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STRENGTHENING LINKAGES IN AGRICULTURAL RESEARCH THROUGH A FARMING SYSTEMS PERSPECTIVE: THE ROLE OF SOCIAL SCIENTISTS

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SUMMARY

The principal contribution that the farming systems perspective brings to agricultural research is a farmer and problem-solving orientation. Development of this orientation helps strengthen linkages in national research systems between commodity programmes and between disciplines for both applied and adaptive research. It can also strengthen linkages between research and extension and between research and policy analysis. Issues in strengthening each of these linkages are briefly reviewed with particular emphasis on the socio-economic dimensions and the potential role of social scientists. It is argued that the farming systems perspective in agricultural research should be seen as performing an integrative role in research systems. This can often be developed without significant institutional reorganization.

Derek Byerlee y Robert Tripp: *Reforzando vínculos en la investigación agrícola a través de una perspectiva de sistemas agrícolas: La función de los científicos sociales.*

RESUMEN

El principal aporte que trae la perspectiva de los sistemas agrícolas a la investigación agrícola es una orientación hacia el cultivador y la resolución de problemas. El desarrollo de esta orientación ayuda a reforzar los vínculos dentro de los sistemas nacionales de investigación entre los programas de productos y entre disciplinas para la investigación tanto aplicada como adaptiva. También puede reforzar vínculos entre la investigación y la extension y entre la investigación y el análisis de políticas. Se repasan brevemente los temas en el refuerzo de cada uno de estos vínculos, con énfasis especial en las dimensiones socioeconómicas y la posible función de los cientificos sociales. Se argumenta que la perspectiva de los sistemas agrícolas en la investigación agrícola deben verse como cumpliendo un papel de integración en los sistemas de investigación. Esto a menudo puede ser desarrollado sin una gran reorganización institucional.

INTRODUCTION

In the past decade a number of attempts have been made to define farming systems research (FSR) (Dillon *et al.*, 1978; Gilbert *et al.*, 1980; Byerlee *et al.*, 1982; Simmonds, 1986; Merrill-Sands, 1986; IARC, 1987) but, judging by the continuing debate on the part of research administrators and scientists (CIMMYT and ISNAR, 1984), much uncertainty remains. Part of the problem is that too much attention has been devoted to considering FSR as a type of research when in reality it is an approach or even an attitude to research. Hence, rather than identify FSR as a distinct class of research, we propose to treat it as a perspective in research (IARC, 1987).

The basis of the following discussion of FSR is its role in providing a farmer orientation to agricultural research. The one undeniable common feature of all of the versions of FSR is a concern with the uneven success of agricultural research in reaching the majority of farmers in developing countries. That concern has led to an approach that explicitly recognizes the farmer as the principal client of research. The fact that agricultural research was concerned with clients long before the advent of FSR, and that the basic methods for interacting with farmers and assessing their needs (such as surveys and on-farm experiments) are not novel to FSR, does not imply that FSR is merely old wine in new bottles. If it is successful, the FSR approach can encourage the contributions of a range of institutions, research methods and disciplines in identifying and addressing high priority problems of farmers. A farmer orientation is the basis of the approach, and the better articulated that orientation, the more efficient will be the research.

Developing an explicit farmer orientation in research through strong researcher-farmer linkages usually implies that other linkages within the research system must also be strengthened. Whereas farmers, and especially small farmers in developing countries, often operate complex farming systems reflecting strong interactions among enterprises, most research systems are organized along commodity lines, with weak linkages between commodity programmes. These farming system interactions also reflect a complex mix of biological, physical and socio-economic processes; hence, research oriented to solving farmers' problems will usually be more effective when a multi-disciplinary approach is used. But many research organizations are characterized by disciplinary specialization and the absence of key disciplines such as social science. Finally, farmers' capacity to utilize the results of the research system is also often constrained by weak linkages between research and other organizations and institutions such as those between research and extension, and between research and the broader policy environment.

We propose that a FSR approach is best implemented through a more careful examination of these linkages among existing research activities and institutions. Research leaders can ask which of these linkages most limit the ability of the research system to generate and deliver relevant and useful technology to farmers, and focus efforts accordingly. In some cases, this process may lead to new farm-level research activities to provide a farmer orientation to research. In others, it may lead to emphasis on communication among crop breeding programmes to ensure that varieties are compatible with farmers' multiple cropping systems. In still other cases, an analysis of research linkages may result in greater emphasis on research-extension collaboration to enable farmers to exploit available appropriate technology. *The important point is that the linkages emphasized will be determined by the current organization, resources and managerial capacity of the agricultural research system, the institutional and policy environment and the type of farming systems to which the research is directed.* Depending on these factors, quite different priorities may emerge.

The aim of the first part of this paper is to review briefly the potential of the farming systems perspective in strengthening linkages of the research system that have particular relevance to providing a strong farmer orientation to research. We emphasize the role of social science in identifying those linkages. Within this framework, the second part of the paper focusses more specifically on the place of social science as a discipline within the research organization, and its relation to the farming systems perspective.

PART I - STRENGTHENING RESEARCH LINKAGES

Researcher-farmer linkages

Most activities that are described as FSR have been devoted to methods of improving communications between researchers and farmers as a basis for developing technologies appropriate to farmers. These methods are extensively discussed in the literature (e.g. Simmonds, 1986; Zandstra *et al.*, 1981; Byerlee *et al.*, 1980; Gilbert *et al.*, 1980; Collinson, 1987) and will not be reviewed here. For the purpose of this paper, we simply note two of the main characteristics of these research methods: first, they are part of a systematic research process centred on diagnosis and experimentation (i.e. identifying farmers' problems, considering solutions to those problems that are compatible with the farming system, and testing promising solutions) and, second, the research is conducted at the farm level with the active participation of farmers.

The development of FSR has made a significant contribution to the advancement of these research methods. The literature on survey techniques, research planning, and experimental design and analysis has been a subject of debate, refinement, and real progress. Although the notion of a client orientation to research is common sense, developing efficient research methods for achieving that orientation is often quite difficult. Farmer surveys or on-farm experiments may seem quite straightforward, but imperfections in their logic and coordination continue to be the cause of wasted resources in many research programmes. Most researchers would say that their work is client-oriented, but relatively few are able to present a systematic strategy of information gathering and analysis based on a careful definition of a clientele and its needs.

Progress in research methods has not been matched by the development of mechanisms by which farmers are able to participate in the research process. Although the FSR literature urges farmer participation, there are few successes in this area (Chambers and Jiggins, 1986) and 'the rhetoric of intent' (Cernea, 1985, p. 10) far surpasses the availability of practical guidance on developing farmer input to research. Some good advice exists (e.g. Kirkby and Matlon, 1984) but more work needs to be done. Many FSR programmes in developing countries have been implemented from the 'top down', often with donor support, and have neither tackled the difficult institutional issues of providing incentives to researchers for problem-solving and client-oriented research, nor developed mechanisms for farmers themselves to pressure research and extension systems to service their needs.

Although a number of efforts in FSR have made a major contribution to strengthening researcher-farmer linkages, there has been a tendency to polarize research between on-farm and on-station research. This places too much attention on the location of research, rather than on its purpose. In this paper, we distinguish between applied research aimed at generating new technological components (e.g. plant breeding for a new variety) and adaptive research aimed at generating information to tailor available technology to specific locations and groups of farmers (e.g. a recommendation on the time, method and dose for fertilizer application). Although most applied research must be conducted on experiment stations (to provide adequate control) and most adaptive research should be carried out in farmers' fields (to be relevant to farmers), the farming systems perspective should be an integral part of *both* applied and adaptive research. For example, diagnosis to analyse factors limiting productivity at the farm level for specific groups of farmers is as important to a plant breeding programme as to an adaptive research programme. Typically, too little emphasis is placed on farm-level diagnostic activities for applied research programmes. Where applied and adaptive researchers work together on the same on-farm research activities, the prospects for effective linkages between their research programmes is enhanced.

More important than the location of research is the appropriate balance between applied and adaptive research. Adaptive research has its highest returns when there is a back-log of technologies 'on the shelf' that need to be adapted to the circumstances of local farmers (e.g. Martinez and Arauz, 1984; Moscardi *et al.*, 1983). Although FSR is often considered to be most useful for small farmers in marginal environments, we believe that the returns to farmer-oriented adaptive research are potentially very high in post-green-revolution agriculture (i.e. where new wheat and rice varieties have been adopted) because of the increasing complexity of management and information needs of farmers in such systems (Byerlee, 1987). But in some cases, where there is little available technology to be adapted, the introduction of an FSR programme may have led to an over-emphasis on adaptive research when the real need was for a careful diagnosis of farmers' circumstances as a basis for orienting applied research.

Inter-commodity linkages

During the 1960s and 1970s many agricultural research systems were reorganized from disciplinary units into commodity programmes, often with a national crop coordinator and commodity-oriented research stations. A major impetus for FSR has come from the fact that individual commodity research programmes were not addressing the reality of complex farming systems. To complement and, in some cases, substitute for single-commodity research programmes, there has been a major push for research organized on the basis of farming systems and involving several commodities. However, research administrators are offered few guidelines on how to translate this into practice, or indeed when and how much multi-commodity research is needed.

Interactions between commodities in a farming system can conveniently be

Table 1. *Classification of farming system interactions*

	Examples
1 *Direct interaction between crops*	
(a) Interactions in space	(i) Interactions due to intercropping
(b) Interactions over time	(i) Conflicts in planting crop in relation to harvest of previous crop
	(ii) Carry-over of soil structure and crop residues from preceding crop
	(iii) Carry-over fertility from previous crops
	(iv) Carry-over and build-up of weed seeds and other pest populations from previous crops
2 *Interactions between crops and livestock*	(i) Use of crops and crop residues for fodder
	(ii) Use of farmyard manure as crop nutrient source
	(iii) Use of animals for draught power
3 *Resource competition and complementarity*	(i) Conflicts in labour use and cash needs between enterprises including non-farm enterprises
	(ii) Competition for irrigation water between enterprises
4 *Meeting multiple objectives of farm households*	(i) Choice of multiple crops, livestock and production practices to manage risk
	(ii) Planting and storage of food crops to balance seasonal food needs and off-farm work to provide seasonal cash needs

classified as shown in Table 1. They include biological and socio-economic interactions between commodities at a particular point in time and interactions that occur over time due to crop rotation and cropping sequences. A social science analysis helps identify the importance of the various interactions in different farming systems.

In rainfed environments with short growing seasons, interactions are usually characterized by biological competition between intercrops and competition for resources (e.g. land, labour) between crops grown at the same time. This competition is made more complex by socioeconomic factors such as farmers' multiple responsibilities towards their families and their communities, the necessity of maintaining a seasonal supply of food and cash, and concern with the risks of crop failure.

In irrigated farming systems or in rainfed areas with long growing seasons, on the other hand, the strongest interactions often occur over time, as a result of multiple cropping sequences. Often, one crop is so dominant in a particular season that interactions between crops within a season are unimportant. This situation results in dominant cropping patterns in which important interactions arise over time as a result of conflicting harvesting and planting dates and carry-over of crop residues, fertility and pests from one crop to the next.

The importance of crop-livestock interactions is highly system-dependent (McIntire and Gryseels, 1987) but is usually greater in harsher environments with long dry seasons or long winters that place severe pressure on managing seasonal fodder supplies, or in areas where farm size is very small and intensive management is required. The integration of livestock into the farming system often engenders compromises in the choice of crops and in crop management practices (Cornick and Kirkby, 1981).

The importance of farming system interactions as a focus for research is determined in large part by the socio-economic environment. In subsistence-oriented agriculture, the management of household labour and other resources, combined with the necessity for supplying most of the household's food and other needs from the farm, sometimes leads to exceptionally complex interactions which need to be considered by agricultural research programmes. As farmers are integrated into the market economy, many farming system interactions become less constraining. For example, mechanization and market specialization may reduce reliance on intercropping, the use of chemical fertilizers partly substitutes for traditional methods of fertility maintenance, seasonal food needs and fodder constraints may be met through purchases, and tractor power substitutes for draught power.

Given these differences among farming systems, the extent to which a research programme needs a multi-commodity focus will vary substantially. As a general rule, *diagnostic surveys should include representatives of commodity research programmes for the major enterprises in the target system, social scientists, and representatives of other relevant disciplines.* This diagnostic exercise by a multi-commodity, multi-disciplinary team is a low-cost method of establishing communication and a common understanding of the farming system among commodity programmes and disciplines, as well as a means of setting research priorities within and between commodities.

In contrast to multi-commodity diagnosis, multi-commodity experimentation (i.e. intercropping, multiple-cropping and joint crop-livestock experiments) is much more complex, difficult to coordinate and expensive. Hence, experimental programmes involving two or more commodities need to be carefully justified. Where system interactions can easily be converted into economic terms, there is less need for multi-commodity experimentation although close coordination among commodity programmes may still be required. As an example, wheat is commonly planted late in the southern Punjab of Pakistan because of prolonged harvesting of cotton. Much of the research for this system (e.g. wheat varieties for late planting or earlier cotton varieties) can be conducted without running complex cotton-wheat experiments although wheat and cotton researchers must closely coordinate research on varietal development and monitor changes in the management of the other crop in the sequence (Byerleee *et al.*, 1987).

Many interactions cannot be reduced to economic terms, however, even in commercialized agriculture. Where biological effects from one crop to successive crops are important, some type of multi-commodity experimentation will be needed. For example, in the rice-wheat cropping systems of Asia, strong physical and biological interactions occur between rice and wheat when they are grown in the same rotation, due to effects on soil structure, crop residues and pest populations (Hobbs *et al.*, 1987). Here a well coordinated rice-wheat experimental programme is needed.

Intercropping experiments may be easier to manage than long-term rotation experiments but the potential number of combinations of crops, plant densities and plant arrangements is often huge. The exact choice of intercropping pattern and management is often determined by the types of land and labour available to the farmer, household food needs and preferences, and marketing conditions for the various crops. In this situation, deriving biologically optimal plant densities and arrangements may be irrelevant if these complex socio-economic decision criteria are not well understood beforehand.

In the case of crop-livestock interactions, a commitment to joint crop-livestock experimentation will also depend on the socio-economic characteristics of the particular system. For example, in areas with well-developed markets for fodder, changes in crop technologies and cropping patterns that affect fodder production can usually be readily evaluated in economic terms. On the other hand in isolated areas that approximate closed economies (e.g. some mountain environments), it may be necessary to conduct integrated crop-livestock experiments in which fodder crops and crop residues are fed to livestock to record farmers' assessment of the effect on output of livestock products.

Clearly the need to strengthen links between specific commodity research programmes depends on the predominant type of interaction in a particular farming system. Our emphasis is, however, on strengthening the capacities of existing commodity research teams and developing appropriate linkages between them, rather than submerging them in some systems-oriented research unit. *Commodity-specific expertise is an important resource for both applied and adaptive research.* In our judgement, much FSR research in recent years has been weakened by over-emphasis on establishing a separate identity through research on whole farming systems which is conducted in isolation from established commodity and disciplinary programmes.

Even in situations in which there is an overriding system constraint such as soil moisture conservation or fodder for draught animals, commodity-oriented research can often accomplish the equivalent of resource-oriented research. If the research for a major commodity in the system is farmer-oriented and uses a systems perspective, it will sooner or later be forced to grapple with resource-based constraints. For example, the cropping systems network in Asia is dominated by rice scientists, but has taken the lead in seeking opportunities for increased cropping intensity and improved crop rotations in rice-based farming systems (IRRI, 1986).

Collaboration among commodity programmes in diagnostic activities should be taken as a bare minimum for establishing effective inter-commodity linkages. An assessment of the socio-economic environment of the particular farming system during these activities is one of the key factors in determining the nature and coordination of further multi-commodity research activities and in developing compatible recommendations for several commodities being produced in a system.

Linkages with policy and extension

The basic argument of this paper is that an explicit, well-defined client orientation makes an important contribution to the efficiency of agricultural research. But this argument begs the question of how to identify the clients.

In theory, national policy goals towards particular crops, regions, and types of farmer are translated to research and extension organizations, who then incorporate those goals in setting their priorities. In practice, however, this linkage between national policy and research and extension is rarely well articulated.

Linkages between research and policy can also be improved by encouraging feedback from the research system to those who formulate policy. An agricultural research system with a strong farmer orientation can provide at least two important types of information not readily available to policy makers: (a) technical information related to physical and biological responses under farmer conditions, and (b) information on institutional constraints to effective use of appropriate technology at the farm level. Technical information is often underutilized by policy makers in taking decisions concerning production inputs. For example, the analysis of fertilizer subsidy policies in many countries has employed macro-level data despite the fact that thousands of fertilizer experiments may have been conducted in farmers' fields and considerable survey data on farmers' use of fertilizer are available.

Social scientists using a farming systems perspective are also in an excellent position to identify institutional constraints at the farm level that impinge on the adoption of technology and efficient use of existing technology. These institutional constraints frequently revolve around the performance of input marketing, credit, extension or water supply systems. They often reflect inadequate knowledge by policy makers and the private sector of technical and economic parameters in crop and livestock production at the farm level. For example, the presentation of results of on-farm experiments and surveys to policy makers and input suppliers has led to changes at the local level in credit policy in Panama (Martinez and Arauz, 1984) and has pointed the way to reforms in fertilizer marketing in Haiti (Yates *et al.*, 1987) and Mexico (Pagliettini, 1986). These experiences suggest that there is much scope for social scientists to improve the flow of information from the national agricultural research system to key decision makers in the public and private sector to help accelerate the pace of adoption of technology.

Extension is often pictured as the intermediary between the research system and the farmer. Information from research is passed to extension for transfer to farmers, and farmers' problems are fed back by extension to help shape research priorities. In practice, the first linkage is usually not well developed and the second is almost non-existent. Although on-farm problem-solving research offers an opportunity for rectifying this situation, there is much that remains to be done.

An important feature of the research-extension linkage is that extension, unlike research, is often organized on an area-specific basis. Area-specificity offers the potential for sustained contact with farmers, which the research organization may lack, but the boundaries of the extension service are usually political rather than coincident with the limits of particular farming systems.

The farming systems perspective helps to resolve this dilemma by organizing adaptive research and extension around recommendation domains (Harrington and Tripp, 1984), relatively homogeneous groups of farmers who share similar production circumstances and problems and who are potentially eligible for the same recommendations. Recommendation domains define targets for research that are at the same time compatible with the organization of extension.

PART II - INTER-DISCIPLINARY LINKAGES - SOCIAL SCIENTISTS AND THE FARMING SYSTEMS PERSPECTIVE

The farming systems perspective in research requires the integration of the physical, biological and socio-economic dimensions that influence farmers' acceptance of new technology. Social scientists (i.e. economists, sociologists, anthropologists and communication specialists) have an important role in analysing the socio-economic dimensions of technology use and incorporating them into research design. In addition, more so than the physical and biological sciences, social science tends to be integrative and holistic. Hence, social scientists can contribute by synthesizing information from different disciplines and commodity programmes and from multiple sources (surveys, experiments, secondary data, etc.) in designing research and formulating farmer recommendations.

Despite this potential, many national research programmes are only now beginning to build a social science capacity. Because social scientists are new to the scene, administrators often do not appreciate their roles, and may simply assign them 'statistical chores'. If left to themselves, the most likely result is an isolated group of social scientists with a research programme organized along traditional disciplinary lines.

The role of social scientists

Table 2 provides a framework for viewing the possible roles of social scientists in an agricultural research organization. The *ex post* role is easiest for technical scientists and research administrators to appreciate. Economists analyse experimental data to ensure that research recommendations are economically sound for farmers. Social scientists may also monitor the adoption of technological recommendations to document pay-offs to research or to understand socio-economic or policy-induced constraints to the acceptance of research recommendations.

However, useful recommendations for farmers can only be derived if the initial selection of research priorities and the design and implementation of the experimental programme are relevant to farmers; hence, the most important contribution of the social scientist is *ex ante* in the design and planning stages of research, especially through participation in diagnostic surveys at the farm level. In this role, social scientists are able to provide skills in interviewing and

Table 2. *Relevant research activities for social scientists in research with a farming systems perspective*

Point at which social scientist enters research process		Research activity	Major user of research results
Ex ante	1	Understanding and analysing factors limiting productivity at the farm level and helping to select solutions to these factors which will be relevant to local farmers	Technical scientist
	2	Macro-level information and analysis to define research policy, improve research resource allocation and identify target farmers	Research administrators and policy makers
Ex post	1	Economic analysis of experimental data in order to derive recommendations for farmers	Technical scientist, extension and farmers
	2	Monitoring the adoption of technological recommendations	Technical scientists and research administrators
	3	Analysis of institutional and policy-induced constraints at the farm level on technology adoption (e.g. input supply)	Policy makers

observation, insights into the socio-economic dimensions of farmers' decision-making, and an integrative systems perspective which goes beyond particular commodities or production factors.

The explicit inclusion of a diagnostic stage in research planning, especially informal surveys by multi-disciplinary teams, provides the opportunity for social scientists to play an *ex ante* role in technology development. Nonetheless, the movement from *ex post* participation to a truly *ex ante* role is not easy. Even in well-developed research systems, the social scientists' *ex ante* role is often tenuous (Remenyi and Coxhead, 1986). The fact that most social scientists in national programmes are newcomers to the research system and lack the experience and seniority of the established disciplines has slowed progress. Despite this, successful examples of social scientists' contributions to technology generation are documented by Horton (1984), Matlon *et al.* (1984) and Moscardi *et al.* (1983).

But over-emphasizing the key role of social science in a farming systems approach to research can be harmful. FSR is often seen as 'a social scientist's invention' (Chambers and Jiggins, 1986, p. 11) and there is a tendency to equate FSR with the social science component of agricultural research. The two are not synonymous. Although in diagnostic techniques, such as formal farm surveys, social scientists will probably take the lead, biological scientists have much to offer in suggesting ways for learning about farmers' problems and priorities. Nor should social scientists be viewed as the only researchers responsible for contact with farmers. Applied researchers such as plant breeders, for instance, need direct contact with farmers and their fields both to observe the performance of promising varieties under farmer management and to understand farmers' criteria for varietal selection.

Social scientists in national research systems face the challenge of dividing their efforts between diagnostic activities aimed at improving the efficiency of technology generation and policy-related work concerning constraints to technology adoption. This situation poses a dilemma for social scientists in allocating their resources. To what extent should the policy and institutional environment be taken as given when designing research programmes or alternatively, regarded as variable and subject to manipulation by the results of social science investigation? FSR has tended to take a conservative stance that assumes the policy and institutional environment is given. This assumption sometimes imposes severe restrictions on the type of technology that can be developed. We believe that social scientists should become more active in providing information and analysis to stimulate changes in the policy and institutional environment in order to promote the efficient use of appropriate technology.

The role of social scientists described above applies to both agricultural economists and researchers in other social science disciplines such as rural sociology and anthropology. Few research organizations have the luxury of defining distinct roles for each, and functions will necessarily overlap a great deal. Similarly, there is often considerable blurring of the roles of technical and social scientists in diagnosis, planning and analysis tasks in FSR. Just as over-specialization in technical fields may be counterproductive for an agricultural research system, so may rigid boundaries between the different social sciences serve little purpose in agricultural research. Given the complexity of human behaviour and the limitations of disciplinary models (Hirschman, 1984), a broader approach to understanding farmers' production decisions is advisable.

Each of the social sciences, however, will contribute different skills and approaches to data collection and analysis. Anthropologists and rural sociologists can make specific contributions which are not always recognized (e.g. by Simmonds, 1985, p. 51). With respect to diagnostic skills, the use of unstructured interviews and participant observation are already an important part of FSR, and are useful well beyond an initial diagnosis (Tripp, 1985). The implementation of location-specific adaptive research programmes requires an understanding of local social and political organization, and some thought about the interface with extension (Sutherland, 1986). In addition, new technologies may imply changes in community organization and patterns of cooperation among farmers which requre careful analysis (Goodell, 1984).

Implications for social scientists

If social scientists are to play an effective role in agricultural research organizations generally, and more specifically, in implementing a farming systems perspective, several lessons can be learned from experiences over the past decade. First, social science research methods need to be flexible, relatively simple, well focussed and rapid. The use of long and tedious baseline questionnaires to obtain information about all aspects of the system - and the consequent long delays (often several years) in data analysis - is a problem frequently experienced in social science research. Effective participation in diagnostic activities requires timely results for planning experiments, and informal and well-focussed formal surveys are best suited to meet that need. Likewise elaborate whole-farm modelling is usually a luxury that delays results and is often not well understood by technical scientists.

Effective participation of social scientists in a multi-disciplinary setting also requires that they have a working knowledge of such technical disciplines as weed science, soil fertility and plant breeding. Much of this technical expertise is quite specific and can be gained through continuing on-the-job experience. Hence, social scientists should have a well-focussed research agenda that enables them to build up technical expertise on a particular commodity or system over time, rather than an *ad hoc* project-by-project approach to research. Participation by social scientists in on-farm experiments is a particularly valuable way of building up technical expertise as well as continuing the diagnostic process through frequent contact with collaborating farmers.

Multi-disciplinary collaboration depends in large part on establishing good personal relationships with fellow scientists. These relationships take time to develop, which again points to the need for specialization and continuity of social scientists in a particular commodity or area-based research programme. Multi-disciplinary collaboration is also better developed informally in the field rather than in formal meetings. Joint inverviews with farmers and observations in their fields help establish a common understanding of farmers' problems and needs. Informal diagnostic surveys and monitoring tours of on-farm experiments are particularly valuable ways of enhancing multi-disciplinary communications and collaboration.

Cooperation across disciplines does not imply the elimination of disciplinary boundaries, but rather a pragmatic, problem-oriented coordination of activities (Maxwell, 1986). Social scientists in a research programme should have strong leadership and well-defined priorities, rather than try to do a little bit of everything. If social scientists are placed under a separate unit, it should not be equated with a 'Farming Systems' unit. The contribution of social scientists in such a unit to a farming systems perspective in the research system will emerge only if there is strong institutional coordination of the unit with other disciplinary and commodity programmes.

CONCLUSIONS

We have emphasized that the perspective represented by farming systems research is of most value if it is seen as performing an integrative function. It can serve to strengthen the linkages between various parts of the research system; linkages between researchers and farmers, extension workers and policy makers; and linkages between researchers from different commodity and disciplinary reseach programmes.

To focus on these linkages is not to say that FSR is ephemeral. FSR has provided some new perspectives on research and many improved methods. And the basis of this contribution is an integrated, systematic way of setting research priorities and evaluating research products in terms of farmers' requirements.

Hence we do not agree with Heinemann and Biggs (1985) when they suggest that methodological contributions of FSR have been overemphasized, but we strongly endorse their warning that organizations and methods are two separate concerns. A recent review of the failures of adaptive research in developing countries cites both 'ambiguities in the assigning of responsibility for adaptive research among research, extension, and area development staff, and methodological uncertainties concerning the conduct of adaptive research' (World Bank, 1985, p. 3). But the same report suggests conducting 'commodity research when appropriate and farming-systems or problem-oriented research when needed' (p. 52). We would suggest that this treatment of farming systems research as something apart from and opposed to commodity research is at the root of the confusion over organization and method. If the problem is one of integration, the solution is not to create a new and separate FSR unit but rather to strengthen existing programmes and the linkages between them.

If the farming systems perspective is to be adopted, there will have to be some changes in agricultural research organizations, however. This paper does not pretend to suggest what those might be, but it does urge that the decision be based on a consideration of existing linkages in the research system. An identification of the key linkages, combined with an analysis of the research priorities of the farming system(s) under study, and the resources available to the research institution, will help determine appropriate institutional forms. Research priorities may dictate some coordination between commodity research programmes (Stoop, 1986). Neither commodity chauvinism nor the loss of identity in a farming systems unit are acceptable alternatives where specialized commodity knowledge needs to be brought to bear on the challenge of increasing the productivity of complex farming systems. The assignment of area-specific responsibilities may be considered to help focus research and improve linkages with extension. Multi-disciplinary working groups, either permanent or *ad hoc*, may need to be formed. And to the extent possible, researchers should have the opportunity to participate in both on-farm and on-station activities (Biggs, 1983).

We have said that social science has much to offer conceptually and methodologically in strengthening research linkages, and that social science itself should be looked upon as an important discipline, participating in the activities of the research organization. Social scientists can play a key role in developing the farmer focus in research. But a farmer focus is not exclusive to social science, and unless national research organizations as a whole are committed to this approach, they will not be able to take full advantage of the potential contribution of social scientists.

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REFERENCES

Biggs, S. D. (1983). Monitoring and control in agricultural research systems: maize in northern India. *Research Policy* 12:37-59.

Byerlee, D. (1987). *Maintaining the Momentum in Post Green Revolution Agriculture: A Micro-level Perspective from Asia.* International Development Paper No. 10. East Lansing, Michigan: Michigan State University.

Byerlee, D., *et al.* (1980). *Planning Technologies Appropriate to Farmers: Concepts and Procedures.* El Batan, Mexico: CIMMYT.

Byerlee, D., L. Harrington, L. & Winkelmann, D. (1982). Farming Systems Research: issues in research strategy and technology design. *American Journal of Agricultural Economics* 64:847-904.

Byerlee, D., Akhtar, R. & Hobbs, P. (1987). Reconciling conflicts in sequential double cropping systems through plant breeding; the example of cotton and wheat in Pakistan's Punjab. *Agricultural Systems* 24:291-304.

Cernea, M. (1985). Sociological knowledge for development projects. In *Putting People First: Sociological Variables in Rural Development*, 3-21 (Ed. M. Cernea). New York: Oxford University Press.

Chambers, R. & Jiggins, J. (1986). *Agricultural Research For Resource Poor Farmers: a Parsimonious Paradigm.* Institute of Development Studies Discussion Paper 220. Brighton, UK: University of Sussex.

CIMMYT & ISNAR (1984). *Issues in Organization and Management of Research with a Farming Systems Perspective Aimed at Technology Generation* (Ed. M. J. Chang). The Hague, Netherlands: CIMMYT and ISNAR.

Collinson, M. P. (1987). Farming Systems Research: procedures for technology development. *Experimental Agriculture* 23:365-86.

Cornick, T. & Kirkby, R. (1981). *Interactions of Crops and Livestock Production in the Generation of Technology in Sloped Areas.* Cornell International Agriculture Mimeograph 90. Ithaca, New York: Cornell University.

Dillon, J. L., Plucknett, D. L. & Vallaeys, G. S. (1978). *Farming Systems Research in the International Agricultural Research Centers.* Rome, Italy: Technical Advisory Committee to the Consultative Group on International Agricultural Research.

Gilbert, E. H., Norman, D. W. & Winch, F. E. (1980). *Farming Systems Research: A Critical Appraisal.* Rural Development Paper, 6. East Lansing, Michigan: Michigan State University.

Goodell, G. E. (1984). Bugs, bunds, banks and bottlenecks: organizational contradiction in the new rice technology. *Economic Development and Cultural Change* 33:23-41.

Harrington, L. & Tripp, R. (1984). *Recommendation Domains: A Framework for On-Farm Research.* CIMMYT Economics Working Paper 02/84. El Batan, Mexico: CIMMYT.

Heinemann, E. & Biggs, S. D. (1985). Farming Systems Research: an evolutionary approach to implementation. *Journal of Agricultural Economics* 36:59-65.

Hirschman, A. (1984). Against parsimony: three easy ways of complicating some categories of economic discourse. *American Economic Review* 74:89-96.

Hobbs, P., Mann, C. & Butler, L. (1987). A Perspective on Research Needs for the Rice-Wheat Rotation. Paper presented at the Conference on Wheat Production Constraints in Tropical Environments, Chang Mai, Thailand, Jan. 12-23, 1987.

Horton, D. (1984). *Social Scientists in Agricultural Research: Lessons from the Mantaro Valley Project, Peru.* Ottawa: International Development Research Centre.

IARC (International Agricultural Research Centers) (1987). *Proceedings of the Workshop on Farming Systems Research.* India: Patancheru, A.P.: International Crops Research Institute for the Semi-Arid Tropics.

IRRI (1986). The Cropping Systems Research Program of the International Rice Research Institute. Paper presented at the Intercenter Workshop on Farming Systems Research, ICRISAT, Hyderabad, India, February, 1986.

Kirkby, R. & Matlon, P. (1984). Conclusions. In *Coming Full Circle: Farmers' Participation in the Development of Technology.* Ottawa: International Development Research Centre.

Martinez, J. C. & Arauz, J. R. (1984). Developing appropriate technologies through on-farm research: the lessons from Caisan, Panama. *Agricultural Administration* 17:93-114.

Matlon, P., Cantrell, R., King, D. & Benoit-Cattin, M. (1984). *Coming Full Circle: Farmers' Participation in the Development of Technology.* Ottawa: International Development Research Centre.

Maxwell, S. (1986). The social scientist in farming systems research. *Journal of Agricultural Economics* 37:25-35.

McIntire, J. & Gryseels, G. (1987). Crop-livestock interactions in sub-Saharan Africa and their implications for Farming Systems Research. *Experimental Agriculture* 23:235-243.

Merrill-Sands, D. (1986). Farming Systems Research: clarification of terms and concepts. *Experimental Agriculture* 22:87-104.

Moscardi, E., Cardoso, V., Espinosa, P., Soliz, R. & Zambrano, E. (1983). *Creating an On-Farm Research Program in Ecuador.* Economics Working Paper 01/83. El Batan, Mexico: CIMMYT.

Pagliettini, L. (1986). Orientacion de Decisiones de Politica Agricola con Datos Generados en Campos de Agricultores: El Caso de Los Fertilizantes Nitrogenados en La Fraylesca, Chiapas, Mexico. MSc Thesis, Colegio de Postgraduados, Chapingo, Mexico.

Remenyi, J. V. & Coxhead, I. A., (1986). A survey of Farming Systems Research in Australia. *Journal of the Australian Institute of Agricultural Science* 52:135-143.

Simmonds, N. W. (1985). *Farming Systems Research. A Review.* World Bank Technical Paper No. 43. Washington, DC: World Bank.

Simmonds, N. W. (1986). A short review of Farming Systems Research in the tropics. *Experimental Agriculture* 22:1-13.

Stoop, W. (1986). Organization and Managerial Implications of a 'Farming Systems Approach' for NARS. Paper presented at the Intercenter Workshop on Farming Systems Research, ICRISAT, Hyderabad, India, February 1986.

Sutherland, A. (1986). *Extension Workers, Small-Scale Farmers, and Agricultural Research: A Case Study in Kabwe Rural, Central Province, Zambia.* Agricultural Administration Network Discussion Paper 15. London: Overseas Development Institute.

Tripp, R. (1985). Anthropology and on-farm research. *Human Organization* 44:114-124.

World Bank (1985). *Agricultural Research and Extension: An Evaluation of the World Bank's Experience.* Washington, DC: World Bank.

Yates, M., Martinez, J. C. & Sain, G. (1987). Fertilizer Provision in Les Cayes, Haiti: Addressing Market Imperfections with Farm-Based Policy Research. Draft Paper, CIMMYT, Mexico.

Zandstra, H. G., Price, E. C., Litsinger, J. A. & Morriss, R. A. (1981). *A Methodology for Onfarm Cropping Systems Research.* Los Banos, Philippines: International Rice Research Institute.