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The Farming Systems Approach: Relevancy for the Small Farmer

by

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THE FARMING SYSTEMS APPROACH: RELEVANCY FOR THE SMALL FARMER*

by

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Preface

Over the past few years Farming Systems Research (FSR) has gained a "ground swell" of support among donors and international research institutes. The thrust of FSR is to carry out farm level research through a farmer/researcher partnership in problem identification and farm level testing of improved technologies. The proponents of FSR contend that the farmer/researcher partnership is needed because much of the "top down" research in experiment stations has not given sufficient attention to the relevance of a technology in terms of the goals and resources of small farmers.

FSR starts with the premise that there are substantial institutional, political, informational, and attitudinal barriers which inhibit the "voice" of small farmers in shaping research priorities in commodity and disciplinary research programs in the Third World. Farming Systems Research is advocated as a more immediate and systematic way to provide a voice and research assistance to small farmers. But while FSR can theoretically give "voice" to small farmers it does not follow that small farmers will have political power to press for the reform of other institutions and policies which limit their access to extension, credit and reliable markets.

There is a great deal of confusion over whether FSR is a philosophy of research (farmer/researcher partnership) or whether it is unique and different from commodity and disciplinary research. If it is unique and different then FSR units should be established within research institutes, FSR projects prepared for donors, and special training programs established to train FSR researchers. Many observers question whether FSR is new or simply farm management research under a new label. Finally there remains the question of why it has been so difficult to move FSR beyond the International Agricultural Research Centers and into national research systems.

To understand these issues it will be helpful to examine FSR within a historical perspective. First, on the question of whether FSR is the same as farm management research, we note that in the 1920s and 1930s farm management research in the United States emerged, and emphasis was placed on a holistic approach to examine alternative farm enterprises. At that time farms were primarily subsistence in orientation and the rural household was engaged in a wide range of production and consumption activities. The record shows that farm level research was underway in the United States by Tennessee Valley Authority (TVA) researchers in the 1930s. TVA researchers carried out a wide range of fertilizer trials on farmers' fields throughout the Southeastern states. The "balanced farming" program in Missouri in the 1940s is another example of farm level research. If FSR is defined to mean an active farmer/researcher partnership, then FSR is not a new approach. But most current FSR in the Third World is focused on only one enterprise--crops. Much work remains to be done to integrate research on cropping and livestock systems in the developing world before FSR can claim to be as broad as farm management research.

Second, on the issue of the uniqueness of the FSR approach, there is a striking parallel between the conflicting views on Community Development (CD) and agricultural development in the Third World in the 1950s, and whether FSR is a philosophy of research which can be carried out by commodity research programs or a unique system which requires separate FSR units and specially trained farming systems researchers. In the 1950s many experts argued that community development was a "philosophy" of helping farmers and rural people to express their "felt needs", to increase their participation in the development process, etc., and that this philosophy could be incorporated into ongoing agricultural programs. Other experts argued that CD was unique and different from agricultural development and that a Ministry of Community Development should be established, along with CD projects, for donors to fund. Another issue was whether CD agents were needed in addition to agricultural extension agents. The Ministries of Agriculture and Community Development fought over these issues in many countries in the 1950s. However, as Akhter Hameed Khan[1] and Lane Holdcroft[2] have pointed out in earlier papers in this series, after a few years the Ministry of Agriculture invariably won the battle. Currently

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[1]Akhter Hameed Khan, "Ten Decades of Rural Development: Lessons from India," MSU Rural Development Paper No. 1, 1978.

[2]Lane E. Holdcroft, "The Rise and Fall of Community Development in Developing Countries, 1950-1965: A Critical Analysis and an Annotated Bibliography," MSU Rural Development Paper No. 2, 1978.

many people argue that FSR should be given a separate identity, just as CD was given in the 1950s. Others argue that FSR is a philosophy of research which can be carried out within established research programs. For example, although CIMMYT does not have a FSR program, substantial farming systems research (farm level research) is being carried out as an integral part of CIMMYT's three major research programs--wheat, maize and economics programs. The debate over whether FSR is a philosophy of research or a new approach requiring separate organizational arrangements will continue in the 1980s.

The historical insights suggest a need for not only debate and dialogue on FSR, but also the publication of papers on the FSR experience in different regions of the world. We are pleased to announce that four papers on FSR are being prepared for our MSU Rural Development Paper series. These papers are being published as part of an AID financed contract "Alternative Rural Development Strategies" with Michigan State University; some will be translated into French and Spanish. These papers are designed to provide insights from FSR experiences which can be used by researchers, policymakers, rural development practitioners and donors in designing research and action programs relevant to small farmers.

The author of this FSR paper--Dr. David Norman--is writing from first-hand experience in helping organize and carry out multi-disciplinary research on problems of small farmers in Nigeria for 11 years (1965-1976). Dr. Norman's analysis is an honest assessment of the strengths and limitations of FSR. He rightly points out that FSR is neither a panacea nor a substitute for, but a complement to strong commodity and disciplinary research programs.

The second paper in our FSR series is a state of the arts paper by Elon Gilbert, David Norman and Fred Winch. This May 1980 paper will provide a worldwide assessment of FSR research, including examples from international and national research systems in the Third World. The third paper is an annotated bibliography of FSR by Doyle Baker of MSU. Since there is considerable regional variation in FSR approaches we shall publish several papers on farming systems research in different regions of the Third World. The fourth paper, by Mike Collinson, will assess CIMMYT's multi-disciplinary farming systems research program in Eastern Africa. Regional papers will be published for Central America and Southeast Asia.

Carl K. Eicher, Director
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Two of the most common development slogans of the 1980s are "basic human needs" and "growth with equity". Both describe strategies for helping specific groups--especially small farmers in less developed countries (LDC's). These strategies imply that instead of taking a welfare approach, development programs should help the poor to increase their income earning opportunities, and crucial to creating such opportunities is providing small farmers with relevant and improved technology to meet their needs. It is from the quest for relevant technology that the farming systems research (FSR) approach has emerged.

The aims of this paper are to:

(a) Briefly review the evolution in thinking about agriculture and technology development in the LDC's;

(b) Define a farming system and the general characteristics of the FSR approach;

(c) Discuss the role of the FSR approach in designing and implementing projects to help small farmers;

(d) Discuss some of the problems of implementing a FSR program.

EVOLUTION IN THINKING ABOUT AGRICULTURE AND TECHNOLOGY DEVELOPMENT

People originating from or trained in high-income countries have displayed strong biases, sometimes unknowingly, about how to achieve development in the LDC's. Over the last two or three decades thinking has evolved through four successive strategies: (a) taxing agriculture to finance industrial/urban development; (b) transferring technology from the high-income countries to the LDC's; (c) developing technology within the LDC's by drawing on elements of technological packages in high-income countries; and recently, (d) supplementing the selective importation of technology with a "bottom-up" approach[1] to technology development, or what is now commonly called the farming systems approach.

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[1]"Bottom up" refers to the strategy of starting the research process at the farmers' level by first ascertaining their needs, and then using these needs to determine research priorities. This contrasts with earlier "top-

A number of factors explain the move to farming systems research and local technology development. First, previous strategies to improve the livelihood of small farmers have repeatedly failed. Second, many agricultural programs have led to an unequal distribution of benefits. While the success of the Green Revolution should not be underestimated, numerous equity problems arose in the process of increasing agricultural production (Saint and Coward, 1977). Despite claims that Green Revolution technologies were intrinsically neutral to scale, for instance, many small farmers and the landless found it difficult to gain access to land and the technological packages (Khan, 1978; Poleman and Freebairn, 1973). A third reason for the shift to farming systems research has been the rising cost of fossil energy which is embodied in much of the Green Revolution technology. The fourth reason is the increased realization, supported by empirical evidence, that many traditional practices used by small farmers for generations are sound and should be preserved (Jodha, 1978; Navarro, 1977). These and other factors have contributed to the emergence of a "bottom-up" or farming systems approach to the development of small farmer technology. The FSR approach, however, is not easy to define.

DEFINING A FARMING SYSTEM

A system can be defined conceptually as any set of elements or components that are interrelated and interact among themselves. Thus, a farming system is the result of a complex interaction of a number of interdependent components. At the center of this interaction is the farmer himself; he is the central figure in FSR. Moreover, both farm production and household decisions of small farmers are intimately linked and should be analyzed in farming systems research. A specific farming system arises from the decisions taken by a small farmer or farming family with respect to allocating different quantities and qualities of land, labor, capital, and management to crop, livestock, and off-farm enterprises in a manner which, given the knowledge the household possesses, will maximize the attainment of the family goal(s).

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down" approaches where research priorities, determined at the experiment station level, are transmitted "down" to the farmers, who are not directly consulted in the research process.

Figure 1 illustrates some of the underlying determinants of the farming system. The total environment can be divided into two elements: technical and human (Institut d'Economie Rurale, 1976). The technical element determines the types and physical potential of livestock and crop enterprises, and includes physical and biological factors that have been modified to some extent by man--often through technology development. Man has developed, for example, mechanical techniques to improve the availability of water through irrigation, and chemical techniques to improve soil quality, etc. The farming system that actually evolves, however, is a subset of what is potentially possible as defined by the technical element.

The human element is characterized by two types of factors: exogenous and endogenous. Exogenous factors (i.e., the social environment), which are largely outside the control of the individual farmer, influence what he will and/or is able to do. They can be divided into three broad groups:

(a) Community structures, norms and beliefs.

(b) External institutions. These can be subdivided into two main groups: inputs and outputs. On the input side, extension, credit and input distribution systems are often financed and managed by government agencies. On the output side, the government may directly (e.g., marketing boards) or indirectly (e.g., improved evacuation routes, transportation systems, etc.) influence the prices farmers receive.

(c) Miscellaneous influences, such as population density and location.

Unlike the exogenous factors, the endogenous factors are controlled by the farmer himself, who ultimately decides on the farming system that will emerge, given the constraints imposed by the technical element and exogenous factors.

The farming system as defined above highlights the complex nature of the underlying determinants. An appreciation of these determinants can provide insights as to why small farmers have failed to adopt improved technology. Specifically, most conventional approaches to technology development, utilizing a "top-down" approach, tend to modify the technical element to fit crops or animals and to ignore the human element. The farming systems approach, on the other hand, potentially imparts greater reality to technology development by making technology a variable instead of a parameter

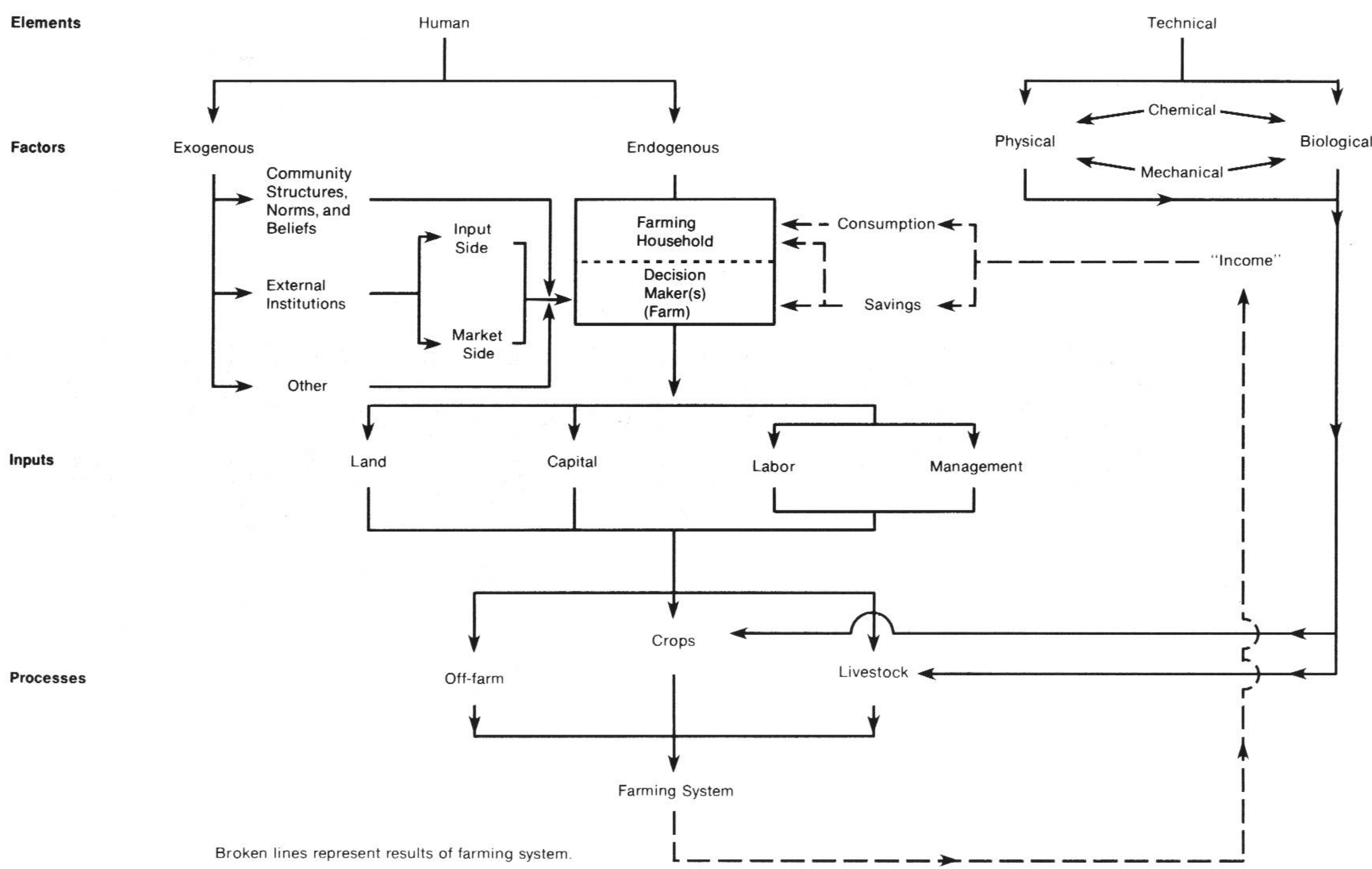

Figure 1 Schematic Representation of Some Determinants of the Farming System

(Saint and Coward, 1977). FSR increases the potential for fitting the animal or crop to the environment rather than vice-versa (Van Schilfgaard, 1977).

COMMON ELEMENTS IN FARMING SYSTEMS RESEARCH (FSR)

FSR recognizes and focuses on the interdependencies and interrelationships between the technical and human elements in the farming system. As such it is more holistic in orientation than the reductionist approach traditionally used by technical agricultural scientists--an approach that requires studying one or two factors at a time while attempting to control all others (Dillon, 1976). The primary aim of the FSR approach is to increase the overall efficiency of the farming system; this can be interpreted as developing technology[1] that increases productivity in a way that is useful and acceptable to the farming family, given its goal(s), resources and constraints.

Research on farming systems in the LDC's has developed mainly in the last decade and is now being pursued in Africa, Asia, and Latin America at national institutes (e.g., ISRA in Senegal, ICTA in Guatemala, etc.), regional institutes (e.g., CATIE in Costa Rica, GERDAT in France--which serves Francophone countries in Africa, etc.), and international institutes (e.g., IRRI, ICRISAT, ICARDA, IITA, CIAT, etc.)

There are two basic types of FSR programs--"upstream" and "downstream" (Technical Advisory Committee, 1978). Upstream FSR uses research from experiment stations to find prototype solutions to the major constraints on agricultural improvement in a relatively large region or area (e.g., the semi-arid tropics). Downstream farming systems research is a farm level research approach whereby farmers and a multi-disciplinary research team work together to diagnose, design, modify and improve farming systems in a local area. Downstream FSR uses information from upstream FSR, experiment stations and commodity research programs in order to design improve-

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[1]The use of the FSR approach for improving rural development strategies is currently being tested by Michigan State University in the Eastern ORD of Upper Volta.

ments in particular farming systems, but only after the constraints of that system have been analyzed. The schematic framework in Figure 2 outlines the downstream or farm level FSR approach at various institutions. Upstream and downstream farming systems research are mutually supporting and reinforcing. Also, FSR is a complement to rather than a substitute for commodity research programs.

The following should be taken into account in carrying out farming systems research:

(a) There are four successive research stages: descriptive (diagnostic), design, testing and extension.[1] The descriptive stage identifies the constraints and flexibility in the current farming systems. Based on interviews with farmers, this information is used to design, test and extend programs for improving farming systems. These programs are then assessed by applying evaluation criteria derived from farmer interviews.

(b) Because the farm household is central to the research process, the farming system research approach could aptly be called farmer's system research (Gotsch, 1977). This concept emphasizes the important role that a farmer's knowledge, derived from experience (Swift, 1978) and traditional experimentation (Johnson, 1972; Jodha et al., 1977; Vermeer, 1979), can play in improving his farming system. Moreover, the farmer's involvement in the research process increases the possibility that improved systems will address farm level problems. Ultimately, a new system arises which combines the best of the system he already uses with the results of the research process (Harwood and Price, 1976). Thus, many changes envisioned in FSR involve small adjustments rather that complete changes in the system. The role of the farmer is maximized and reality in the research process is ensured

[1]These stages were specified at a seminar in Mali on improved agricultural production systems (Institut d'Economie Rurale, 1976). The stages will be discussed in more detail in Gilbert, Norman and Winch, (1980).

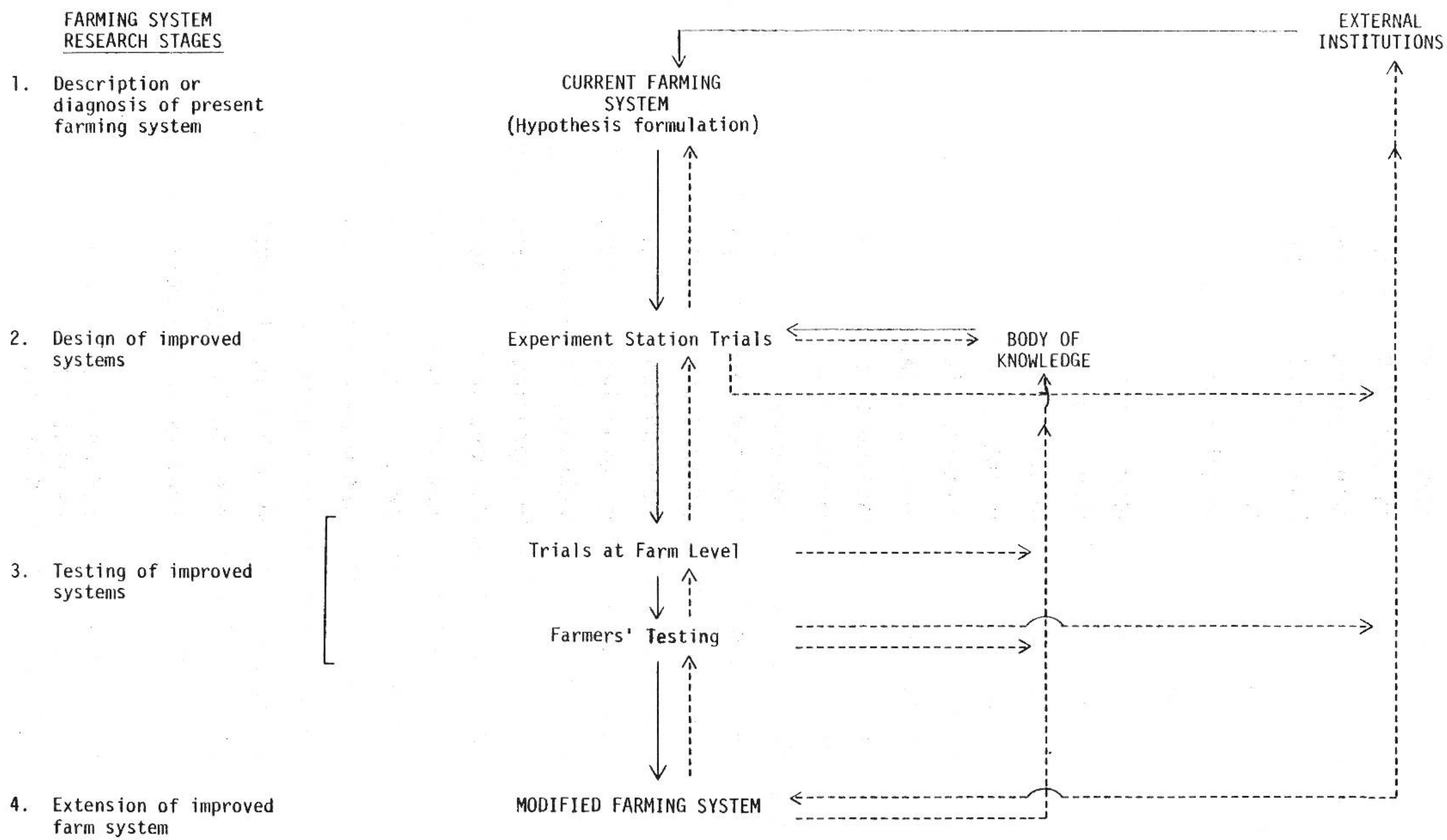

Figure 2 SCHEMATIC FRAMEWORK FOR FARMING SYSTEMS RESEARCH AT THE FARM LEVEL
(Downstream Farming Systems Research)

by minimizing research on experiment station fields and maximizing it on the farmer's fields. Initially, the researcher manages field trials (Figure 2); later the farmer provides this input through farmer testing.[1] And the value of on-farm research can also be enhanced by involving extension personnel.

(c) A multidisciplinary team is required to understand the interaction of the technical and human elements. With the aid of a social scientist who plays an ex ante rather than the traditional ex post role, this team would work in an interdisciplinary manner at the first three stages of the research process and, possibly, at the fourth.

(d) There is recognition of the locational specificity or heterogeneity of the technical, exogenous, and endogenous factors. Disaggregating such heterogeneity into homogenous subgroups and developing improved technologies appropriate to each are central to the farming systems research approach. The disaggregation is done first in terms of ecological systems or differences in the technical element and then, if further disaggregation is necessary, in terms of differences in the human element.[2] Its purpose is to maximize the variance between farm systems in the subgroups and minimize the variance within subgroups; the goal is to produce useful classifications for developing relevant improved technologies and for implementing programs. The most limiting constraints found in the farming systems of each subgroup then become the focal point for developing technologies either to overcome them or to avoid them by exploiting the flexibility that exists in the current farming systems. The pro-

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[1]On-farm research involves an analysis of the actual system instead of simply attempting to simulate actual conditions through models such as unit farms, linear programming, simulation, etc. (Technical Advisory Committee, 1978).

[2]For example, subgroups could be disaggregated by ethnic origin, differing access to the external institutions, size of farm, land per worker ratio, etc.

posed technologies must, however, be compatible with the exogeneous factors.[1]

(e) In evaluating a farming system, researchers must understand the multi-utilization of resources and the rural household as a production and consumption unit, in order to ensure that evaluation criteria will be relevant to the rural household. Returns per man-hour of labor, for instance, may replace the traditional net return per unit of land in land surplus economies.[2]

(f) The research process is recognized as dynamic and interactive and emphasizes linkages between the farmer and research worker.

(g) The FSR approach provides a feedback mechanism for shaping priorities for basic and commodity research programs.

FSR GIVES "VOICE" TO SMALL FARMERS

The priorities of public-financed agricultural research are often based on: (a) expressed needs of more influential farmers, who also may hold influential non-agricultural jobs; (b) types of research which appeal to professional "peer groups"; or (c) the types of technology that have been developed and adopted in high income countries. In contrast, the FSR approach gives the small farmer, often for the first time, a "voice" in tailoring research priorities, both in technology development and evaluation, to his needs. The small farmer becomes the central figure in the

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[1]In developing strategies to overcome the most limiting factor or factors, new technology may not always be necessary; other approaches might be appropriate, such as group action in irrigation, (Binswanger and Ryan, 1977). However, as mentioned in footnote 1, page 5, the FSR approach is currently being tested and has not yet established itself in solving such problems.

[2]The value of a proposed technology will be determined by whether or not it satisfies the relevant evaluation criteria. In general, all proposed technologies must be compatible with the technical element and with exogenous factors (e.g., community structures, norms, beliefs, external institutions such as extension, credit and input distribution system, and markets for products produced, etc.) However, the technical feasibility and social acceptability that this implies is not sufficient. Specific evaluation criteria relating to endogenous factors will tend to be farmer and farming system specific. In general terms, it must be economically feasible, dependable and compatible with the farming system used by the farmer (Norman and Hays, 1979).

research process, particularly at the descriptive and testing stages when dialogue with him is so important. In LDC's to date there has been little communication between the small farmer and the researcher. Ideally communication should be possible via the extension worker, but for a number of reasons this has not often worked.

Small farmers draw on traditional skills and experience in shaping their farming systems. By ignoring these skills, researchers in experiment stations have often cut themselves off from valuable sources of knowledge and wisdom. As a result, considerable time is spent in experiment stations in "rediscovering the wheel" rather than building on knowledge the small farmer already possesses. For example, for many years agricultural scientists, and even officials in ministries of agriculture in LDC's, regarded the traditional practice of growing crops in mixtures as "primitive" and not compatible with "modern" agriculture. Hence mixed cropping was not considered worthy of serious research endeavor. Yet farmers resisted growing crops in sole stands and as the next section indicates, their reluctance is understandable.

EMPIRICAL RESULTS OF FARMING SYSTEMS RESEARCH

FSR has already contributed to the development of improved technological packages for small farmers.

Sole Versus Crop Mixtures

In many parts of the Third World researchers and extension workers have often failed in their attempts to encourage farmers to plant improved crop varieties in sole stands. Why? The results of research on farming systems in northern Nigeria help answer this question (Norman, Pryor and Gibbs, 1979). In this region agriculture is primarily rainfed, with rainfall varying in the areas studied (Table 1) from 752 to 1102 mms. There is marked seasonality in rainfall distribution and the growing season ranges from 150 to 190 days. Hand cultivation systems are the rule. There is also a marked seasonality in the agricultural cycle, with labor demands peaking

TABLE 1

COMPARISON OF SOLE AND MIXED CROPS GROWN BY FARMERS ON RAINFED LAND IN THREE AREAS OF NORTHERN NIGERIA, 1966-68[a]

Variable Specification	Sokoto Area		Zaria Area		Bauchi Area		
Location	13°01'N	5°15'E	11°11'N	7°38'E	10°17'N	9°49'E	
Annual Rainfall (mm)	752		1,115		1,102		
Days in Growing Season	150		190		180		
Percent Cultivated Area Devoted to Sole Crops	9.1		23.0		46.1		
Sole or Crop Mixture	**Sole**	**Mixture**	**Sole**	**Mixture**	**Sole**	**Mixture**	**Average percent change from sole to crop mixtures**
Labor (manhours/ha):							
Annual	425.8	485.6	362.3	586.4	564.9	597.5	27.2
Labor peak period[b]	232.5	237.9	122.3	157.9	247.3	247.3	10.5
Yield (kg/ha):							
Millet	736.4	686.0	--	366.5	727.4	393.4	-26.4
Sorghum	652.3	122.2	785.7	644.5	839.5	728.6	-37.5
Groundnuts	429.3	188.3	587.3	412.5	392.3	217.5	-43.5
Cowpeas	--	56.0	--	132.3	--	51.6	--
Value of production:							
(₦)/ha[c]	31.65	40.80	37.96	61.36	29.50	33.73	34.9
Annual man-hour	0.06	0.12	0.13	0.11	0.08	0.08	28.2
Man-hour put in during peak period	0.13	0.32	0.35	0.42	0.24	0.25	56.8
Net return (₦/ha):							
Labor not valued	30.74	38.94	36.79	59.48	30.74	35.76	34.9
Costing hired labor	28.27	36.13	33.41	54.02	28.64	31.18	32.8
All labor costed	17.96	24.36	18.31	29.60	14.80	18.68	41.2

[a]The weighting system used to derive the figures used for comparison in the table is discussed elsewhere (Norman 1974). Sample size of farmers = 330.

[b]Peak periods were: June - August in Sokoto; June and July in Zaria; and July - September in Bauchi.

[c]One Naira (₦) = $1.50.

during weeding between June and September. In many areas in northern Nigeria a seasonal labor shortage, rather than land, is the major constraint on expanding farm output. Farmers have traditionally grown crops in mixtures of two or more crops together on the same field.

The following results (Table 1) were obtained by comparing sole stands and the more common crop mixtures on farms.

(a) The annual labor input per hectare from crops grown in mixtures was 27% higher than crops grown in sole stands. However, this differential was reduced to 10% when only labor committed during the peak farming period was considered. Labor is truly limiting only at this time.

(b) On farms where crops were grown in mixtures the average yield of individual crops was 26% to 43% lower than yields of sole crops.

(c) When the yields of individual crops were expressed in monetary terms, however, the average value per hectare of crop mixtures was 35% higher than sole stands, indicating that the reduced yield of some crops in crop mixtures was more than offset by yields of other crops in the mixture.

(d) The return from crops grown in mixtures per annual man-hour was 28% higher than from growing crops in sole stands. This return was even greater when labor applied during the bottleneck period of weeding was considered separately: the average increase in return per man-hour was 57% higher for crop mixtures. It appears, therefore, that mixed cropping helps alleviate the labor bottleneck problem. Linear programming studies provide additional empirical support for mixed cropping (Ogunfowora and Norman, 1973).

(e) The level of profitability or net return per hectare also reveals the superiority of crop mixtures over sole crops; it ranged from 32% to 41% higher, depending on how labor was costed. Finally, results given elsewhere (Norman, 1974) indicate that growing crops in mixtures gave a more dependable return, which is very important to farmers pursuing risk aversion strategies.

These research results have demonstrated that mixed cropping in traditional farming systems in northern Nigeria is compatible with both the technical and human elements. Hence, it is not surprising that farmers in northern Nigeria have been reluctant to follow the advice of technical researchers and change to sole crops. Mixed cropping is a rational strategy for farm families faced with a land or labor constraint and high risk associated with uncertain weather.

In the last few years technical scientists in Nigeria and other countries have expressed considerable interest in developing improved technology for mixed cropping. The FSR approach can be helpful in applying the total sum of knowledge about agriculture, including the practices of traditional farming, in developing relevant and improved technology.

Traditional Versus Improved Cotton

Another example from northern Nigeria illustrates the potential advantages of the FSR approach when developing improved technology for small cotton farmers. Traditionally, cotton is planted after food crops have been planted and partially weeded. Researchers at Ahmadu Bello University developed an improved cotton technology package with emphasis on higher yields. This package required not only planting earlier and in sole stands, but also the application of fertilizer and six sprayings with a knapsack sprayer that used 225 litres of water per spray per hectare. The cotton package was developed in the experiment station and, in retrospect, overlooked the human element of small farmers.

The following conclusions were derived from an *ex post* farming systems survey of farmers who used the improved cotton practices over a four year period (Beeden, *et al.*, 1976):

(a) The results in Table 2 indicate that the net return per hectare of improved cotton was considerably higher, except in the drought year (1973), than the returns from traditional cotton.

(b) Yet even though the net returns per hectare of improved cotton were higher, virtually no farmers adopted the improved cotton recommendations in their entirety. Reasons were numerous.

TABLE 2

COMPARISON OF TRADITIONAL AND IMPROVED TECHNOLOGY FOR SOLE CROP COTTON, DAUDAWA VILLAGE, NORTHERN NIGERIA, 1971-1974[a]

				Improved Cotton						Percent Change From Traditional to Improved Cotton					
							Net Return (₦)[b]						Net Return (₦)[b]		
					Man-hours/ha			Man-hours/ha			Man-hours/ha			Per man-hour	
Year	Growing Season (days)	Annual rain-fall (mm)	Price of seed cotton (₦/kg)	Yield (kg/ha)	Annual	June/July	Per ha	Annual	June/July	Yield (kg/ha)	Annual	June/July	Per ha	Annual	June/July
1971	153	968	0.12	666	429	141	31.89	0.07	0.20	177.5	50.5	101.4	90.6	40.0	- 4.8
1972	214	929	0.13	838	496	139	48.87	0.09	0.09	124.1	64.2	124.2	94.0	28.6	-13.9
1973	153	595	0.13	658	375	61	28.03	0.07	0.07	44.9	22.1	103.3	-13.4	-22.3	-57.4
1974	185	1163	0.20	784	422	98	89.96	0.19	0.19	115.4	100.9	71.9	111.3	5.5	22.7
Average	176	914	0.15	736	430	110	49.69	0.11	0.14	115.5	59.4	100.2	70.6	13.0	-13.3

[a] Some operations were undertaken using oxen.

[b] One Naira (₦) = $1.50.

First, the results in Table 2 indicate that the average labor inputs required for growing improved cotton were 59% higher than those for producing traditional cotton. Although the higher yields compensated for higher labor costs and increased the annual return in Naira per total man-hour by 13%, the return per man-hour during the June-July labor bottleneck was 13% less for improved cotton than for the traditional cotton. Second, because the improved cotton had to be planted earlier than traditional cotton (Figure 3), a labor conflict emerged and the farmer had to choose between weeding his food crops or planting the improved cotton. Whereas the cotton researchers had compared traditional and improved cotton yields on research plots, the farmers had analyzed improved cotton as part of their total farming system. The *ex post* farming systems research revealed that the farmers had not compared improved cotton technology with the traditional cotton technology but instead with labor requirements for food crops. Thus, one of the major reasons for rejecting improved cotton was the incompatibility of the new technology with endogenous factors such as family labor bottlenecks and labor availability for food production.

(c) Other reasons for non-adoption related to the difficulty of transporting large amounts of water required for spraying and the lack of adequate extension, fertilizer, etc.[1]

In the light of the above results, obtained through *ex post* farming systems research, it was recommended that plant breeders develop cotton varieties which could be planted later. Even though yields would be potentially lower, the later varieties could be accommodated in a farming system which gives first priority to family food production and second priority to cash crops such as cotton. Also recommended was the replacement of a water-based insecticide with an oil-based one; this would be applied with an ultra low-volume sprayer and its use would decrease labor inputs for carrying water. If a FSR approach had been applied much earlier in

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[1] Recently these deficiencies have been largely overcome as a result of an IBRD integrated agricultural development project in the area.

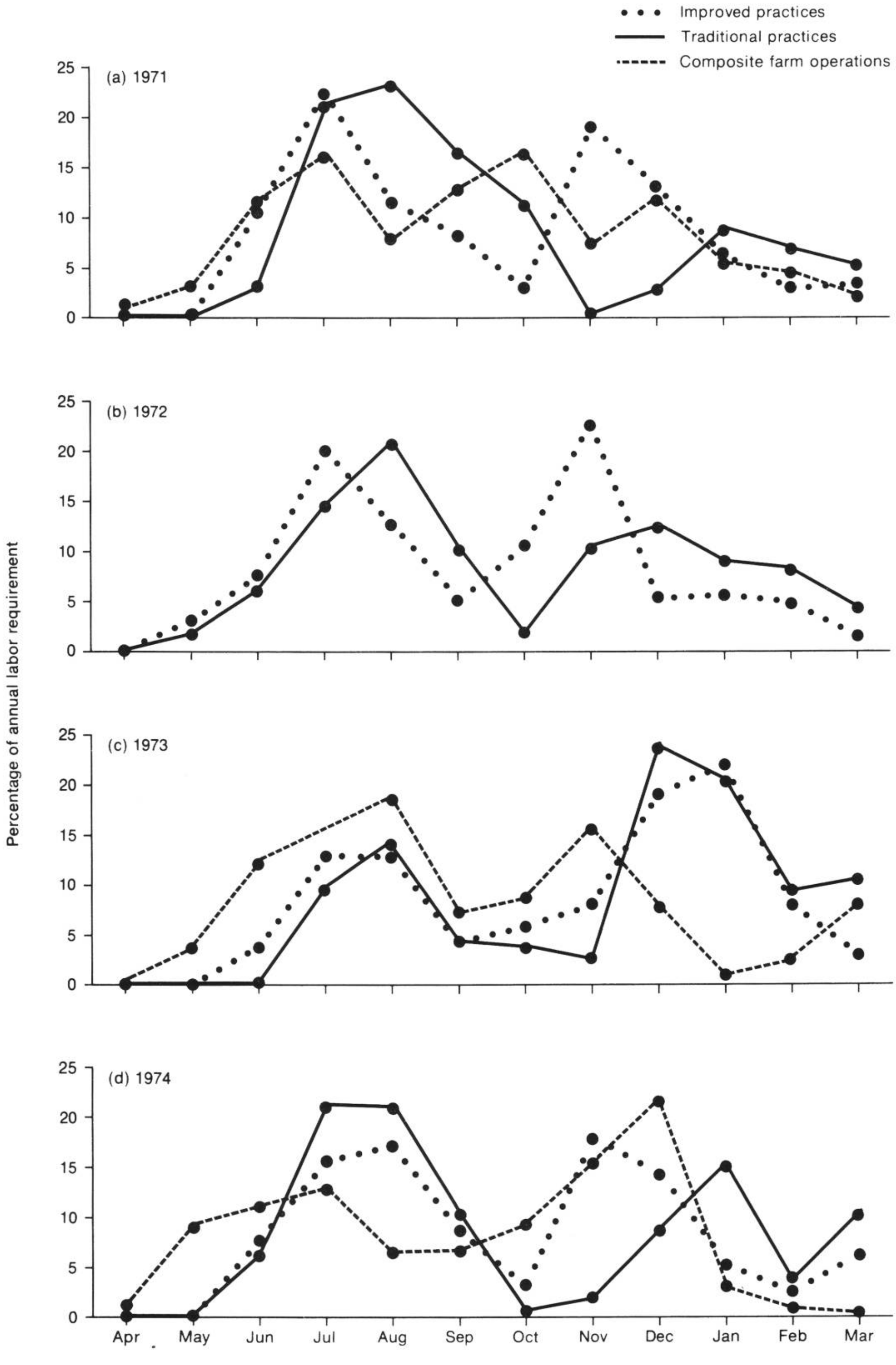

Figure 3 Monthly Labor Distribution of Total Annual Labor Requirement for Cotton, Daudawa Village, Northern Nigeria, 1971-1974

the development of improved cotton packages, the efficiency and the credibility of the research process would no doubt have been increased.

Increasing Cropping Intensity[1]

The development of high-yielding and early-maturing rice varieties has opened up possibilities for increased cropping intensity in land-scarce Southeast Asia. The Cropping Systems Program at the International Rice Research Institute has focused on rice-based cropping systems of small farmers located in rainfed areas. Drawing on the knowledge that exists for facilitating the introduction of additional crops in a crop sequence, researchers are able to select techniques appropriate to the agro-climatic and socio-economic conditions prevalent in areas under investigation. Growing seasons of intermediate length[2] are potentially adaptable for intensified cropping systems. In such production situations, researchers seek to lengthen the effective growing season by a variety of methods, alone or in combination. These include (Zandstra and Carangal, 1978):

(a) The use of shorter duration varieties,

(b) The use of techniques which allow earlier planting at the beginning of the rainy season,

(c) The overlapping of growing periods by relay cropping and intercropping,

(d) The extension of the growing season into the dry season, by using drought-tolerant crops,

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[1] I wish to thank Jim Chapman of Michigan State University for this information.

[2] A growing season of intermediate length is characterized by 5-6 months of rainfall above 200 mm per month plus at least 3 months with rainfall between 100 and 200 mm.

(e) Improving soil moisture utilization,
(f) The use of supplementary irrigation.

An important example of these methods in application is the use of new short duration varieties in combination with direct planting techniques. When IRRI established a Cropping Systems Outreach Site in Iloilo, Philippines in 1975, 82 percent of the rainfed land was planted to a rice-fallow pattern (Table 3). By modifying their existing farm systems to incorporate new technologies, Iloilo farmers have been able to plant upland crops before or after rice and, in lower lying areas, harvest two rice crops in a single season. In the years since 1975, when rainfall patterns are normal, farmers have planted two or more crops on roughly 75 percent of their cropland. For example, Table 3 shows that in 1978-79 farmers planted two or more crops as follows: two or more rice crops, 24 percent; one rice and one or more upland crops, 40 percent; two or more upland crops, 11 percent; or a total of 75 percent. Even in years of low rainfall, such as occurred in 1977-78, cropping intensity still greatly increased over previous levels. This example illustrates how cropping systems research has led to a rapid increase in cropping intensity in the short span of 4 years.

Increasing Small Farmer Income in Guatemala

An example in eastern Guatemala (Hildebrand 1977) demonstrates the potential of the FSR approach for improving small farmer productivity and income. Here, farming systems research revealed that the two controllable factors most responsible for limiting traditional farm production on the steep hillsides were the short planting season and the limited amounts of bean seed available for planting. Traditionally corn, beans, and sorghum were planted simultaneously, and land was not a limiting factor for most farmers in the area. Research indicated that if farmers planted twin or double rows of corn and sorghum and concurrently planted fewer beans (which require the most time to plant), labor productivity would increase because each farmer could plant more land than under the traditional cropping system. That is, with the same amount of planting labor and somewhat less bean seed farmers could plant 40% more land, produce 75% more corn, 40%

TABLE 3

PERCENTAGE OF RAINFED CROPLAND IN VARIOUS CROPPING PATTERNS, ILOILO OUTREACH SITE, PHILIPPINES, 1974-79[a]

Cropping Pattern	1974-1975	1975-1976	1976-1977	1977-1978	1978-1979
Two or more rice crops	5	20	27	16	24
One rice + 1 or more upland	11	28	47	31	40
Two or more upland	2	5	4	10	11
One rice + fallow	82	47	19	41	22
One upland + fallow	-	-	3	2	3

Source: Derived from Genesila, Servano and Price, 1979.

[a]The 1974-75 data represent average results of a 205 farm baseline survey conducted in January 1975. Data from 1975-79 came from a farm record-keeping study of 45 farmers selected randomly from the baseline list.

more sorghum, and the same quantity of beans. Farmers received 33% more income from the revised planting system.

IMPLEMENTING FARM LEVEL FARMING SYSTEMS RESEARCH

While the FSR program approach may lead to a more efficient development of improved technology for the small farmer, numerous problems exist in mobilizing multidisciplinary teams and in implementing the research.

Creating the Proper Working Environment

An efficient FSR program often requires substantial changes in both administrative arrangements and philosophy in agricultural research institutions. For example:

(a) Research programs in agricultural institutes are usually organized along disciplinary lines. Some institutes have moved recently to commodity based research programs, but a FSR program will require changing to an even more holistic approach. Attempts to do this may be frustrated by two other problems:

- (i) The farming system approach requires the integration of livestock and crop production. Research on livestock and crops, however, is often undertaken by different institutions, making integration virtually impossible.
- (ii) A similar problem exists for social scientists (e.g., agricultural economists and sociologists) who are often located in academic institutions which are separate from government agricultural research institutes.

(b) The FSR approach requires a fundamental change in the philosophy and research approach of scientists. The new dimensions are as follows:

- (1) The FSR approach starts at the farm level (descriptive stage) and moves to the experiment station (design stage) and then back to the farm (testing and extension stages). This represents a major change for scientists whose traditional work on the experiment station was only supplemented, perhaps, by research managed trials at the farm level (Figure 2). The inevitable loss of controlled factors in the experimental process (i.e., diminuation of ceteris paribus conditions) can be a frustrating experience!

(ii) The research worker needs to interact with the farmer, the extension worker and the government agencies which influence the external institutions (Figure 2). If his work is to have relevance the researcher must listen and take into account the comments of others when deciding on an approach and research priorities. This will be a fundamental change for some researchers and will require them to be extremely sensitive to the needs of various clientele groups.

(c) Identifying individuals suitable for FSR programs may be a problem. Much of the FSR is now undertaken by individuals trained in and/or originating from high-income countries. Their training has usually been discipline oriented and unintentionally, perhaps, culturally biased. Hence, it is sometimes difficult for such persons to appreciate and understand the local wisdom and values, the complexities of a farmer-household system, the role of non-economic variables, and the potentially significant role to be played by rural sociologists or anthropologists. Researchers must be able to fit in and interact effectively with an interdisciplinary farming systems research team. Currently those with many years of field experience are acquiring such an appreciation--helped sometimes through short courses at regional and international institutions. Less experienced researchers should also be encouraged to pursue research on farming systems and to place emphasis on building local capacity in the less developed countries.

Implementation Problems

Even if a favorable working environment can be created with a FSR program, there are a number of implementation problems:

(a) Presently there is no standard methodology for undertaking FSR. Indeed, the term farming systems research is somewhat of a misnomer. To date most FSR has been confined to crop production processes. Yet even here methodologies for undertaking such work need to be improved. Apart from pleas for its desirability (Boer and Welsch, 1977), the FSR approach has rarely been applied to livestock processes unless these impinge directly on crop processes. There is a need to develop a more holistic systems approach which goes beyond agricultural and livestock production and includes the marketing process and off-farm enterprises (Gilbert, Norman and Winch, 1980).

(b) A time lag inevitably exists from the recognition of a problem to the discovery of a relevant solution and its adoption by farmers. FSR can be time consuming. A farming systems approach is now quite rightly being advocated in places where applied research is not well established and relevant. Funding agencies, however, must recognize that time is required to derive results from FSR. Otherwise problems will arise in maintaining the continuity of the research. Also, FSR results may not be visually spectacular, even though they may be large in the aggregate. Time between recommended solutions and farm adoption might be shortened if the link between FSR and extension is strengthened. Representatives of extension agencies should be integral members of the research team.

(c) Because of the location specificity of farming systems research, it appears to be expensive to execute. Ways must be explored to make results more widely applicable and thereby maximize the return from such research. For example, technological packages need to be developed which can be adopted by a large number of farmers, even through there is some sacrifice of both yields and relevance to the better farmers.

CONCLUSION

The farming systems research approach is consistent with current notions of equity, participation, and employment generation in rural economic development. Because it is largely in the developmental stage, however, the FSR process is not yet established as an efficient way to improve the livelihood of small farmers.[1] As soon as the problems mentioned have been overcome, the FSR approach can be of considerable help to small farmers and can complement commodity and disciplinary research.

Because of the increased concern with "growth with equity" and the increased willingness of agricultural research workers to shed some of their professional, and sometimes cultural, arrogance, the future for helping small farmers in LDC's is promising. To paraphrase the words of a wise Islamic scholar, Alhaji Junaidu (1972), sound development must build upon rather than destroy the farmers' traditional techniques.

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[1]For a survey of the state of the art of farming systems research in the Third World see Gilbert, Norman, and Winch (1980).

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