AN OVERVIEW OF FARMING SYSTEMS RESEARCH

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INTRODUCTION

Farming systems research (FSR) represents a new approach to agricultural research. It was formulated in response to the complex production methods encountered on small, often mixed farms in the developing world. Its history during the 1970's is a fascinating area for study, and shows antecedents of FSR in rural development, farm management economics and on-farm testing of agronomic practices. These divergent sources probably explain why so many different activities can bear the same FSR label.

The confusion about FSR's identity has led to disappointments among research administrators and funding agencies who, generally unfamiliar with FSR to start with, often obtained something they had not bargained for. The range of objectives and research methods that are conveniently subsumed under the FSR label also meant that recent students and trainees in the subject had to deal with contradictions and incomplete arguments. While this may be not a bad selection procedure for FSR practitioners, it is hardly an endearing way to deal with newcomers.

As an introduction to this symposium, I will review the more common objectives, research approaches, technology evaluation techniques and institutional formats encountered in FSR, and describe their relationship to agricultural research and development activities.

This overview will also serve as a commentary on trends in methodological developments and problems encountered in field applications of FSR.

HISTORICAL CONTEXT AND GENERAL OBJECTIVES

Earlier FSR-like activities, as reviewed by Gilbert et al (1980) and Whyte (1981), were motivated by a desire to develop improved production methods for small farms in developing countries. Part of the early researchers decided to study the existing system, part opted for experimentation with new techniques. Those who described existing systems tended to be social scientists concerned with the behaviour of the systems and with changing the priorities of agricultural research centres. The experimenters were typically agronomists, bent on conducting trials of new production techniques in an appropriate environment.

In the mid-seventies, researchers increasingly combined descriptive activities with experimentation (Garrity et al, 1981) or used experimentation as part of descriptive work (Norman, 1974). An increased realization of the social, economic and institutional constraintes under which farmers operate and the complex goal structure of the family farm, led to a search for new performance criteria for agricultural technology; criteria that would reflect the demands placed on new technology by the farmer's goal structure and his production constraints (Zandstra et al, 1976, 1981).

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Institutionally, research station bound biologists were encouraged to venture into the farm community and to consider economic returns and limitations to production inputs in their formulation of production recommendations. The emphasis on problem specification (f) or "upstream" FSR, probably received its greatest impetus from International Research Centres most of which, until recently, did not consider the support of location-specific technology development to be within their mandate. The ever suspect social scientists in these centres therefore, had to find an acceptable justification, that would allow them to conduct on-farm research and provide them with information about existing production systems and the performance of the Centre's technologies. This information had to be convincing enough to change the ways of plant scientists, and to change the Centre's reluctonce to support downstream FSR.

The controversy about FSR activities of International Centres (CGIAR, 1978) and the difficulties encountered by funding agencies and U.S. universities in understanding FSR, shifted the attention away from some of the original objectives of early workers in FSR-like research :

- To make available to small farm communities an effective agricultural research system.
- To expose weaknesses in the institutional support to agricultural production from small farms.
- To familiarize young researchers with the problems, of small farm communities

Increasingly, on-farm research was conducted for methodological reasons, or to solve general commodity or disciplinary controversies. Also, the research direction and execution has become dominated by Ph. D. level scientists and foreigners.

On-farm FSR also became confused with assorted research activities that use a farming systems approach to the solution of perceived production problems such as phosphorous deficiencies, nitrogen-efficiency or varietal performance. The FSR approach is also widely applied to identify selection criteria for breeders and management bottlenecks for agonomists, to test in the farm setting an imported production solution (ULV sprayers), or to develop a better survey or record-keeping technique. Although a systems research approach to the solution of these problems is undoubtedly laudable, these activities do not satisfy the original FSR objectives.

I suggest that the term FSR be limited to a research activity that has the following characteristics:

- Its objectives should be to generate improved technology that is acceptable to farmers of a defined region, farm type or well circumscribed production environment.
- The technology search should not be confined to a pre-conceived input (e.g. irrigation), or crop or animal enterprise. It should consider land use as a variable.
- The technology should remain within recognized limits on the availability and productivity of purchased inputs and resources of the farm and the community.
- The technology should be evaluated in its effect on all production subsystems of the farm.

For those not familiar with FSR, appendix I provides a summary of an FSR methodology widely used in Asia and Central America.

RESEARCH METHODS

A wide range of methods is used to arrive at production recommendations for small farms. Recommendations are still on occasion formulated strictly from results of research station experiments. A better single-step approach is the direct formulation of a recommendation from an on-farm diagnostic study. This is similar to the farm management approach to extension used in the United States. Without institutional intervention this will, however, rarely lead to farmers' adoption of recommended practices in small farm communities of developing countries. The approach also fails to exploit opportunities offered by new technologies.

Recommendations are at times based on the results of widespread on-farm testing by researchers of fertilizer or other inputs. These tests are designed and executed by researchers who often ignore the farmers' method of land preparation, planting and intercropping. Beyond information on biological responses, such research contributes little to improve productivity of small farms.

At times, a farm diagnostic is used to complement on-station research conducted to arrive at a recommendation. In the best cases, this research carefully copies management procedures, input use (where not experimentally varied) and implements from the target farm group. This "module" approach is particularly common where substantial land modifications (ponds, channels, corrals) or large animals are involved in the research and where modifications are complex and have effects on the whole farm. Where farmers are involved to provide feedback on the module (Riesco, 1982), or to manage it (Nitis, 1982), and when the design of the alternative system and its performance criteria reflect constraints of the farm community, the module approach combined with a farm diagnostic and farm monitoring, can be an effective research tool.

A more desirable approach is to combine on-farm testing with research station work in a complete program of testing activities that provides information on the performance of component technology (planting date, varieties, insect control, feeding methods etc.), that compares alternative subsystems to the existing one (s) and that involves farmers in the execution of trials (Work group 3 report, in Fitzhugh et al (1982). For crop-animal production systems, this testing will undoubtedly have to include comparisons among sample farms with and without the alternative production method (De Gracia et al, 1982). This research, as well as the approach that employs modules, should arrive at a specification of the recommendation to be extended to farmers, the adaptation domain for the recommendation, and the institutional intervention (input and credit availability, price or market support etc.) required for adoption.

To summarize, FSR methods must include a farm diagnostic; a valid comparison of experimental systems, subsystems or components to existing ones; a meaningful participation of farmers in the execution and design of experiments and surveys; and the specification of the adaptation domain and the institutional demands of any recommended practice.

PERFORMANCE CRITERIA

Although there is still a wide range in approaches, at this day and age, few agricultural researchers will formulate recommendations based on maximum yield or biological efficiency. Most will compare the alternatives they test by some economic performance measure–generally returns over variable costs (RAVC). Unfortunately, many tests omit comparison with the farmers' practice, and where the "farmers level" is included it is often poorly simulated.

In order of increasing preference, the performance measures often used to compare an experimental management component or sub–subsystem (feeding system) or subsystem (goat production system) to that used by the farmer are:[1/]

1. RAVC of the system component under study
2. RAVC and marginal benefit cost ratio (MBCR) of the introduced component (e.g. maize+beans–sorghum, goats) and enterprise under study over the existing one.
3. As for 2, adding checks for conflicts in resources (labour) available to the whole farm.
4. As for 3, adding checks for conflicts with other enterprises, off–farm employment, or social obligations–and adding risk considerations.
5. Whole farm analyses using simulation or linear programming methods, including risk considerations.

Experience with B.Sc. level research teams has been that the second alternative when augmented with detailed questioning of farmer cooperators about risks, resource conflicts and the effects on the remainder of the farm enterprise, is a manageable and effective approach. Although a sensitivity for high risk and high input alternatives should be developed, complex numerical treatment of risk is not for field teams. The same applies to quantitative whole farm analyses.

INSTITUTIONAL FORMATS

In the loose sense of the term, FSR has been conducted by isolated voluntary groups, universities, temporarily funded regional development projects, and extension, research and planning divisions of ministries of agriculture. Although university involvement is important because of the educational implications, it achieves little towards providing the small farm communities with stable access to the country's research capability.

To achieve developmental objectives in small farm communities, FSR activities should be included as an on–going part of the national agricultural research program. The framework for FSR and the methodological expression given to it must therefore project forward to an institutional model that is within reach of developing country governments Zandstra, 1980). This implies a judicious allocation of research and training responsibilities to staff working in the farm community, in regional and central research stations and at universities.

1/ See for examples : Norman (1977), Jayasuriya and Price (1980), Banta (1980).

The experiences gained in cropping systems in research in Asia were strongly based on an institutional model (Table 1). This model considers a national research program in which area-specific systems research is conducted by interdisciplinary teams of three to four professional with locally hired technicians and village assistants. These teams are supported by a technical committee of experienced farming systems researchers that can provide support in the design of technology and in the design and execution of research on the site. Through decentralization of research decision-making, the site teams must become increasingly instrumental in the formulation of their research. They must always be responsible for the initial analyses (be it graphic) of their results and for the presentation of these results to their peers and superiors. The site research teams are completely dependent on provincial and national research centres for their awareness of new component technology. They should have access to a range of varieties of the crops with which they work and to the agricultural chemicals or supplements they may need to employ. They should be kept aware of ongoing research in the commodities they deal with through visits and publications. There is a great deal of truth in the observation that the success of FSR depends as much on the range of component technology available at the research site as on the methodological capabilities of the research team. Too often, a lack of viable improved seed of forage crops and grain legumes limits the effectiveness of on-farm research.

The structure and leadership provided to interdisciplinary teams at the on-farm research sites or at the national or international research level are key elements in farming systems research (Flinn and Denning, 1982). The most successful research teams have a sharp focus, are small (not more than seven persons), and are encouraged by the team leader to arrive at a consensus through mutual discussion among team members. It is therefore important to limit the scope of the teams' research activities to those farm enterprises on which they can have substantial impact and for which they have access to component technology.

The scope of FSR activities is an important consideration. To conduct research on several crops requires access to a range of varieties, knowledge of different planting methods or intercrop combinations, a strong diagnostic capability for damage due to diseases, insects and nutrition related problems, and familiarity with experimental and measurement techniques that are specific to certain crops. Adding to this a similar capability in animal enterprises can quickly overload the team's capability, and will require technical support from a different department in the Ministry. For these reasons, a careful choice of research emphasis must be made for an FSR team in a certain target area. In this choice, access to expertise and existing component technology and the expected impact on the farming system are of course important considerations.

INTERNATIONAL SUPPORT TO FSR IN DEVELOPING COUNTRIES

The principle objective of international support to FSR is to help national research programs respond to the needs of small farm communities. It is to install a national capability through training and practice. Support to such an endeavour should be in the form of collaboration, not of leadership.

The whole purpose of international support to national FSR activities is to develop the national capability and research structure for the effective functioning of on-farm research teams and the required technical support and coordination at the provincial and national level. This purpose is best served by assuring that expatriates do not conduct the research and that leadership and decision-making about the role of FSR and its institutional place remains in the hands of the recipient.

Expatriate FSR advisors can stimulate the formation of, initially, a few on-farm research teams. They can back these up through training, advice, analytical and operational support and encouragement. The research should, however, remain the responsibility of each team. At the regional or national level, the advisors can encourage the coordination of operational and technical support to FSR teams. They can influence support research by scientists based at research stations and in universities, involve students in thesis research and encourage the formal feedback from FSR teams to commodity programs through meetings and workshops. The use of large multidisciplinary teams of expatriates in FSR&D projects is counter productive. It overloads the host institution, which is kept busy to contain the foreigners ; it shifts the responsibility for FSR implementation from the recipient to the expatriate institution; it emphasises a centralized highly capable group, whereas major emphasis should be on B.Sc-level field teams and; it reduces the probability of selecting excellent, patient, development oriented advisors.

The presence of one, at the most two, expatriates, should be sufficient. These should be young enough to be approachable and to learn with national colleagues, yet old enough to have had in-depth experience in agricultural research in a small-farm community. They should be thoroughly familiar with FSR concepts and should be asked to work for an extended period with national scientists and in the national research organization towards an institutional model for the application of downstream FSR.

Any support to commodity and disciplinary research in the same institution, while recognizing the required linkages with the FSR activities, should not be labelled FSR.

CHANGES IN ON-FARM PRODUCTION SYSTEMS RESEARCH METHODS

Description or diagnostic phase

During the last five years, continuous change took place in the methods for the description of the existing production systems in selected target areas. Initially, elaborate farm surveys were the norm. These were generally static (once over) in nature and depended considerably on farmers' recall of events in the production cycle. Many researchers found this approach cumbersome and felt that limited insight was obtained about biological or socioeconomic production constraints. Increasingly, initial surveys have changed towards more interactive studies that focussed in on perceived constraints (Collinson, 1979; Hildebrand 1981; Van Der Veen, 1980). These surveys began to employ interdisciplinary research teams (less input from interviewers). They continuously incorporated their findings into a generally agreed upon format and adjusted their questioning of farmers, community leaders, and key informants towards aspects that required further elaboration. This approach has allowed a much quicker start of experimental work on key components.

The reduced duration and cost of the diagnostic study was also encouraged by an increasing awareness among applied research teams, that the descriptive component of FSR continues during the experimental research phase. Record-keeping, generally on a small number of case farms or selected sub-enterprises (e.g. fields, swine enterprise), continuously refines the teams' understanding of the performance of the existing system. A major advantage of this approach is that the performance of the existing system becomes understood in comparison with a number of alternatives.

The diagnostic phase of FSR has also improved in efficiency because FSR researchers gained experience in identifying which variables were critical and which variables could be measured at a later stage. In this respect, further work is needed towards simple graphic representations of the mixed farm and the contributions of the sub-enterprises to each other, to the farm family, and to the market and vice versa. Presentations such as those used by McDowell and Hildebrand (1980) and those developed by Hart (See e.g. Hart et al, 1981) provide an excellent insight into the interactions and limits that operate on the farm.

These presentations of existing farming systems should give more attention to the multiple objectives of the animal enterprise. For the crop enterprise, the importance of shade, litter formation, dry season feeding of by-products or clippings and wet season use of thinnings and weeds for feed are still often ignored. For the animal enterprise, the relative importance of its multiple products for consumption or sale (milk, meat, hides, fiber, heat, fuel, cooking, fat), or for the function of the farm (e.g. traction, secruity through savings, on-farm and off-farm scavenging, recycling of nutrients, control of pests, capturing marginal labour), should be determined.

Design of alternative systems

The design phase involves the formulation and ex ante evaluation of one or a number of alternative management components or subsystems. It also involves the design of research techniques that allow the evaluation of the performance of these alternatives in a background set of management methods that is as close as possible to that used by target farmers and that allows their comparison to the farmer's methods.

Many FSR research programs have been overly hesitant to encourage field teams to include substantial changes in farming practices. This hesitation comes from numerous experiences of farmers' rejection of new technology. In part, this careful approach to the formulation is also a result of our avowed objective to generate technology that is acceptable to farmers. This has led to notions of incremental change and low input systems becoming predominant in FSR circles.

One of the most common constraints of small farm production systems is precisely farm size and the farmers' limited access to inputs that would increase production. These communities often have excess labour or available labour can be created by increasing the labour efficiency of selected operations. Such labour can be invested in farm improvements such as field leveling or drainage, building of storage structures, or in secondary production processes often involving animal products. It can certainly be used to support additional labour demands that arise from a greater production of food or fodder crops obtained from changes in crop varieties and input levels.

It may be instructive for research teams to approach technology design with a knowledge of biological potentials and an understanding of the yield gaps that operate to reduce production to the level observed on farms. By estimating the value of yield and production losses, researchers can then identify which constraints, when removed, will be most efficient in improving production per unit cost. They can also estimate how much the additional inputs that are required for the removal of the production constraint are allowed to cost. (less than one half the value of the yield gap is a good starting point).

Analyses of the reasons for the rejection of new technology by farmer reveals that they are generally because :

- claims made about the benefits of technology are not realistic because yields are lower, costs are higher or product prices and acceptability are lower than those assumed by the researchers.
- infra-structural support is lacking because of lack of political will, poor management by the institutions involved or weak design of institutional support programs (credit, input availability, marketing).

Extensive on-farm testing, careful economic analyses and serious consideration of farmers opinions helps FSR teams avoid the first set of reasons. Research teams should be continuously reminded to be critical of the technology they test and to take farmers' comments seriously. The failure of the delivery system, or of production programs, has become a major concern of FSR teams (Zandstra, 1982). The major reasons for this failure has been that researchers were not realistic in their assessment of the type of infra-structural support that will be available and that extension staff had not participated in the selection of the target population and in the final evaluation of the new techniques to be recommended. It is therefore important for researchers to discuss with extension groups the type of technology they are considering and to consult them about the credit and input support this technology may require. FSR researchers should also participate in the design of production programs to ensure that the institutional prerequisites of the new recommendations are met.

Other aspects of the design of technology that merit discussion are :

□ The design process is a critical step in the functioning of cross-disciplinary research. Care must be taken to avoid disciplinary bias and the teams energy should be channelled towards the synthesis of feasible and promising alternative production methods.

□ Procedures for ex ante analyses of the relative merit of alternative technologies should be strengthened. (Flinn and Denning, 1982). Anderson and Hardaker (1979) conclude that skilled intuition, complemented with the careful application of simple budgeting-based models, remain the most useful techniques. Skilled intuition is, however, hard to teach. The ex ante evaluation of designed technology that influences both the crop and animal production enterprise becomes very complex. The animal production sub-system can interact in many ways with the crop sub-system and testing of substantial changes in animal production is difficult on small farms. For this reason, at a recent meeting, animal production systems researchers emphasized the need for simple whole-farm models. (Li Pun and Zandstra, 1982). These models would be used to estimate the performance of designed component technology before on-farm testing. They would also be used to compare the performance of alternative sub-systems which incorporate several technological innovations.

More importance should be given to the objectives the farmer has for his production activities. The fact that he has a few pigs scavenging around the house, does not mean that he necessarily should become a commercial swine producer, who would depend on the availability of commercial concentrates and the presence of a veterinarian. Such a change may destroy the original objective of his keeping a few pigs as a low risk, low input activity on which he can fall back in times of need. This does not mean his pig production methods cannot be improved. Improvements must, however, fit the objectives the farmer has with this enterprise. For research purposes, these objectives have to be expressed in terms of limitations on cash and labour inputs (including by whom) and productivity and risk criteria.

Testing phase

Results of farming systems research have shown the importance of a critical comparison between the alternative introduced by researchers and the system used by the farmer. This comparison should be based on as similar a data collection scheme as is possible for both sets. The use of paired comparisons of both systems within land type, farm type, village and if possible, farm family, is advisable.

Testing should actively involve farmers and, where community decisions are affected, the farm community. This applies to the evaluation of simple technological components as well as to the testing of complete sub-systems. In this respect it is useful to recognize a range of farmers' participation:

a) as observer, when the researcher designs and executes a trial on the farmer's land, often through a rental agreement

b) as executor of a test designed by the researcher but realized by the farmer, who conducts all operations. The farmer uses his resources, often augmented by production inputs or implements and supervision from the researcher

c) as participant in design of the trial and its execution as under b)

d) as originator of the test, through partial or complete adoption of a recommendation, using his own means to obtain additional inputs that may be required, from a production infra-structure specifically designed for the introduction of the new technology (pilot production program).

e) as originator of the test without access to special institutional arrangements.

It should be emphasized that only the test situations in d) and e) can provide realistic estimates of the performance of the new technology. In the case of complex alternative production systems, involving substantial land modifications or large ruminants, it has been suggested that researchers should resort to co-operatively managed farmer-executed trials of the whole system. For these trials, the inputs not available to the farmer will be provided through a pilot production program that assures availability of credit and inputs and that insures farmers a return at least equal to that obtained from his actual production system. Examples of such underwritten tests of new technology are the maize and onion production pro-grams described by Zandstra *et al* (1979) and the Zamboanga del Sur Development Project (Denning, 1981).

There is a continued need to improve measurement and analytical techniques for performance criteria that can be used with confidence to separate attractive and non-attractive technologies. These criteria have to be in relation to existing or designed socio-economic and institutional (tenure, cooperatives, credit, inputs, market, prices) structures. It may not be an exaggeration to blame the absence of this analytical ability for the fear among researchers of substantial changes in production systems, even though there are radical changes initiated or adopted by farmers.

CONCLUSIONS

The mojor thrust of FSR activities should be to make an effective research system available to small farm communities that lack economic and political power. This objective has research methodological and institutional implications that should be taken into account in International programs supporting FSR research.

The term FSR should be more selectively used to refer to the inter-disciplinary research activity that considers all enterprises of the farm, the farm's re-source base and its environment in the identification of improved production systems that are acceptable to a defined population of farmers.

Groups involved in farming systems – cropping systems – or animal production systems research, should not feel obliged to seek simultaneous technical change in all farm enterprises. It is more important for them to focus on the enterprise (s) to which they can bring to bear the required expertise and component technology and to make sure that biological and resource use interactions with other enterprises are given due consideration.

Although research teams must continue to be critical about increasing purchased inputs, the use of additional inputs and equipment to increase productivity should not be ignored. More work is needed to insure that realistic assumptions about the availability of credit and inputs are made in consultation with ex-tension services and the institutions *responsible for input and credit delivery to the farm* community.

On-farm testing of crop and particularly animal production technology requires careful structuring and normally is associated with difficulties. With patience, sensitivity to farmers limitations and considerable dialogue with farmers, many of the technological innovations can be tested as individual components under farmer's management. Continuous efforts should be made to arrive at more efficient test arrangements with the farm community that protects individual farmers, allows monitoring of inputs and results, and allows researchers to differentiate with confidence between existing and introduced production methods.

Much farming systems research has been conducted by international centres and highly qualified advisors to national programs. Such activities were necessary to develop the needed research techniques and to train future members of research teams. More emphasis should, however, be given to the training of national program research teams and the development of an on-site research structure that is cheap, is technically and operationally well supported, has access to new technology and research methods, and has good links to commodity programs and extension services.

Scientists involved in the development of FSR methods must therefore give serious consideration to the technical level of personnel that will be asked to do on-farm research in national programs. Research methods for on-site research teams must be simple enough for good B.Sc. level professionals, and analytical techniques should be such that they can be managed with hand held calculators.

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Table 1. Division of responsibilities among components of a national cropping systems program.

Program Component	Responsibility
Network of test sites	Site description, design of improved patterns, testing. Formulation of recommendations with support from Technical Support Team (s) (TST).
Regional research stations (Commodity and disciplinary programs)	Component technology research ; Varietal screening, long term cropping pattern trials ; Performance of agricultural chemicals ; Operational support to nearby sites.
Technical Support Teams (TST)	Full time team. Visit test sites to provide support in research design, experimental design, analyses and interpretation, ensure feedback on technical and operational problems to the Cropping Systems Program Committee (CIP). Identify trainees, serve as trainer, organize Workshops, combine site results.
Coordinated inter-agency Cropping Systems Program Committee (CIP)	Sets policy, selects sites, structures staff compliments at sites and in technical support teams, monitors methodology used, insures feedback to commodity and disciplinary programs or departments, identifies training needs.
Commodity and disciplinary programs or departments	Conduct research on aspects of component technology, environmental classification, research methods and problems identified in on-farm test sites.

From Zandstra, 1980

APPENDIX I: FARMING SYSTEMS RESEARCH FOR IMPROVED SMALL FARM PRODUCTION SYSTEMS

The following is essentially the production systems research farmework used by the International Rice Research Institute (IRRI) and the Tropical Agricultural Research and Training Centre (CATIE). It consists of seven research phases, which form a conceptual sequence. In practice however, several research phases may take place at the same time.

1. Selection of the target areas. One or more geographical areas representative of a large homogenous production zone are selected. The area should be a priority area for development by the national government. In this way, when the potential for increased production has been demonstrated, support for production programs will be given.

2. Site description. The first activity of the research is to describe the existing farming systems, the physical environment, the socioeconomic environment and constraints to production. The characteristics of the farm environment will decide research priorities at the on–farm research site and at supporting research stations. At this time, the area is also divided in different land types, each of which may require a different production recommendation.

3. Selection of land types or farming systems. The stratification of the target area into land types is based on important environmental traits that are generally reflected in the type of food or forage crops grown and the type of animal feeding system or animal species that predominate. Land types are usually differentiated on the basis of pedological, irrigation, market, climatological or social factors. They should be general enough in occurrence to warrant research expenditures. Because of the staff and funding limitations and to reduce complexity, the research is generally confined to one or two land types and the predominant farm types associated with them. For the selected land types, the predominant farm types are studied in depth over time. This occurs while other research is ongoing and continues through the testing phase. This analysis concentrates on the biological and economic performance of the existing systems and its components. In mixing farming systems, particular attention has to be paid to the competition for farm resources- cash, labour, land, at certain times of the year, and to input transfers between subsystem–crops as feed, manure as fertilizer, animal power, etc. The particular roles that livestock play in the farm enterprise have to be clearly defined.

4. Design of alternative systems. This includes the design of alternative cropping patterns, feeding systems, animal housing and management methods that are well adapted to the area. The design of alternative production methods takes into consideration the physical and socio–economic site characteristics, the performance of the existing production methods and the available component technology for the crops and animals in the farming system. There are numerous practices which must be specified at the design stage. Many can be specified on the basis of existing knowledge and local methods. Oters warrant separate experiments to establish optimal input levels or time and method of application. This component technology research may be conducted in national, regional, and local experiment stations or where possible in the farming systems sites.

5. Testing of alternative systems. This involves the testing of the designed systems or selected management components in their respective environments on the farm. Farmers participate in the testing by managing the crops and animals according to the designed methods, with frequent advice and constant monitoring of the research staff. Based on the biological and economic performance of designed systems, problems that limit intensification of production can be identified and fed back to discipline or commodity oriented researchers. This scheme helps orientate such research to solve relevant problems of the target farmers. The evaluation of alternative systems involves careful analyses of the performance of each component management change in terms of its contribution to farm productivity. Where possible, a whole-farm analyses has to be used to evaluate the performance of a number of changes in management components that constitute the alternative system under evaluation. Farmers' observations and their tendency to adopt changes in the study area are important means for the evaluation of alternatives.

6. Extrapolation areas. When acceptable production alternatives have been identified, greater benefits from these research results can be achieved by their extrapolation to a wider area. Identification of similar land types and confirmation of the suitability of the new production methods to those environmental homologues is a necessary step prior to extension activities.

7. Pilot Production program. The on-farm testing and the identification of extrapolation areas for the recommendation have at this stage provided substantial information about the performance of the new production methods. A pilot production program is often advisable before embarking on a large scale extension activity. Such a program generally starts off in the original testing area and has the objective to identify the institutional support and intervention required to assure the successful introduction of the recommendation. If successful, this experience will provide the information needed in the design of a full-fledged production program.