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Farming Systems Research: Diagnosing the Problems

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The term farming systems research (FSR) is used to describe a range of activities with varied objectives and approaches, although these usually have been associated with agricultural research. This diversity has caused confusion over the role of FSR in agricultural development. Projects to devise new, often technically sustainable or economically optimal farming systems have come under the FSR umbrella. The "Unités Experimentales" in the agricultural research programs of francophone West African countries are examples. Some international agricultural research centers, such as the International Institute of Tropical Agriculture (IITA) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), have embraced soil and water resource management programs within an FSR program.

Increasingly, FSR refers to the application of a systems perspective in identifying technologies appropriate for location-specific farm situations or systems. Both Arturo Gomez, in chapter 8, and Glenn Denning, in chapter 12, provide significant evidence from the Philippines, particularly from the International Rice Research Institute (IRRI), that confirms our experience in Mexico and Kenya as to the contribution of FSR to specifying emerging technologies in line with variable local farm circumstances. By acting as an interface between the technical perspective of researchers and the managerial perspective of small farmers, FSR helps build up a continuum from the identification of farmers' priority problems and opportunities, through the research and extension process, back to the farmer. Perhaps the greatest potential of FSR lies in the insight it can provide into existing smallholder systems; this is the role addressed here.

In the present early stage of the application of FSR to agriculture in the developing countries, it is still safest to look behind the phrase to the objectives of the research and of the research approach being applied to avoid confusion over the term itself.

The closer that farmers operate to the subsistence level, the more important is effective problem identification. It is obvious, although often overlooked, that farmers themselves make the decisions about what is good for them. Among other things, they decide whether to adopt innovations in the light of the economic circumstances within which they operate. A thousand and one problems can be observed on any farm, all reflecting eventual development opportunities. But small farmers will be most willing to reallocate limited resources—whether of cash, labor, or land—to implement appropriate solutions to current problems that most inhibit a better realization of their priorities. Hence, there is a need to understand farmers' priorities, and how current management practices and the resource allocations these imply limit their satisfaction, in order to identify the problems farmers would be most interested in solving.

This chapter has six sections. The introductory paragraphs that follow outline the sections, touch on the issue of terminology, and emphasize the importance of effective problem identification to the development of smallholder agriculture. The second section outlines some important concepts underpinning the application of FSR as a means of effective problem diagnosis. The third and fourth sections detail, respectively, an FSR approach and FSR methods. The fifth section reviews the potential for FSR in technology generation (and, through this, in linking research, extension, and farmers in an interactive continuum), in project identification and preparation, and in policy formulation. The final section sets out some current and longer-term needs if the potential of FSR is to be realized.

Underpinnings to the Use of an FSR Approach

The first and most fundamental fact to recognize in attempting to understand small farming systems is that small farmers behave rationally and purposefully.

Small-Farmer Rationality

As in any population, levels of motivation and ability vary among small farmers, but within this diversity and within the limits of the knowledge available to them, small farmers work toward the achievement of their own goals. These goals change with development. Small farmers with a low resource base and low incomes are dominated by the priorities of subsistence farming: producing a supply of food, day in and day out, for their families. As income levels rise, subsistence priorities are first balanced, and then outweighed, by cash-earning goals. Farmers' priorities can be thought of as the "engine" of their farming systems. Where subsistence dominates, risk aversion (avoiding a failure in food supply in all likely circumstances) dictates many farmers' decisions, their management strategies, and much of their resource allocation, and thus the organization of their farming systems.

Small Farms as Systems

As has been repeatedly intimated, small (and large) farmers operate their farms as systems. This is the second underpinning to the use of FSR, and all concerned with agricultural research and development should know what this implies for both understanding and improving farmers' performance. Farmers do not seek technical optima, or even optimal economic results, from a single activity. They seek to satisfy their priorities through a combination of activities. Such activities compete for land, labor, and cash—one or more of which are always scarce—often at the same time in the season. This competition obliges the farmer to compromise the quality of his management of a particular farm activity in the interest of the performance of the system as a whole. Husbandry of poor quality is *not necessarily* bad farm management; it may in fact be good management, given the farmer's situation. Nevertheless, such compromises, once understood, often represent effective leverage points for the improvement of farm performance.

A clear conceptual model of a farming system is an essential foundaton of FSR. The one I have found useful is presented in figure 9-1. The diagram is read from the top down, and it illustrates the following exigencies of the farmer's experience:

- The farmer faces a set of local circumstances that he cannot significantly influence, certainly in the near term.
- His management task is to exploit these circumstances to meet his family's priorities with family resources.
- Those circumstances underlined (climate, biology, and prices) are common sources of uncertainty that complicate his task.
- Being aware of family priorities and resource endowments, the farmer makes decisions on what activities to follow out of the set of opportunities presented by local circumstances, and on what methods and timing to use in following them, given family endowments of land, labor, and cash and his own knowledge and skill.
- His decisions result in resource allocation to a combination of activities that reflect his farming system.

Clearly this decision process is not followed by every farmer each season. A traditional pattern evolves locally, and for many farmers these "general-level" decisions are habitual. Day-to-day decisionmaking, adapting to the circumstances of the particular season or to exigencies arising from special family needs, preoccupies the traditional farmer. With changing local circumstances, new market opportunities or price ratios, or different knowledge, however, leading managers in the community will retread all or part of this decision path to evaluate how these changes should influence their activities and methods.

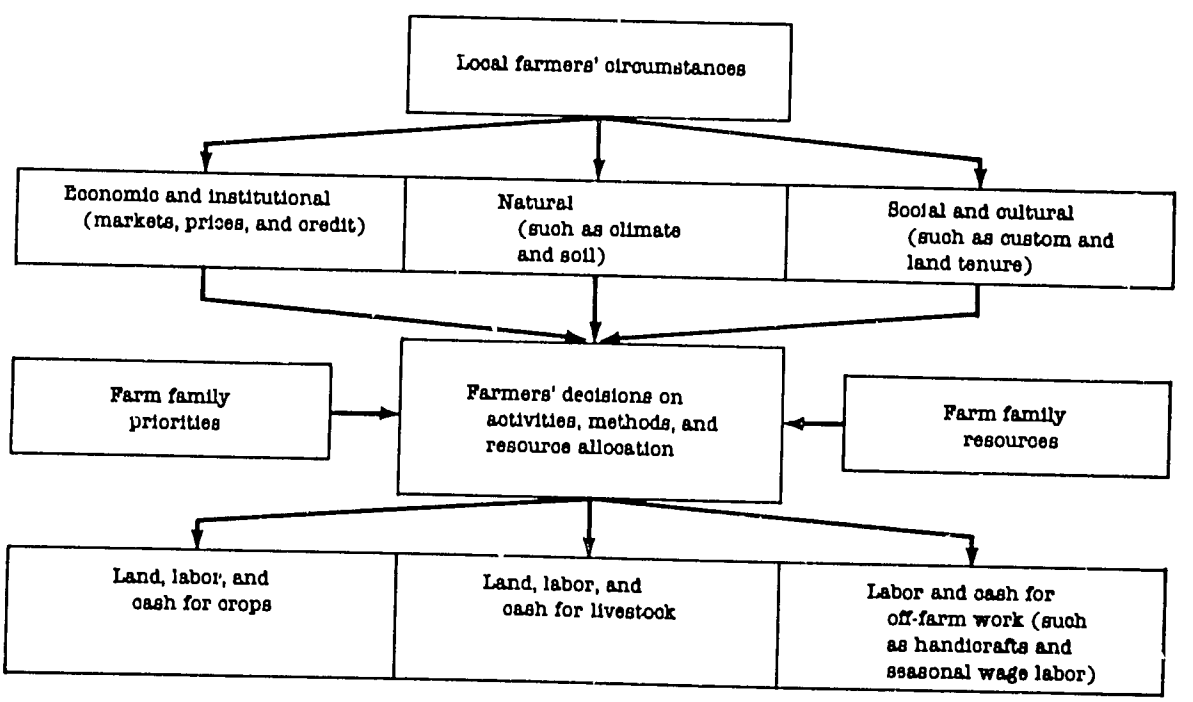
This type of general model is essential for researchers attempting to apply FSR in small-farm systems. It serves as a framework in which to place pieces of information as they become available in the research process.

Sources of Variation among Farming Systems

A third underpinning for the use of FSR in small-farm systems is an awareness of sources of variation among systems. Much of the current interest in FSR stems from a realization that small farmers differ, that their problems differ, and that improving the effectiveness of the development effort depends on identifying important differences and tailoring initiatives more closely to local needs. Clearly, every farm differs from every other; equally clear is the fact that interventions cannot be tailored and administered so subtly. A good compromise may be to tailor programs to farmers operating the same system. Research and programming applied across systems can be wholly confounding, both to farmers and to developers. This said, it is important to be aware of four main sources of variation among farming systems.

- Natural circumstances of climate, soil, and biology create the basic set of opportunities open to farmers and vary geographically.
- Economic circumstances external to the farm restrict the basic activities to those that can profitably be pursued. Economic circumstances often vary geographically, although it is common to find differences facing farmers in the same area. Proximity to the main road offers wider market opportunities, for example, while access to production quotas or credit is frequently restricted.
- Social and cultural circumstances may further restrict the set of opportunities open to farmers or the ways in which they can exploit these opportunities. Tribal origin frequently influences food preferences; community obligations may dictate animal disposal; and some farmers, because of religious custom, may never keep pigs, no matter how good the market. These cultural differences tend to vary geographically. Where people of different cultures have intermingled, variation—with its effects on activity patterns and methods of production—may occur in the same area.
- Households with relatively high income and high resource endowments may have a different balance of priorities and consequently a different pattern of activities. Greater resources may encour-

Figure 9-1. Conceptual Model of a Farming System



age different methods (with capital substituting for labor) and an increase in scale (by the use of capital to draw in extra land and labor). Such differentials in income and resource endowments will often be found side by side within the same geographical area.

Differences in systems can be traced back to one, or more than one, of these four sources. Identifying the source will allow better evaluation of the nature of the differences among groups of farmers to determine the need for discrete research and development programs.

How Small Farmers Change

A fourth and final underpinning in the effective application of FSR is an appreciation of how small farmers change. Smallholders evolve step by step from their existing situation. Changes that may better satisfy their priorities are tried on a small scale. If a change meets expectations on the output side and either appears compatible with present resource allocations for meeting priorities or is clearly a superior way to use resources, the scale of adoption is expanded and sustained.

The "package" idea has come into some disrepute. Usually it is not the package principle—of a synergistic effect from multiple components—that is at fault. It is the tendency to offer farmers "a final solution" (to maize growing or whatever). In such packages, either particular components make resource demands beyond the farmer's resource endowment or implementation requires radical resource reallocation within his system. Dramatic resource reallocation is too risky for the small farmer, represents too complex a management task, or is simply too costly in terms of other production opportunities forgone. None of these constraints can be taken into account in technology generation without an understanding of the client's farming system. The approach to FSR described in the next section is based on the four broad concepts just discussed.

A Farming Systems Research Approach

This section sets out the sequence of an FSR approach to understanding an existing small-farm system. The next section discusses alternative methods for applying the approach and sets out the methodological sequence followed by the Centro Internacional de Mejoramiento de Maiz y Trigo (International Center for the Improvement of Maize and Wheat; CIMMYT). The approach rests on the underpinnings outlined above and is applied by an interdisciplinary FSR team (CIMMYT favors an agronomist and a social scientist, with an animal production scientist where the farming system includes livestock activities).

A preliminary step is to acknowledge both geographical and hierarchical specificity and to identify a group of farmers operating the same system—referred to as a "recommendation domain" in CIMMYT jargon related to technology generation. The approach is most easily applied in a single farming system. The conceptual model rendered in figure 9-1 and elaborated above guides the approach, which is applied in four stages:

- Understanding the main management challenges for local farmers by investigating the circumstances of their production environment
- Describing what farmers are doing, and how they do it, to meet their priorities within this environment
- Understanding why they do these things in these ways to meet their priorities
- Identifying constraints that prevent them from achieving their priorities more effectively.

Three facets of the conceptual model are relatively visible to researchers: local circumstances, farmers' activities, and farmers' production methods. The key to the approach is to describe these visible facets and, by interpolating them into the relationships of the conceptual model, create hypotheses on the less visible

facets of the model and subsequently verify them. The starting point, then, is a description and understanding of the local production environment.

Understanding Farmers' Circumstances

Farmers use their knowledge and management skills to exploit their natural, economic, and social circumstances to satisfy their family needs. Farm system researchers investigate farmers' circumstances from this perspective. Their goal is to identify the production opportunities offered and, particularly, the challenges posed by the environment, in the knowledge that these opportunities and challenges will dominate farmers' management strategies.

NATURAL CIRCUMSTANCES. The review of the natural circumstances of the local environment—climate, soils, and biology—falls within the purview of the agronomist on the team. All three categories will be important in bounding and ranking the production opportunities facing the farmer. Usually one or two will be crucial in managing these opportunites. It is beyond the scope of this chapter to elaborate all the challenges created by the natural factors in the production environment. But perhaps the major factor challenging small farmers with high levels of risk aversion, because of the acute uncertainties it creates, is the reliability of the rainfall. It is of widening importance as more and more marginal areas must be farmed because of population expansion. Variation in the amount of rainfall to be expected, variation in the timing of both the start and finish of the rains (and, thus, in the length of the growing season), periodic within-season droughts—all these represent difficult management challenges for farmers and are readily identified by the agronomist. Where these sources of uncertainty exist, preemptive strategies (for example, insurance cassava) or reactive strategies (for example, early-planted sweet potatoes) will be a feature of farmers' management. The more frequent and severe the uncertainties and the closer farmers are to the subsistence level, the more such strategies will dominate farmers' decisions and resource allocations. Within this category of natural circumstances, other important sources of challenge are soil status and the local plant and animal pest and disease complexes (see Mehta 1983).

ECONOMIC AND SOCIAL CIRCUMSTANCES. Using the same perspective (the description of production opportunities and the identification of challenges to farm management), the farm economist of the team reviews the local economic and social circumstances. The need for integrating economic and sociological analysis deserves some emphasis because of the importance of sociocultural influences in small farmer decisionmaking. Most often, the process cannot afford more than one social scientist. Where this is an economist, he must be fully aware of the importance of the modifying influence of sociocultural circumstances on economic decisions. Where it is an anthropologist or sociologist, he should have a clear view of economic rationality and see sociocultural circumstances as a modifier of these underlying principles.

The economic circumstances that need to be reviewed include formal and informal market opportunities, producer and retail price movements for farm products (both over the long term and seasonally), and the effectiveness of enabling and marketing services in both the formal and informal sectors. On the social side, off-farm employment opportunities, specialization of function among farm families, customs related to land and animal holdings, and other social or cultural factors affecting farmers' decisionmaking and management are reviewed. Serious challenges to management from economic and sociocultural circumstances are uncertainty of retail food supplies, wide seasonal variations in food prices, uncertainty of informal market opportunities, uncertainties of payment through normal market channels, fragmented decisionmaking from absentee household heads, competing economic and noneconomic needs of family members, and the like.

In this review of local farmers' circumstances, the perspective is all important. The farmer operates within this context. Knowledge of the context is an initial step toward understanding his activities and decisions. The identification of management hazards, whether from natural, economic, or social sources,

provides foci for subsequent investigation. For FSR teams posted regionally, there is an initial investment in understanding the varied production environments throughout the region. Periodic monitoring of the important and changing facets of these environments keeps this understanding up to date.

Describing Farmers' Activities and Methods

Farmers' activities and methods are a second relatively visible part of the conceptual model. They show *what* farmers are doing and *how* they do it. Describing these is the next step in applying the FSR approach. Some useful ways of looking at activities and methods are summarized below:

- Activity listing. Describe the crop, livestock, and off-farm activities pursued by farmers in the system. Assess the relative importance of these activities in terms of the approximate land area committed to each and the approximate income levels arising from each. Establish which activities are pursued by most farmers, which are pursued by only a few farmers, and what is special about these few (for example, location next to water for vegetable growing). For each activity, enumerate the uses made of the output; in particular, note multiple uses (for example, the use of both maize grain and stover) and alternative uses (for example, the use of finger millet to make starch flour in years of maize failure, to brew beer, and to hire casual labor in years when maize is plentiful).
- Activity calendar. Draw up a monthly calendar of the operations involved in managing each productive activity, including the methods and purchased inputs related to each operation. Add to the calendar the timing of identified outputs from the activity.
- Food and feed calendars. List and rank in importance the starch and protein foods used in the common dishes eaten by local farm families. Note particularly the substitute starch and proteins used when preferred foods are not available; note also which are homegrown and which purchased. Add to the food calendar the timing of the use of homegrown and purchased foods, noting periods when homegrown foods are plentiful, uncertain, or not available. Draw up a similar calendar showing the main sources of animal feed over the year, including fall-back sources when major sources dry up.

Descriptions of the local production environment and of farmers' activities within this environment provide the FSR team with the basic facts needed to understand the farming system.

Understanding a Local Farming System

The two sets of descriptions are interpolated into the conceptual model. Local circumstances have stimulated farmers' decisions, and farm activities have resulted from those decisions. The research approach has so far filled in the origins and outcome of the farmers' decisionmaking process. It remains for the FSR team to understand that process.

Some clues will have been gained from the identification of management challenges during the review of local circumstances. Two other important sets of clues about farmers' priorities emerge from the description of farmers' activities and methods. First, farmers' priorities are reflected in the use of the outputs from their activities. Second, each activity undertaken—and the timing and method of each operation for each activity—represents a commitment of resources as a result of farmers' decisions on resource allocation. The social scientist's experience and skill are needed to estimate the resource commitments implied by the method used in an operation for any given activity (for example, to be aware of the order of magnitude of labor inputs required to hoe an acre of light soil or to weed an acre of finger millet). Given the land normally allocated to the various crops, an estimate of livestock numbers and uses, and an idea of the importance and timing of off-farm activities, the social scientist builds a rough profile of land, labor, and cash commitments over the year for the farming system being researched. These commitments also reflect farmers' priorities.

The social scientist follows through his research by identifying levels of farmer's resource endowments—the amount of land, labor, and cash available. Relating this to his estimates of commitments, the social

scientist hypothesizes how resources are constraining system activities, then verifies his hypotheses by further research.

This completed, he has an understanding of three causatives dictating farmers' management strategies: achievement of their priorities; challenges thrown up by the production environment; and limitations because of land, labor, and cash resources. Any of the three may create compromises in farm management that are usually manifested in suboptimal technical practices.

A common example of such a compromise is late maize planting. Although late planting can, of course, be a result of low motivation or low management ability, it can also result from any of the three causatives—alone or in combination—dictating farmer management strategies.

- A farmer's priority. A late planting gives prolonged supply of green maize, either as a preferred food or for high-priced sales on the local market.
- An environmental challenge. A late planting avoids maize tasseling and silking during the mid-season drought. Late maize carries over the drought more successfully at an early stage of growth when transpiration is more limited.
- A limited resource endowment. Limited labor but plentiful land makes it profitable for the farmer to continue to establish maize well past its technically optimal planting time.

It must be emphasized that an understanding of the reason for late planting is essential to the choice of an intervention. A different orientation in the search for interventions would be appropriate in each of the three cases.

It is useful for the agronomist and animal scientist to follow through this sequence and for each to understand the system. However, they will tend to identify management compromises by a different route. Part of their required experience is an awareness of sound technical management practices for crops and animals under local conditions of climate and soil; often the current recommendations form a basis for such awareness. In addition to gaining an overview of the system by interaction with the social scientist, they investigate the detailed management regimes for the crop and livestock activities that are absorbing high levels of limited resources. Using their knowledge of sound technical management as a frame of reference, they identify the compromises in present management practices. Thus, the social and natural scientists on the team arrive at the shortcomings of management practices in the main farming activities by different routes but with an understanding of the farmers' decisionmaking processes and the origins of such shortcomings.

Problem Identification

The FSR process identifies two sets of problems: management compromises and resource constraints.

MANAGEMENT COMPROMISES. Development opportunities are related to two of the three sources of compromise: can farmer priorities and environomental challenges be met in other ways that obviate the need for compromises in management? Alternatives may be sought in technology (materials and methods that alleviate the compromises) or in policy and programs (which modify local circumstances, shifting farmers' priorities or removing the challenge from local circumstances). A reliable, fairly priced retail source of starch staple is an example here. The focus and appropriate content emerge from an understanding of the system.

RESOURCE CONSTRAINTS. The management strategies and husbandry practices absorbing high levels of limited resources—whether land, labor, or cash—represent a second set of development opportunities. Again, changes can be researched in technology, in looking for materials and methods that either are more efficient in their use of limited resources or raise productivity without using limited resources. Changes can also be researched in policy and programs to supplement the farmers' resource base. Credit and farm

equipment programs are obvious examples. Again, and most important, the focus and the appropriate content emerge from an understanding of the system.

The research process brings with it an understanding of the interactions within the system. Interactions are important in two ways. First, a problem that often arises in evaluating new technologies is not the actual cash costs of the purchased inputs, but the opportunities that must be forgone by reallocating land, labor, or cash to the innovation. An understanding of the interactions in the system allows researchers to identify properly the opportunity costs of a reallocation of resources to absorb a new technology.

Second, understanding the system's interactions opens up possibilities for indirect intervention and thus widens the spectrum of potentially relevant technologies. A classic indirect intervention is to intensify or merely change management on the food crop side of the system in order to release limited resources to allow the introduction or improvement of a cash crop. A more detailed example is useful. Whereas herbicides may not economically solve a weeding problem for the maize crop, applying herbicide to the cotton in the system may release enough labor to improve the weeding regime on the maize to make the use of maize fertilizer economically attractive. (See chapter 14 for related findings in Pakistan.) An awareness of this kind of competition for resources allows consideration of interventions for both crops, not just for the one seen to be suffering from the competition.

Finally, understanding the system's trends—that is, understanding which activities and methods are failing and which are gaining in popularity among farmers—can be a valuable aid in the choice of interventions. Reinforcing or reversing trends provides further focal points for change.

Farming Systems Research and Farm Management

Two approaches have dominated farm management in Europe and in the United States. First has been comparative analysis, in which performance data for a single farm are compared with averaged data for farms of that type to identify strengths and weaknesses in the farm's business. The farm management specialist advises the farmer accordingly. Second has been individual farm planning, in which the resource endowments and input-output coefficients of the farm itself form a starting point for analysis. Both approaches involve direct contact between the farm management adviser and the individual farmer. Neither approach can be cost-effective in small-farm sectors of the developing countries, where farm management advisers are rare and increments in productivity on the very small farm units could never cover the cost of professional advice. The FSR approach applies farm management principles at the system level, allowing the cost-effective use of very scarce manpower.

The controversy over the most useful approach for the discipline of farm management in small-farmer agriculture in the developing countries is unresolved. A stimulating discussion can be found in Johnson (1981). He argues, I think convincingly, that production economics abducted farm management at the end of the 1930s. FSR is an attempt to reassert the original, interdisciplinary nature of farm management in a milieu—the small-farm sectors of developing countries—in which approaches based on production economics are difficult to implement and often do not provide useful answers. The controversy inevitably spills over into methodology.

Methods for Implementing FSR

There are two interacting areas of controversy over alternative research methodologies. First, the objective functions of small farmers are strongly influenced by subsistence and risk considerations and are very complex. The production environments of small farmers are fraught with uncertainties, and farmers' reactions to these environments are often conditioned by social and cultural circumstances. Under these conditions the economic principles on which most analytical tools in farm management depend have limited relevance. Only a detailed prior understanding of the farming system can bring even the limited relevance to bear in analysis. Anderson (1978) has discussed this system-modeling issue thoroughly.

Second, data collection among a wholly literate population accustomed to recording information about their farm activities is relatively easy. This task becomes both complex and expensive among an illiterate population: enumeration of verbal responses or direct measurement by the research team is the only means of recording. The World Bank's experience—its detailed data collection for monitoring and evaluation of projects such as the Lilongwe Development Program in Malawi, the Regional Integrated Development Projects in Tanzania, and the Northern Nigerian Agricultural Projects—demonstrates the bottlenecks in processing and analyzing detailed data, which compound the time and expense of collecting them. Again, a sound understanding of the system is needed *before* the parameters requiring detailed measurement can even be specified.

CIMMYT Choice of Methods

CIMMYT economists have been guided in the development of their FSR methods by the following precepts:

- A good understanding of a system is required before the appropriate parameters for data collection and analysis can be identified.
- The economic principles underlying most traditional analytical tools have difficulty embracing the complexities of smallholders' motivations.
- Accurate data are very difficult, time consuming, and thus expensive to collect and to process.

Given the few professionals in developing countries who are available to undertake these activities, CIMMYT feels justified in the use of a rapid, low-cost sequence of methods to obtain a sound understanding of the local farming systems. Detailed data collection and analytical methods including modeling may improve that understanding, but the extra cost of this effort is not justified (Byerlee and others 1982). This is especially true when the opportunity costs of professional time are considered. One set of professionals may implement CIMMYT methods in several different systems in the time that it would take to measure and model accurately one system with the use of sophisticated, traditional farm management methods (Collinson 1980).

Sequence of Low-cost, Rapid Methods

A low-cost, rapid sequence of methods for FSR has been detailed elsewhere (Byerlee, Collinson, and others 1980; see also chapter 8). The sequence is iterative, steps are increasingly focused, and the methods used are increasingly expensive. More expensive methods are thus reserved for data collection on the few parameters found to be vital to the objectives of the research effort. The sequence of methods is outlined below.

DEFINING RECOMMENDATION DOMAINS. As already mentioned, the implementation of FSR is preceded by an identification of discrete farming systems, or recommendation domains. This is a stratification in the true statistical sense and is intended to maximize the variations between domains and to minimize variations within each. Such stratification may be achieved by the use of secondary data, by a preliminary regionwide survey, or by discussion with knowledgeable local informants. Any initial stratification may be regarded as preliminary and subject to refinement as the sequence of investigation proceeds. The stratification should, however, specify as far as possible the area and the target group in that area within which FSR will subsequently be undertaken.

UNDERSTANDING FARMER CIRCUMSTANCES. The first step of the FSR approach proper is to understand the local production environment. A review of available secondary data forms the basis for this understanding and is supplemented when necessary by interviewing reliable local informants. Published

data are often available on climate and soils and on markets and prices. The informal market and local sociocultural circumstances are often less well documented, and key informants (for example, merchants and village elders) often can expand the research team's insights into those facets of the system. This step represents less than a week of work for the team, including visits to the research area.

THE INFORMAL SURVEY. The informal survey is essentially a rapid rural appraisal device (Chambers forthcoming) and is the pivotal step in the sequence of methods that can lead to an understanding of the farming system. Fieldwork centers around the team's discussions with farmers in the target group. Such discussions can be preceded by a review of available agricultural surveys of the area. These surveys often provide information about on-farm and off-farm activities, including areas cropped, number of animals, quantities produced and sold, inputs purchased, and equipment owned and used. Such reviews make the team familiar with the farming system and, together with a knowledge of local circumstances, form a basis for subsequent discussions with farmers.

These discussions occupy some six to ten days among farmers operating the system under research. Unstructured interviews are based on a set of guidelines (Collinson 1982) that are divided into sections and designed to elicit a description and understanding of the system and to identify local development opportunities. The interviews are best conducted during the growing season, a timing that aids verification by observation. The informal survey can, however, be carried out at any time. The research team interviews a farmer on one or more sections of the guidelines or the same farmer or different farmers on the same sections and make notes. At the end of each day, after each member has talked to perhaps three farmers about the same (or different) sections of the guidelines, the team meets and jointly evaluates the information obtained. Additional farmers are interviewed about each section of the guidelines until researchers are satisfied that they know and understand those aspects of the system.

The guidelines are designed to move from description to understanding to problem identification. Farmer interviews follow this sequence, with researchers seeking to verify the understanding gained and the problems identified in subsequent interviews. The output from the informal survey is a joint team report with the content described in the preceding section (subsections on farmers' activities, the farming system, and problem identification).

THE FORMAL SURVEY. The formal sample survey among the target population is carried out to verify facets of the system important to meeting the objectives of the research. Such facets include the homogeneity of the recommendation domain, farmers' priorities and decision criteria, their resource endowments and limitations, the incidence of key management compromises and of resource-intensive management practices, the effects of particular external circumstances on farmers' resource allocation, and the importance to farmers of the problems identified. Where researchers are confident that they understand these facets of the system and that the facets are uniform throughout the target population, there may be no need for a formal survey in the research sequence. Where a formal survey is implemented, some facets of the system may be explored more deeply and perhaps some parameters measured for further analysis to aid the objectives of the research.

A single-visit survey method is used for verification. The questionnaire, developed from the informal survey findings, is completely location specific and is highly selective in content. Within a single recommendation domain a sample of fifty to sixty farmers will be adequate. Working at a rate of two to three farms a day, twenty to twenty-five enumerator days will be needed to complete the survey—about a week of work for four or five enumerators.

Overall, the sequence of methods—including the review of secondary sources, the informal survey, and the verification survey—will occupy the team for a minimum of six weeks, and they will also need some lead time to prepare the community for the activities of researchers among them. This time may be halved if the team judges that the informal survey is adequate for their needs.

Potential for FSR in a Farmer-Research-Extension-Farmer Continuum

To date FSR has been used largely as a tool of agricultural research. This role is clear, and alternative institutional niches are beginning to emerge. It also seems probable that FSR can make contributions to project preparation and management and to overall development strategy. Its roles in these areas are less clear, but some possibilities are briefly examined below.

FSR in Technology Generation

New technology, as the only type of intervention capable of changing technical input-output relationships (and, therefore, the physical productivity of small farmers' resources), is of central importance to agricultural development. Agricultural research, as now established in developing countries, is based on a technical perspective of agricultural problems. This perspective manifests itself in research recommendations that are unfinished products with respect to the needs of the small-farm managers they seek to serve.

- Farmers never use a purely technical perspective in managing their farms and consequently never use it in evaluating new technologies recommended to them by the extension services.
- Recommendations inevitably take the form of "final solutions"—the "best way" to produce. They seek *full* exploitation of biological potential under the present state of the art. Farmers may be willing and able to handle only intermediate or partial solutions because of both the managerial perspective they use and their limited resource endowments.
- Recommendations are made on a "blanket basis," at best, for a specific agroecological zone. This fails to recognize that economic and cultural circumstances dictate farmers' decisions and modify, often drastically, these agroecological influences.

Agricultural research is tied to a technical perspective and technical criteria by the essential features of experimental methodology. In the course of the research and extension sequence, which is directed toward the development and dissemination of new technology appropriate for farmers, the perspective and criteria have to change from the technical ones inherent in experimentation to the managerial ones used by farmers. FSR uses a managerial perspective[1] to review technical research outputs and identify, and where necessary modify, those most relevant to the current needs of specific groups of farmers. One major role for FSR is to help finish the research products to meet the demands of differentiated farmer markets.

Its second major role is to identify technical problems crucial to the rapid development of farming systems and to feed these back as agenda to commodity and disciplinary research specialists. This feedback is the other side of the technical and managerial loop and focuses technical research effort on farmers' most important management problems.

In Africa and possibly in other places as well, the institutional linkage failures between extension and research are relatively superficial. The fundamental problem in the research-extension sequence commonly followed in Africa is the failure to use a managerial or systems perspective in the diagnosis of farmers' problems and in the development of recommendations for farmers.

Neither research nor extension establishments are truly farmer oriented because of the dominating technical perspective. In many countries, research and extension staff remain skeptical that small farmers

1. The managerial perspective is exactly the same as the systems perspective, and the term was used here to emphasize the identity. However, systems perspective has more validity in the small-farm sectors of developing countries. To be cost-effective, the perspective must be brought to bear at the level of aggregation of a number of farmers operating the same system. Management perspective is appropriate in developed countries where the professional farm management adviser interacts with the individual farmer. Very small farms and a dearth of professionals mean that this individual treatment is not operationally viable in developing countries.

are managers in any accepted sense of the word. Such skepticism leads to the assumption that "we know what is best for you." This, in turn, inhibits the extension services from understanding small farmers and feeding back key problems to research. Further, technical compromises (often the essence of good management) are inevitably seen as farmer shortcomings. Such attitudes reduce the credibility of the extension staff in the eyes of the local community.

Similar anomalies occur in disseminating recommendations. The contact extension officer or the contact farmer, who lives in and must live with the community, is often charged with promoting new technologies he sees as inappropriate for his neighbors. He is caught in a squeeze between his bosses and his neighbors. Since the bosses hold the purse strings, their view prevails, but at high cost to the credibility of the contact person in the community and his own morale.

This fundamental problem of perspective is certainly reinforced by the characteristic institutional and operational gap between research and extension services, and by the physical isolation of station-based researchers from their farmer clients. Integration of the planning and operation of research and extension is clearly desirable. However, only the introduction of a managerial perspective to generation and dissemination will solve the technology transfer problem. Farmers' management priorities must be given full weight—first, in modifying technical research findings to meet the needs of differentiated technology markets, formed by sets of farmers operating the same system; second, in the planning of research agendas for commodity and disciplinary specialists at research stations. The FSR procedures described are a cost-effective means of interfacing the technical and managerial perspectives.

Because the use of FSR in technology generation is fairly well accepted, it may be worthwhile to follow the sequence of activities that the research team goes through after it has gained an understanding of the existing system. The team reviews materials and methods, the output from national or international technical research. It identifies those technologies that appear potentially relevant as solutions to identified management compromises, as more efficient alternatives to practices absorbing high levels of constrained resources, or as interventions to improve productivity by taking up only slack resources. The team casts its net as widely as possible, seeking several alternative strategies to solve each problem. The more options it identifies, the more likely it is to find solutions appropriate to the local situation.

Take, for example, the problem of declining ox draft capacity in a community: fewer and weaker animals at the start of the rains will have repercussions on the timeliness of planting and the quality of seedbed preparation. Two broad, initial approaches are to improve dry season feeding and to reduce the demand on animals. The first leads to consideration of a wide range of possible feed sources—crop residues, by-products, planted grass or legumes, improved pasture, and so forth. The second leads to consideration of reduced draft requirements through better harness, lower draft implements, minimum tillage techniques, or alternative tillage timing (and its consequences) to reduce the peak demand on oxen at the start of the rains. A whole gamut of possibilities unfolds—at this stage the wider the better. The FSR team then follows through a prescreening process, essentially an ex ante evaluation of the appropriateness of each possible solution to the local farm situation. The process has both technical and economic dimensions and requires close cooperation within the team and with appropriate technical specialists. In the example above, such specialists would, at a minimum, include pasture and forage agronomists and an agricultural engineer. Steps in the prescreening process are summarized below.

1. The technical scientists on the team will review the relevant output from technical research, often with the specialist responsible for the work. They will seek answers to two questions:

- Considering the context in which these technical results were obtained—climate, soils, and input regime—can the relationships be expected to hold when findings are implemented in the local farming situation?
- What are the detailed management requirements for implementing the technology, how flexible are these requirements, and how will invoking that flexibility modify the results?

2. The social scientist on the team will study the resource and management requirements of the technology, and the expected output, and will try to answer three questions:

- Are the resource demands of the technology reasonable, given the endowments of the local farmers?
- What resource reallocation within the system is implied by the managment requirements of the technology—that is, what are the opportunity costs of its introduction?
- How far do the flexibilities in management requirements for the technology allow better compatibility (and thus lower opportunity costs) with the system?

3. For technologies that pass through this filter, the technical scientists must decide—on the basis of their level of confidence that the relationships found experimentally will hold when the technology is applied locally—what type of experiment is required? If their confidence is low, they may find it necessary to run a relatively formal experiment to identify the relationships locally, under farmer conditions. If their confidence is high, they will move directly to a farmer-managed comparison of the new and the existing technology. The higher their confidence, the more rapidly will the on-farm research program generate technology for the extension and diffusion process.

FSR and the Research-Extension Linkage

The use of FSR to generate appropriate technology brings researchers to the local level in direct contact with local extension staff. Both are working with and for the same farmers. FSR has the potential to solve the outstanding problems of research-extension linkage (see also chapter 12). Historically, research has stopped too early in what should be a continuous and dynamic process of development and diffusion of new technology. Researchers have been physically and mentally isolated from farmers and have handed down an unfinished, untested product to extension staff. Extension contact staff—squeezed between farmers they live among, who often ridicule the technologies they bring, and their superiors, who demand results—have been caught in a crisis of morale. With few exceptions, extension staff have sought refuge among those in their communities—often businessmen and teachers—who have maintained them as advisers for the more direct benefits (access to credit, inputs, and information) these benefactors might bring.

In an on-farm research and FSR approach, the continual interaction between farmers, researchers, and extension staff allows a ready consensus when improved technology is ready for dissemination.The most obvious sign is host farmers beginning to use experimental techniques on their own crops and animals. Extension staff who have been involved with the on-farm research program have an intimate knowledge of the managerial implications of the new techniques, as well as the ability to conduct demonstrations on farmers fields and widen exposure to the interventions across the community. Where a relatively senior cadre of extension staff are involved in the on-farm research program, those who perform the role of subject matter specialists within the training and visit (T&V) approach are obvious candidates. They will emerge as ideal trainers of contact extension staff throughout the target group area.

Two points should be emphasized about the approach described. First, extension staff have a great deal of confidence in recommendations developed in this participatory way on local farms. Second, the approach pulls down into local farm situations whatever technology is diagnosed as appropriate. This is the main difference between the FSR approach and the current, top-down pushing of technologies at farmers, regardless of the specifics of their local situation.

FSR and Project Preparation and Management

FSR has not yet found a place in project identification and preparation. If technology selection is the "engine" of agricultural development projects, however, FSR must surely have a place because of its effectiveness in technology development. The FSR approach would seem an appropriate sequence for project identification and preparation where an evolutionary strategy for small-farm development is to be pursued. It can accommodate both the technology and the service and infrastructural needs for technology

mobilization through the evaluation of local farmers' circumstances. These form the two essential sides of project content. The time frame for the application of the FSR methods set out in the preceding section—from three to six weeks depending on the need for a formal survey--seems readily compatible with existing project preparation commitments.

I believe that the recent interest shown by the World Bank in within-project research capacity is an important development, as long as this capacity operates from a systems perspective. It could be used to introduce the concepts and organization of on-farm research and FSR into national agricultural research services and to build, through counterpart staffing, a national capacity to implement an FSR perspective. T&V extension, institutional arrangements for monitoring and evaluation, and (infrequently as yet) on-farm research and FSR methodologies have been part of project organization. These three have arisen over the past decade as fairly discrete components. To my mind, we need to take a hard look, forgetting the labels, at the way the functions of these three components can best be integrated and staffed. If a capacity for technology generation is accepted as necessary for agricultural projects, this need might indeed influence how projects are prepared and managed. If one speculates a little, one can see that, if an FSR team is put in place in a region, a project might unfold from team findings on technology and its servicing and policy requirements. Evolution of a national FSR capacity to do such location-specific project formulation could be a means both to more active national project preparation and to the decentralization of planning that currently are being widely advocated.

Several points come to mind in pondering the idea of integrating T&V, monitoring and evaluation, and on-farm research and FSR.

- A systems perspective is the new element that FSR brings to extension projects. FSR researchers should be the repository and promoters of this perspective.
- Programming procedures should be arranged so that on-farm researchers at the local level and the technical researchers at research stations are mutually dependent. One half cannot operate without the other.
- With on-farm researchers, subject matter specialists (SMSs), and field extension staff working in the same locale, research-extension liaison posts should be unnecessary; the continuity of the interactive process of technology generation-verification-dissemination-modification should suffice.
- Once on-farm researchers see that the thirty or so farmers who are hosting their trials are using the technologies themselves, the SMSs, having monitored the technology-generation process, will embark on extension training and diffusion. This indicates the division of responsibilities between on-farm research and SMSs in the T&V approach or corresponding roles in other extension approaches.
- Monitoring and evaluation assesses both the generation and diffusion of technology. If monitoring and evaluation can be satisfied with a fairly unsophisticated approach to evaluation, there may be opportunity for integrating the monitoring and evaluation and on-farm research work under a single social scientist, particularly where such professionals are scarce.

FSR and Development Strategy

Improved productivity of small-farmers' resources and, therefore, technology generation and transfer are clearly crucial to agricultural development. FSR can make a substantive contribution to the relevancy of farming technology. At the same time, FSR procedures are effective vehi s for both decentralization and participation, currently stressed as desirable in the development literatu. Indeed, the raison d'etre of FSR is the end for local specificity, and the methods used in FSR a tially a series of interactions between researchers and local farmers. The FSR perspective recognizes that local farmers know a great deal more about their own situation and needs than does anyone else, and that these exigencies can and should form the basis of local development projects in the sector. These properties of FSR create an opportunity for a better reconciliation between local and national development priorities. They allow a move away from the top-down imposition of projects based on national priorities, which often are far removed from local needs and, consequently, are ignored by local farmers.

Better Exploitation of FSR

Several writers (Hildebrand 1978; Chambers 1980) have noted the contrast between the willingness of small farmers to absorb innovations that help them and the reluctance of scientists and bureaucrats to change. The introduction of FSR as an agricultural research tool often puts research administrators on the defensive; there is an implication that all is not well with their departments. In addition, over the past few years of recurrent budget crises, administrators have been reluctant to accept the need for professional staff working among farmers and absorbing large amounts of funds. Since 1976 CIMMYT has increased recognition of the need for on-farm research and FSR in East Africa in five stages:

- Finding national research administrators who identify with the problem of poor development and transfer of technology and with the need for local specificity
- Demonstrating an FSR approach to improving the relevance of technology to local situations, with the help of national research professionals
- Promoting the inclusion of social scientists (economists and/or sociologists or anthropologists) in agricultural research
- Providing training to build up an on-farm research and FSR capacity in national agricultural research services
- Encouraging the reorganization of research planning and operational procedures and the restructuring of research services to accommodate two tiers of researchers and to guarantee their interdependence.

Although the potential of FSR perhaps extends beyond agricultural research alone, CIMMYT's brief, of course, is agricultural research. Moreover, it is felt that attempting such innovation across a wider front (several departments and perhaps several ministries) would multiply the barriers to acceptance. The strategy has therefore been to seek a narrow entry for FSR, with the possiblity of expanded applications once a capacity is established.

Problems of introducting FSR methods have been increased by the ambivalence of major donors to agricultural development efforts. Although donor projects are a valuable vehicle for introducing the FSR concepts and approach to national agricultural administrators, major donors showed little interest until 1979–80. They have belatedly confronted the thorny problem that inappropriate technology is a major reason for poor agricultural project performance. Donors now rightly see FSR as a route to appropriate technology, and heavy interest is creating its own crisis. FSR in the near future will have problems in maintaining its credibility because of poor implementation and possible disillusion with its approach.

Merely changing the jargon and printing new business cards for contracted professionals will not do the job. There is a very limited experience in the use of FSR, particularly in the necessary use of the essentially anthropological methods of the informal survey described above, which are finding favor for their low cost and rapid turnaround. Training in FSR approaches and practices is the single most urgent prerequisite for the effective use of the methodology.

Training in FSR is ongoing, but the resources devoted to it are limited. CIMMYT, for example, with three FSR professionals in eastern and southern Africa, is providing the following types of training:

- Short orientations (two to three days) for new project staff
- Short-term instruction in approach and methods (two regional workshops a year in cooperation with the University of Zimbabwe, totaling five to six weeks with some thirty participants from a dozen countries)
- In-country, on-the-job training and retraining programs for national agricultural professionals (in two countries at any one time).

Effective short-term and on-the-job training is somewhat inhibited because systems concepts and perspectives are new to agricultural graduates of the established universities. Arguably, all undergraduate

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curricula in agriculture in developing countries should give a grounding in such concepts and perspectives, which would contribute a significant context for subsequent specialization. FSR courses are increasingly finding a place at the graduate level in agricultural faculties of U.S. universities. Universities in the developing world are, with some exceptions, reacting to the need more slowly.

Practitioners are confident that FSR has great potential for more rapid development of small farms because it allows farmers to participate in technology generation and project preparation. It has special relevance for farming communities whose management strategies and resource allocation are dominated by subsistence needs, high levels of uncertainty in local circumstances, and shortages of cash and labor in the face of relatively plentiful land. In these situations, the conventional criterion for the choice of technology—output per unit of area—is only indirectly relevant and needs strong qualification. Farming systems researchers, by putting themselves in the shoes of farmers operating such systems, are well equipped to make such qualifications.

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