation models of crops and animals with linear programming models of the economists. Most likely this interface can be achieved in a reasonably short period.This takes place in a research project in Indonesia. The first outlines are given in a paper by Stroosnijder and van Rheenen (1991). At the same time efforts are being made to combine results of farming system research with quantitative models for land evaluation (Fresco *et al.*, 1990). Such interfacing makes it possible to arrive at estimates of potentials and constraints for agricultural development on a regional basis.

The foregoing also indicates that simulation models are becoming powerful tools in agricultural research and can provide a sound basis for integrated rural development. De Wit *et al*. (1988), in "Application of Interactive Multiple Goal Programming Techniques for Analysis and Planning of Regional Agricultural Development," argue that with the help of simulation models, it is possible to access the potential physical production of crops in a specific region on the basis of the physical characteristics of that area.

But this is not without danger, as mentioned by McWilliams, Collison, and van Dusseldorp when they say that,

> Interactive multiple goal linear programming (IMGLP) is an interesting technique when it addresses the complexities of the farm system. When it is used to arrive at policy options at the regional level on the basis of the outcomes of simulation models working at the crop level it bypasses the complex decision processes at the farm level. Introducing IMGLP without farm level analysis brings the danger of plans and projects of a top down nature. These are notoriously unsuccessful and wasteful of limited development resources because they are unattractive to farmers.

Modellers as well as policy makers are looking for possibilities for including socio-economic data in simulation models. But at the same time, some questions must be raised.

— First very complex models should be avoided. They may distract from what is happening in the model. Models should be kept small and clean, as are present crop growth models.

— Interfacing different type of models, in the sense that outputs of one model are used as inputs in other models, seems to be a better way, rather than combining the different levels of the real world. The process also becomes more transparent because it is easier to follow inputs of the various disciplines.

— One has to be careful not to force all disciplines to translate their information into a mathematical language that suits the computer. The social sciences are a case in point. There are no indications, at least at this moment and hopefully not in the future, that human beings and their society can be put effectively into simulation models. Sociological information can always be quantified, but the ranges will be enormous and will pollute simulation models.

The developments mentioned above have to be followed carefully by the social sciences. It is easy to stay at the sideline and to criticize the results post hoc. The green revolution and Feder's (1983) book *Perverse Development* provide good examples. It is crucial to determine at which moments in the agricultural research process, sociological information can be brought in using simulation models. There are possible moments when sociological information can be used:

a) The first moment occurs when the issues that have to be investigated must be selected. Socio-economic constraints at the farm level, identified by farm systems researchers or extension staff, provide ex-ante input to shape appropriate technical parameters in the crop simulation model. Labor availability, status of labor and remuneration of labor often have key influences on present and possible farm practices in the future. Farmers may only be able to weed their rice once, or an acute labor shortage at planting time may dictate the need for direct seeding as the only practical option. Such knowledge may be significant when using the model to identify rice varieties and management practices for a specific farming system. Demographic data and labor films are vital information that the social sciences can provide and that can be quantified. Certain values that can impede the introduction of new innovations can also be identified at this early stage (the steering approach).

b) The second moment occurs when, on the basis of the results of simulation, the selection of options to be tested in the field is made. At that moment the sociologist could already make a first assessment of the potential social impact the proposed variety or management practice could have at farm level, on rural communities and regional development. In case the knowledge required for such an assessment is not available yet, it gives the sociologists time to collect the necessary information.

c) Finally, when the testing has proved the technical soundness of the new variety or farm management practice, it is up to the sociologists to indicate what are the sociological prerequisites that have to be fulfilled for a successful introduction and what the potential social consequences are if the proposed innovations are accepted at farm and regional level (the accommodation approach).

The various issues the sociologist should take into account have been discussed above in the section on “The Role of the Social Scientists in the Interdisciplinary Cooperation in FSR.” Without bringing the sociological information into the model the sociologists can still make an important contribution to agricultural research using simulation models, provided they are informed of the progress made by the technicians and willing to work at this level.

Potentials and Constraints of “Broad” Inter-disciplinary Research

The **potentials** of interdisciplinary studies are obvious. In further analysis of complex phenomena, cooperation of disciplines is necessary in order to expand our present knowledge systems. Many problems that have to be solved are so complex that one discipline cannot provide a sound basis for action. It can be even dangerous when solutions for societal problems are based on the finding of one discipline, because, other disciplines are excluded. A clear example is an IRD programme where agronomists are indicating that the main reason for poverty is that the poor do not have the opportunity to produce more, because they lack inputs like fertilizer. However, often the fact is overlooked that there are socio-political mechanisms like the market system that mean that, even when poor farmers or tenants receive the inputs, their increase in income will be siphoned off to the rich.

This does not mean that all research should be interdisciplinary. There are many problems that can be solved by monodisciplinary research. Because interdisciplinary research is a complex, time-consuming, and, therefore, a costly exercise, there have to be very good reasons for selecting the interdisciplinary approach.

The major constraints when it comes to inter-disciplinary research are communication and organization.

The first constraint is that interdisciplinary research requires cooperation between individuals. Cooperation in general is not an easy affair, in whatever endeavor. However, this general problem is aggravated by the diverse educational backgrounds of members of interdisciplinary teams.

1) Due to the educational system, especially in universities during a considerable period of time, young people are specialized in one discipline and indoctrinated with its paradigms, levels of theoretical integration, methods and analytical tools, and last but not least its scientific jargon.

2) This education in disciplinary education isolation often leads to the conviction among post graduates that their discipline is the most important one and most suited to solve specific societal problems.
3) University education is often oriented very much towards the individual's performance, thus stimulating orientation towards individual achievements.

Inevitably this type of educational background provides a poor basis for the kind of open and intensive discussion needed to arrive at compromises and does not increase willingness to respect the views of members from other disciplines and to change perspectives and ideas derived from one's own discipline. The solution is simple, at least on first sight. Change the university educational system. Give students more time to become acquainted with other disciplines so that they are able to understand other scientific languages and become aware of the relative importance of the discipline they study. Good interdisciplinary research is only possible when it is performed by scientists who are well qualified in their own disciplines. Universities must continue to produce individuals highly qualified in their specializations, but at the same time attention must be paid to their capabilities for communicating with other disciplines. Finding the optimal mix in educational programs is far from easy, taking into account the limited amount of time available. With this dilemma Wageningen Agricultural University has been wrestling for some time already — how to train students in a curriculum that was shortened from 5 to 4 years, in such a way that they have a good command of their own discipline, as well as being exposed enough to other disciplines so that they are able to understand and discuss objects of study that transcend their own discipline.

The second constraint is that of organization. Management of research is becoming increasingly an issue. In large research institutes or industrial enterprises, this problem has been solved more or less. However, in universities, with their fragmented structure in departments and faculties, this is certainly not the case. The problem is aggravated by the culture of individualism prevalent in universities. Taking the background of most team members into consideration, interdisciplinary research projects must be allowed a considerable period of time for team members to get to know each other as persons and to become acquainted with the way they handle their disciplines. Therefore joint formulation of a general research problem is an important first step.

Some General Observations

1) Interdisciplinary research is important and often necessary when it comes to expanding the boundaries of our knowledge of complex systems such as farming and household systems. It also plays an important role in policy/action-oriented research.
2) Integrated rural development needs as a basis interdisciplinary analysis of the area or region where development activities are taking place. Often such analysis is missing. Sometimes this is due to poor preparation, but the problematic around this, and costs of interdisciplinary research, could be reasons for such an omission.
3) The recent discussion of interdisciplinary research does not provide many new and applicable ideas. Moreover, performance of this type of research is not impressive.
4) The complexity of interdisciplinary research is often under-estimated, especially the time needed for preparation.
5) There are many problems that can be solved by interdisciplinary research. Yet, due to its costly aspects, sound arguments are necessary indicating its greater suitability over mono or multidisciplinary research.
6) Interdisciplinary research does not mean that disciplines are merged. The disciplines are influencing each other during the research process and, finally, the results of monodisciplinary research have to be integrated.
7) The quality of interdisciplinary research depends on:
   a. the attention given to the preparation stage,
   b. the quality of inputs given by the disciplines involved,
   c. the process of interaction during the research process, and
   d. the quality of the synthesis.
8) In the final synthesis input of the various disciplines cannot always be recognized. However, in order to facilitate appraisal of the quality of interdisciplinary research, and its accountability, the disciplinary building stones used in the final synthesis should be mentioned in appendices, or otherwise.
9) The introduction of simulation models and linear programming models could result in isolation of the social sciences. Researchers should clarify at what moments and in what ways social sciences can play a role in interdisciplinary research using simulation models.

Obviously, there is still much to be learned in the field of practical applications of interdisciplinary research. The best way to learn is via evaluation, be it internal-interim or external-ex post evaluation. Peston has defined some questions which should be taken into consideration when ex-post as well as ex-ante evaluation of inter-disciplinary research projects take place.

1) Does the project formulated in interdisciplinary terms show a recognition of the existing contribution made by the separate disciplines?
2) Is the interdisciplinarity genuine in the sense that the problems are formulated in terms which enable the different disciplines to get together rather than to compete with one another?
3) Is the method of data acquisition likely to be helpful to all relevant disciplines, or is it biased in a particular direction?
4) Does the interdisciplinarity enhance the possibility of hypothesis testing or does it obscure it?
5) What differences will the result of the research make to the policy decisions that will be taken eventually?
(Peston, 1979:59; in Wigboldus, 1991:25).

The first four questions can only be answered when the project design is written in such a way that it gives the internal as well as the external evaluator insight into the way the disciplines have agreed to cooperate and to exchange information. Furthermore, the communication processes taking place during field work and the final reporting should be well documented. When such evaluations are done regularly, more progress in the field of interdisciplinary research can be expected.

Biographical Notes: Dirk van Dusseldorp received his Ph.D. from the Agriculture University in The Netherlands. He has published books on the planning of service centers in rural areas, and the introduction of the Gramodaya Mandala (a participatory system in Sri Lanka), and he is co-author of a book on guidelines for regional planning in developing countries. His research interests are in the fields of popular participation in local level development in Sri Lanka, the role of sociologists/cultural anthropologists in agricultural research. Since 1989 he has been the chairman of the advisory council for scientific research in development problems that serves three ministers. He is currently working on textbooks for the preparation and implementation of projects in developing countries, and action-oriented research for rural development.

Seerp Wigboldus graduated in 1991 in rural sociology, with an emphasis on social agronomy, at Wageningen Agricultural University. One of his theses was on interdisciplinary research, and later, as a research assistant, he did extensive literature research on interdisciplinary research and studied some interdisciplinary research projects. He has done field research in Costa Rica and Nepal and is presently preparing for work in a developing country.

Literature

Beebe, J. (1985). Information collection: Rapid appraisal and related methodologies. Publication No. 4. *Socio-economic research on food legumes and coarse grains; Methodological issues*. Bogor, Indonesia: Center for Research and Development of Coarse Grains, Pulses, Roots and Tubers in the Humid Tropics of Asia and the Pacific.

Birgegard, L.E. (1980). *Manual for the analysis of rural underdevelopment*. Upsala: International Rural Development Center, Swedish University of Agricultural Sciences.

Box, L. (1989). Multidisciplinary research in development. How to get there? *IMWO Bulletin* 17, 4, 17-20.

Brokensha, D., Warren, D.M. & Werner, O. (1980). *Indigenous knowledge systems and development*. London: University Press of America.

Chubin, D.E. *et al*., eds. (1986). *Interdisciplinary analysis and research*. Mt. Airy, Maryland: Lomond Publications.

Daane, J. (1990). *Le diagnostique. Communication au seminar national sur le theme "recherche developpement au Benin": Acquis et perspective*. Coutonou: Université du Benin.

Dewalt, B.R. (1989). Halfway there: Social science in agricultural development. In C.M. McCorkle, *The social sciences in agricultural research*. London: Lynne Rienner. Pp. 39-61.

Doorman, F. (1989). Strengthening qualitative methodology in agricultural research: The social sciences contribution. *Sociologia Ruralis*, 29:250-264.

Dusseldorp, D.B.W.M. van (1977). Some thoughts on the role of social sciences in the agricultural research centers in developing countries. *Netherlands Journal of Agricultural Science*, 25:213-225.

Dusseldorp, D.B.W.M. van & Box, L. (1990). Role of sociologists and cultural anthropologists in the development, adaptation and transfer of new agricultural technologies. *Netherlands Journal of Agricultural Science*, 38: 697-709.

Dusseldorp, D.B.W.M. (1992). *Development projects for rural development in the Third World; Preparation and implementation*. Wageningen: Agricultural University.

Fairchild, H.P. ed. (1955). *Dictionary of sociology*. Ames, Iowa: Littlefield, Adams and Co.

Fodor, E. (1983). *Perverse development*. Foundation for Nationalistic Studies, Quezon City, Philippines.

Fresco L., *et al.* (1989). *Land evaluation and farming systems analysis for land use planning*. Wageningen: FAO, ITC and the Department of Development Economics, Agricultural University.

Gladwin, H. & Murtaugh, M. (1984). The attentive-preattentive distinction in agricultural decision making. In P.F. Barlett, *Agricultural decision making: Anthropological contributions to rural development*. London: Academic Press. Pp. 115-136.

Giddens, A. (1979). *Central problems in social theory*. London: McMillan.

Heckhausen, H. (1972). Discipline and interdisciplinarity. In L. Apostel, ed., *Interdisciplinarity: Problems of teaching and research in universities*. Paris: Organization for Economic Cooperation and Development. Pp. 83-89.

Hildebrandt, P. (1981). Combining disciplines in Rapid Appaisal: The Sondeo Approach. *Agricultural Administration* 8, 6:423-432.

Klein, J.T. (1990). *Interdisciplinarity. History, theory and practice*. Detroit: Wayne State University Press.

Kockelmans, J.J. (1987). *Interdisciplinarity and higher education*. University Park: The Pennsylvania State University Press.

Kunkel, J.H. (1970). *Society and economic growth. A perspective of social change*. London: Oxford University Press.

Lekanne dit Deprez, B.E.J.C. (1976). Macht en onmacht van interdisciplinair samenwerken (Potential and impotence of interdisciplinary collaboration). *Intermediair* 12, 45: 1-7 and 46:61-67.

Lohuizen, C.W.W. (1983). Enkele vraagstukken rond het planologisch onderzoek en beleid. In *Spanning in Onderzoek en Beleid*. Amsterdam: Cahiers beleidsonderzoek nr. 2 Stichting Interuniversitair Instituut voor Sociaal Wetenschappelijk Onderzoek. Pp. 8-57.

Majchrzak, A. (1984). *Methods for policy research*. London: Sage Publication.

Mannheim, K. (1960). *Man and society in an age of reconstruction*. London: Routledge and Kegan Paul.

McCorkle, C.M. (1989). *The social sciences in agricultural research*. London: Lynne Riener.

McWilliams, J.R., Collison, M.P. & Dusseldorp, D.B.W.M. van (1990). *Report on the evaluation of the SARP (Systems Analysis for Rice Production) Project*. Den Haag: Directoraat Generaal Voor Internationale Samenwerking (DGIS).

Penning de Vries, F.W.T. *et al*. (1989). *Simulation of ecophysiological processes of growth in several annual crops*. Wageningen: Pudoc.

Peston, M. (1979). Some thoughts on evaluating interdisciplinary research. *Higher Education Review*, Spring 1979: 55-60.

Russell, M.G. (1982). *Enabling interdisciplinary research: Perspectives from agriculture, forestry and home economics*. Minnesota: Agricultural Experimenting Station.

Shaner, W.W., P.F. Philipp & W.R. Schmehl (1981). *Farming system research and development: Guidelines for developing countries*. Boulder: Westview Press.

Staveren, J.M. & D.B.W.M. van Dusseldorp (1980). *Framework for regional planning in developing countries. Methodology for an inter-disciplinary approach to the planned development of predominantly rural areas*. Wageningen: International Institute for Land Reclamation and Improvement (ILRI).

Stroosnijder, L. & Rheenen, T. van (1991). *INRES farming systems analysis methodology*. Malang, Indonesia: Brawijaya University.

Weintraub, D.J. & Margulies, J. (1986). *Basic social diagnosis for IRDP planning*. Vermont: Gower Publishing Company.

Wigboldus, S. (1991). *An inquiry into the discussions on inter-disciplinarity*. Wageningen: Agricultural University, Department of Rural Sociology of the Tropics and Subtropics.

Wit, C.T. de *et al*. (1988). Application of interactive multiple goal programming technique for analysing and planning of regional agricultural development. *Agricultural Systems* 26:211-230.