The Technology Applications Gap: Overcoming Constraints to Small-Farm development

By: Deborah Merrill Sands
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Deborah Merrill Sands
FAO consultant

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INTRODUCTION

Within the overriding objective of increasing aggregate agricultural output in Third World countries, a primary goal of agricultural development has been to improve the welfare of rural families through enhancing productivity of small-farms and promoting equitable access to resources, markets, and technical assistance.

Yet, with the emphasis in recent years on the development of small-farm agriculture, many development experts and agricultural research scientists remain frustrated by the limited success of their projects. Small-farmers frequently reject or only partially adopt "improved" technology. This occurs despite the technology's demonstrated higher levels of productivity in experimental plots, its calculated economic profitability for the farmer, and its beneficial contribution to the larger society.

The problem of the limited adoption of introduced technologies, which appear sound when evaluated using the criteria of the agricultural scientists and development experts, can be thought of as the "technology applications gap." Many explanations for the lack of successful technology transfer to small-farmers have been advanced in the literature. One school of thought is: "the technology is good, the farmers are at fault." It diagnoses the problem as an attitudinal constraint on the part of small-farmers, such as small-farmers' innate conservatism, ignorance, or resistance to change. This perspective, formally common to both the natural and social sciences (Whyte, 1981), is largely the product of armchair conjecture and is not supported by field investigations of small-farm systems.

The more prevalent diagnosis of the cause of the technology applications gap is inadequate support systems for small-farm agriculture, such as extension, credit, or input supplies. This has been well documented. Such unfavorable conditions external to the farming system clearly figure among the major causes of unsuccessful technology transfer. Yet, they are only part of the problem. Rarely is the viability of the "improved" technology for the targeted small-farm system(s) questioned (Brady, 1981).

This critical review of the literature, in contrast, focuses precisely on the latter as an equally important, yet too often disregarded, cause of limited adoption of "improved" technologies. Many introduced technologies are simply inappropriate for the specific conditions of small-farm systems. This results largely from an inadequate understanding of the socio-economic organization and goals of small-farm systems on the part of those developing and transferring new technologies.

Agriculture is shaped by the interaction of three basic factors: 1) technology and resources; 2) the regional social, economic, and political environment including price policies, input and output systems, development services, communications and infrastructure; and 3) the socio-economic organization of the farm. In mainstream agricultural research and development, most of the intervention has been focussed on the first two factors, while rather arbitrary assumptions have been made about the last. Yet, in technology transfer to small-farms, it is precisely this third factor---the social and economic organization of the farming system---which merits close attention. This review of the technology applications gap represents an initial stage in an effort to analyze more specifically the impact that social and economic factors operative on the level of the small-farm have on the process of technology transfer.

The determinants of the viability of a technology for small-farm application is more complex than simple yield maximization of a single commodity, the common target of most agricultural commodity oriented research. The technology must be evaluated in terms of both its technical performance under environmental conditions typical of small-farms and in terms of its conformity to the goals and socio-economic organization of the small-farm system. This second evaluation criteria is essential because small-farmers operate under a particular set of socio-economic conditions which, in many cases, distinguish them from capitalist enterprises. Consequently, much of the conventional wisdom on farmers' goals, attitudes, management strategies, decision-making, and constraints is inappropriate, if not misleading.

Mature small-farm systems are generally finely tuned to the physical, economic, and social environments in which they operate, but due to the particular, and often marginal, conditions of that environment, they do not function in the same manner or with the same goals as commercial farms. The most import feature of small-farm agriculture is that the farming system is embedded within the economy of the household and, thus, is organized to meet both the production and consumption goals of the farm family.

The household uses an integrated system of productive activities---crop and livestock systems of both a subsistence and commercial nature, as well as off-farm labour and trade enterprises---in order to sustain itself. The specific combination of enterprises managed by a household is largely a product of the resources it controls, the means of access available to the factors of production (land, labour, and capital), and the balance it has struck among its production and consumption goals of quality, quantity, flexibility, and stability. Maximization of the welfare of the farm family is a more accurate approximation of the overarching goal governing management decisions than profit maximization.

Small-farms are typically constrained by limited resources and access to both land and capital. Scarcity of cash to purchase inputs or hire labour is a common impediment to increasing farm output. Small-farms rely disproportionately on labour, largely supplied by the farm family, as their most available and flexible factor of production. Family labour is usually not considered as a production cost because members have to be sustained whether they work or not, but hired labour is regarded as a drain on scarce cash resources of the household and is eschewed. Consequently, as will be evident in the examples given below, the amount of available family labour also affects production.

Finally, most small-farms operate in rural economies of Third World countries characterized by imperfect markets. As a result, other institutions, such as kin groups or tribal membership, commonly regulate farm family's access to land, labour, and capital. This restricts the utility of standard marginalist economic analysis of returns to the factors of production as a means for predicting behavior (Berry, 1975; Chayanov, 1966; Greenwood, 1976; Hill, 1966; Norman et al., 1982; Warman, 1976).

The critical lesson for technology development and transfer efforts that can be drawn from this review of the literature on the technology applications gap is that small-farmers will evaluate any introduced technology in terms of its compatibility with the goals of the farm household and the constraints and opportunities confronting the integrated household production system. These socio-economic criteria must be understood if viable technology is to be designed and successfully transferred to the small-farmer.

This review represents an initial step in bridging this critical knowledge gap. Its primary objective is to heighten awareness among agricultural researchers, policy makers, and development planners of the primary issues contributing to the technology applications gap. The focus of the analysis is on social and economic factors at the level of the farming household which impinge directly on technology use and adoption.

Although the issues are relevant to agricultural research and development in all developing country regions, the examples and analysis emphasize Sub-Saharan Africa. The technology applications gap has been and continues to be a particularly disturbing problem in this region, especially in the light of the current famines and the precipitous decline in per capita food production in the past decade. While the need for technologies to increase food production which are appropriate for the conditions of small-farms is great, the success to date in the development of such technologies has been limited.

In the first chapter of this review, seven short case studies of the technology applications gap are presented. They demonstrate the importance of taking socio-economic criteria, as well as technical, into account when designing and promoting new technologies for small-farmers. The second chapter extracts from the review of the literature relevant lessons on patterns of adoption of new technologies by small-farm households. The third chapter develops basic conceptual guidelines for improving the understanding of the circumstances of the small-farm and the manner in which socio-economic factors influence agricultural production and technology transfer. The final chapter outlines a series of recommendations which could provide national agricultural researchers, development planners and project managers with a more viable approach to the design, development, and transfer of agricultural technology to small-farmers.

CHAPTER 1

CASE STUDIES OF THE TECHNOLOGY APPLICATIONS GAP

Introduction

The following case studies of technology transfer to small-farmers illustrate what we mean by the technology applications gap. The case studies elucidate several common problem areas in agricultural research, technology design, and technology transfer and extension directed at small-farmers resulting from the disregard or misconception of critical socio-economic factors. These typical problem areas are summarized below but are developed in greater depth with supporting arguments in Chapter 3.

Problem 1. Inappropriate designation of the relevant socio-economic unit for understanding farm management.

The household, rather than the parcel, is the relevant unit of analysis. The parcel is but one component of an integrated production system and, in turn, the farming system is often only one of several enterprises managed by the farm household. Management decisions on production objectives, crop mixes, factor allocation, and the timing of operations, are made by members of the farm household within the context of their goals and needs and the various enterprises they exploit to meet their needs (Collinson, 1972; Cornick, 1983; Dey, 1984; Durrenberger, 1984; Gilbert et al., 1980; Hart, 1982; Jones, 1984; Kumar, 1985; Low, 1982; McDowell and Hildebrand, 1979; Merrill Sands, 1984; Murphy, 1985; Norman, 1980; Norman et al., 1982; Palerm, 1980; Shaner et al., 1982).

Problem 2. An insufficient understanding of the multiple production and consumption goals within the small-farm household economy.

Agricultural scientists typically overemphasize the maximization of yields of single commodities when evaluating new technologies. Often other goals are more relevant to the small-farm family. These include the overall benefit to the household from the improved technology, the generation of scarce cash resources, risk avoidance and food security, or economic returns to their most limiting factor of production (Agudelo and Crawford, 1981; Almy, 1979; Barnett, 1969; Byerlee and Collinson, 1980; Carloni, 1983; Chayanov, 1966; Collinson, 1972; Dey, 1984; Dewalt, 1975; Ewell, 1984; Ewell and Merrill Sands, 1986; Franzel, 1984; Gilbert et al., 1980;

Gladwin, 1976, 1980; Gudeman, 1978; Halperin and Dow, 1977; Hardaker et al., 1984; Harwood, 1979; Horton, 1983, 1984; Huang, 1984; Jodha, 1979; Johnson, 1971b; Jones, 1984; Knight, 1980; Matlon, 1984; Mayer, 1974; Merrill Sands, 1984; Moerman, 1968; Morss et al., 1976; Norman, 1980; Norman et al., 1982; Ortiz, 1973; Scott, 1976; Shanin, 1973; Warman, 1976; Wharton, 1971).

Problem 3. A failure to recognize the influence of the social organization and development cycle of the household on management of the farming system.

The social organization of the household has three important implications for management of the small-farm system. It is a principal determinant of the availability of labour because the farm family provides most of the labour in small-farm systems (Chayanov, 1966; Dove, 1984; Durrenberger, 1984; Jorian, 1984; Kluck, 1975; McGough, 1984; Norman et al., 1982). Secondly, it structures the organization of labour. Often the division of labour, tasks, and enterprises between the sexes and age groups is overlooked in development planning and technology transfer (Ashby, 1985; Breeden et al., 1976; Carloni, 1983; Collinson, 1972; Dey, 1984; Elliot, 1977; FAO, 1983, 1984a, 1984b; Guyer, 1980; Hahn, 1985; Henn, 1983; Kumar, 1985; Moock, 1976; Norman, 1980; Norman et al., 1982; Pala, 1980; Safilios-Rothschild, 1983; Unnevehr, 1985). Thirdly, the division among household members of responsibilities and obligations, authority for decision-making, and control over inputs, products, and income within the farm household has important ramifications for targeting development efforts (Carloni, 1983; Collinson, 1972; Dey, 1984; FAO, 1983, 1984; Hahn, 1985; Hill, 1982; Kumar, 1985; Pala, 1980).

Problem 4. An inadequate determination of the organization of the household economy in which agriculture is often only one of several enterprises.

It is necessary to understand: a) the role of agriculture within the total economy of the farm household; and b) how the household's access to resources and the factors of production---land, labour, capital, and management---shape the farming system, determining its organization and areas of flexibility and constraints (Achola Pala, 1980; Bartlett, 1978; Bennett, 1969; Byerlee and Collinson, 1980; Carloni, 1983; Collinson, 1972; DeJanvry and Deere, 1981; Dewalt, 1979; Ewell, 1984; Gilbert et al., 1980; Gladwin, 1976, 1980; Greenwood, 1976; Hart, 1978; Haugerud, 1983; Hill, 1970; Jodha, 1979; Jones, 1984; Jorian, 1984; Kluck, 1975; Low, 1982; McDowell and Hildebrand, 1980; Merrill Sands, 1984; Norman, 1980; Norman et al., 1982; Ortiz, 1973; Warman, 1976).

Problem 5. A disregard for the linkages between small-farms and the larger society.

These linkages influence farm organization and farmers' evaluation of the viability of a technology. They include: input and output markets, government pricing policies, credit institutions, communications infrastrucure, informal and formal organizations for pooling or sharing resources, and rules regulating land ownership (Collinson, 1972; Ewell and Merrill Sands, 1986; FAO, 1984a; Goodell et al., 1982; Hardaker et al., 1984; Jones, 1984; Merrill Sands, 1984; Morss et al., 1976; Murphy, 1985; Norman et al., 1982; Orlove, 1977; Palerm, 1980; Stavenhagen, 1976; Warman, 1976). Furthermore, households are enmeshed in larger supra-household systems, such as communities, patrilineages, or irrigation associations; in which certain key decisions are made on allocation of lands and land-use, labour obligations, or product disposal (Brush, 1977; Fleuret, 1985; Goodell et al., 1982; Huang 1984; Mayer, 1979; Merrill Sands, 1984; Norman et al., 1982).

Case Studies

CASE 1: Potato Production under Traditional and Modern Farming Methods in the Peruvian Andes.

This case study is a good example of the second problem area outlined above in which a technology is evaluated by the agricultural scientists solely in terms of its yield performance rather than in terms of criteria perceived as important by the farm family. In this case, the reasons for the farmers' lack of interest in the recommended technology was revealed by a straight-forward calculation of net returns to the farm family. The International Potato Center compared the low-input traditional agricultural system and the high-input modern system of the intermediate and high zones of the Peruvian Andes in terms of net economic returns (Horton, 1984:41-42). The traditional "tipca" system is based on native varieties, no tillage prior to planting, hand power using the traditional Andean plow, and little chemical fertilizer or pesticides. The modern "barbecho" system uses modern improved varieties, tractor power, and high levels of chemical fertilizer and pesticides.

Despite the approximately 30 percent higher average yields under the modern system, the low-input system generated 10 percent greater net returns when total costs including family labour were calculated and 16 percent higher returns when only the returns to cash outlay for purchased inputs were calculated. The varieties cultivated under the traditional system are not only more appreciated for their culinary qualities among the farming households as would be anticipated, but they receive a better price in the market as well. Clearly under the economic conditions facing the small-farm household in the higher altitudes of the Andes, there is little incentive to adopt the modern technology despite its higher yields per unit of land.

CASE 2: Mixed Cropping Versus Sole Stands in Northern Nigeria

This example from Northern Nigeria is a more subtle illustration of the same problem of incorrect assumptions about what the farmers want to maximize. Again it shows how a traditional system can provide better net returns than a recommended technology when evaluated in terms of economic criteria important to the small-farmer (Norman, 1980).

In N. Nigeria, the efforts of agricultural scientists and extension workers to persuade farmers to plant sole stands has met with little success. The reasons behind farmers' resistance becomes clear when socio-economic criteria relevant to the farmer, instead of yield criteria, are considered. The primary constraint for small-farmers in the Nigerian savannah is the short growing cycle of only 150 to 190 days. There is a critical peak labour demand falling in June-July at the beginning of the rains. This is a more important limitation to increasing farm output than land shortage. Therefore, maximizing output in relation to the labour bottleneck of greater concern to the farmer than maximizing output per unit of land.

Research carried out by the Institute for Agricultural Research in Zaria revealed that traditional mixed cropping practices not only excelled in net returns per unit of land when compared to sole stands (35 percent higher), but also gave 28 percent higher returns per annual man-hour invested and 57 percent higher returns to labour invested during the labour bottleneck.

The mixed cropping system helps smooth out the labour demand peak and increases returns to the most limiting factor of production. It is thus more desirable within the goals and socio-economic organization of the small-farm system. Additionally, the mixed system excelled in terms of the farm households' goal of food security because it gave more dependable returns than the sole stand.

It is no wonder, then, that the recommendation for sole stands has not been adopted by small-farmers. It is incompatible with the goals and organization of the farming system and provides little additional benefit in terms of the factors limiting farm production.

The conclusions from Norman's study has broad implications since intercropping is characteristic of small-farm agriculture in rainfed areas in developing countries. For example, in six villages of India studied in depth by ICRISAT, intercropping with the goal to reduce peak labour demands accounted for 32 to 83 percent of the area under intercrops in the different villages. The intercropping of food and cash crops to meet the multiple objectives of the farm household accounted for 50 to 73 percent of the intercropped area (Jodha, 1979).

CASE 3: Improved Cotton Technology in Northern Nigeria

Another example from N. Nigeria of improved cotton technology (Dagg, 1984, Norman, 1980; Norman et al., 1982) illustrates the importance of understanding the role of the targeted crop within the farming system, the principal constraints determining management practices, and the goals of production of the farm family when developing improved technology. In this case the improved cotton technology first proposed was incompatible with fundamental socio-economic constraints within the production system and was rejected by small-farmers. However, once these were recognized and the technology was modified accordingly, it was readily adopted by the farmers. In this case study I trace the process of adaptive research and modification of the cotton technology to the point that it eventually was suitable for small-farm production systems.

The critical June-July labour bottleneck explained in the previous case study was also the principal constraint inhibiting adoption of the improved cotton technology first developed by the Institute for Agricultural Research in Zaria. The technology was highly productive with demonstrated yield increases of 100 percent in farmers' fields. However, it was poorly designed for the small-farmers because it depended on a fixed planting date which fell exactly during the labour bottleneck period for food crops. In the traditional system this constraint is avoided by sowing cotton after the food crops have been planted and partially weeded, revealing the farm family's clear priority for maximization of food crop production over cash crops. The fixed planting date of the new technology fell a month earlier and, thus, conflicted with the first weeding of food crops which is critical to obtaining good yields and exacerbated an already difficult management constraint (Norman, 1980).

The new technology required twice the labour investment of traditional cotton technology during the June-July period of peak labour demand when both family and hired labour are scarce. On an annual basis the higher yields from the new technology compensated for the higher labour investment with returns per man-hour invested increasing 13 percent. However, the returns to man-hour invested during the critical labour bottleneck, the principal limiting factor in production, were 13 percent less (Norman, 1980).

Due to the technology's conflict with the production cycle o the food crops, farmers either rejected it outright or those who experimented with it, continued to plant at the later date. In th latter case, the technology's performance was disappointing. Delay planting undermined the effectiveness of the recommended spraying gime which was not appropriate for the different pest complex dominant in the latter part of the season (Dagg, 1984).

In its initial form, the new technology had been designed in isolation from the farming system into which it was supposed to be introduced and had only been evaluated in terms of yields and in relation to traditional cotton technology. Consequently, the incor patibility of the early fixed planting date with critical socio-economic factors determining the organization of the farming syster was not recognized as a real constraint. The result was the gener tion of a technology which was fundamentally inappropriate for the farmers' needs.

Once the farmers' rejection of the technology precipitated co laboration between the social scientists and the technical agricultural scientists, the labour constraint was accepted as a bound within which improved cotton technology would have to be redesigne The end of the story is encouraging. When a later planting date w accepted as a given, the agricultural scientists were able to quit quickly develop a new package with equivalent yield performance wh was much more acceptable to farmers (Dagg, 1984). Clearly, however, the costs and time devoted to developing the cotton technology woul have been significantly reduced if the social science department, which already had information on the farm labour cycles and recognized the labour bottleneck as a critical constraint in the farming system, had been involved in the original design of the technology.

The cotton story has one further interesting episode which illustrates how communication between farmers and researchers can result in effective adaptations of introduced technology to local conditions. With the later planting date of the revised cotton technology, farmers were much more interested but as they experimented with it a new problem became clear.

The recommended spraying technology was a water-based method with a hand pump. It required 225 liters of water and two to three hours to spray one hectare with six applications at weekly interval (Norman et al., 1982). Transportation of the approximately 225 kil of water was difficult since cotton fields were located in the oute rings of village cultivation systems (Norman et al., 1982) at a considerable distance from the water sources situated in the villag centers. Farmers found the spraying technology so cumbersome and difficult to manage that they were forced to spend limited cash reserves to hire a spraying operation under contract. Consequently many were not following spraying recommendations (Norman et al., 1

In response to the farmers' critical observations, the agricultural scientists introduced a new spraying technique using an oil-based insecticide and an ultra-low volume sprayer operated with a battery powered spinning disk (Dagg, 1984). Although the technology was more complex than the simple hand pump, farmers found it more attractive and accepted it readily (Dagg, 1984; Norman et al., 1982). In addition to its light weight and ease of operation, the new technology required much less labour investment since the time-consuming task of collecting water was eliminated and actual spraying time was reduced by 23 percent (Norman et al., 1982).

With this final adaptation of the technology, it was now fine-tuned to the small-farm systems and was widely adopted.

CASE 4: Development Intervention in Upland Rice Production in the Ivory Coast.

This case study of a development project in upland rice in the Ivory Coast (Dey, 1984) illustrates the problems that arise in technology transfer when the importance of the social organization of the farming household is not recognized (Problem 3). It is a disturbing example of the technology applications gap resulting from a failure to recognize socio-economic factors organizing production and control over production.

The key obstacle to the success of the project was that the traditional sexual division of labour within the farming system was not recognized. In the traditional system, men are responsible for cash crops, the income from which they solely control. Women are responsible for staple food crops, including upland rice, which they use to feed their families and, in the event of surplus production, they sell in order to generate small cash reserves. Men merely clear and burn the land for upland rice and women carry out all the remaining operations. The development project, however, assumed that men were the farmers and targeted them rather than the women who were the experienced rice cultivators.

The focus on men in the development project changed the role of rice production within the farming system and the economy of the farming household. Because of their linkage with the development program, men were able to turn their rice plots into a personal cash crop from which they alone benefited. They also were also able to demand unpaid labour from the women of the household through the traditional system of obligations which require women to perform certain cultivation tasks in the men's fields.

This resulted in a fundamental conflict which undermined the success of the upland rice project: women were supplying most of the labour in the rice plots, since rice was traditionally their responsibility, but they had little interest in obtaining high yields because they received no personal benefit from the production of these plots. They are reported to have refused to apply the fertilizer provided by the project because the higher yields would only increase their work burden in weeding and harvesting while exclusively benefiting their husbands who controlled the sale of the crop and kept a separate purse. The fertilizer supplied by the project was either thrown away or men used it in their cacao plantations (Dey, 1984).

Irrigated rice projects in the Ivory Coast have also suffered significantly from this basic conflict between women's traditionally recognized role as rice cultivators and the project's insistence on targeting men as the farmers in the projects. Dey (1984) cites the lack of integration of women into the project design as a major factor behind the general failure of the SODERIZ irrigated development program. Of the 11, 000 hectares developed by this program for double cropping of rice in the 1970s, in 1982 only 1,466 hectares were cultivated in the dry season and 5,164 hectares in the wet season.

Again, women provided most of the labour in the irrigated fields, but had little incentive to increase output since men controlled the sale of the crop. Furthermore, harvesting the men's dry season rice crop conflicted with women's planting of their traditional rainy season food crops and their personal groundnut, cotton, and upland rice fields, the product of which they controlled. Consequently, men had a difficult time procuring sufficient labour for the irrigated rice harvest and the price for rice did not merit the additional cost of hired labour.

CASE 5: Irrigated Agricultural Development Project for Victims of the Sahelian Drought

An FAO irrigated agricultural scheme designed to provide an alternative for emergency relief for famine victims of the Sahelian drought suffered from similar problems (Carloni, 1983). The success of the project was compromised because the traditional division between the sexes of labour roles and responsibilities for provisioning the household were ignored in the planning of the project. This occurred despite a detailed documentation of the social organization of farming units generated by an anthropological study executed at the beginning of the project.

In the traditional system operative before the disruption caused by the extended drought, men were the herders and the women were the agriculturalists. The women were responsible for provisioning the household with food grains and condiments. Despite the fact that the women were the experienced cultivators, the project allotted the irrigated parcels primarily to men giving them control over the product, and directed inputs and extension services to men.

As in the previous example, while women provided most of the labour on the irrigated plots because they were the experienced farmers, they had little control over or benefit from the product. They, thus, had little incentive to maximize output. Furthermore, in order to meet their obligations to the household, they had to cultivate personal rainfed sorghum plots outside of the scheme as they had done before the drought and resettlement in the camps. This had a negative impact on the productivity of the irrigated plots because the labour demands between the two enterprises conflicted and women gave first priority to their own fields.

Disappointing cotton yields in the irrigated parcels were found to derive primarily from neglect. Women farm workers were not interested in the cotton crop for three reasons. First, the returns to labour were lower than for the food crops (grown in the other half of the irrigated parcel). Second, although the women provided the arduous labour, it was the men, in whose name the plot was registered, who received the money from the sale of cotton. And third, the production cycle of cotton conflicted with the labour demands of their personal sorghum plots, the product from which they controlled and could use to fulfill their obligation to feed their dependents.

A farm management study revealed that in plots which were registered in the woman's name, the woman cultivator invested more labour in the irrigated fields placing less emphasis on rain-fed sorghum cultivation. Furthermore, the maize yields in the plots of the women were consistently higher than those registered to men but worked by women.

The advantages of recognizing women as the farmers in this region is demonstrated by a collective scheme for irrigated vegetable and citrus production that was organized solely for women within the same project. Participation has been high, yields have steadily increased, subsistence crops have been incorporated by the women, and although the area per member is smaller than that of the individual plots, the profits earned by the collective members are equivalent.

In reviewing the project, it seems clear that women, who are the traditional farmers and have responsibility for provisioning the dependents of the household with food grains and condiments, should have been the group targeted by the project in the beginning. Despite available information to the contrary, false assumptions were made about the socio-economic organization of the households which resulted in the failure of the project to meet its objectives.

CASE 6: Post-Harvest Food Loss Project in West Africa

Overlooking women's roles in agriculture was also a primary obstacle to the success of a FAO Post-Harvest Food Loss Project in West Africa (Carloni, 1983). The goal was to reduce post-harvest rice losses with simple techniques, devices, and extension support. After two years, the project has met with little success and adoption of the proposed technology is minimal.

Although the project did preliminary research to determine the nature and extent of post-harvest losses before designing technical solutions, the results were unreliable because it neglected to recognize that women had <u>sole</u> responsibility for post-harvest processing and storage of family grain reserves in the household. Furthermore, women "jealously guard access to the kitchen stores" and the presence of men in this area was not approved.

Despite the fact that men had no expertise in this area, the project consulted male heads of household rather than their wives, who controlled the stores on the extent of post-harvest losses. The project also erred in sending male enumerators to inspect kitchen stores. The women refused to cooperate because men traditionally are not allowed access to the stores. Finally, the technology designed for the project was communicated to the male head of household, not to the women who would have been the users of the technology.

When the project was eventually restructured to compensate for this planning error and the women of the household were consulted by female investigators, it was discovered that the women, in fact, did not perceive storage losses as a significant problem. There was, thus, little incentive for the women to adopt the relatively expensive technology recommended by the project. Had women been correctly identified as the relevant target group at the beginning of the project, the post-harvest food loss problems could have been more accurately identified, the needs and resources of the women as managers of the grain stores determined, and appropriate technical solutions designed. This would have increased the chances of adoption of the technology significantly.

CASE 7: Small-Farmer Adoption of Commercial Honey Production in Mexico.

This is a positive example of the rapid and wide spread technological diffusion of commercial beekeeping among small-farmers in Yucatan, Mexico. It illustrates the willingness of small-farmers to adopt a new technology which is both feasible in terms of the technical and environmental resources of the farming system as well as compatible with its socio-economic organization (Ewell and Merrill Sands, 1986; Merrill Sands, 1984).

Since the early 1970s approximately 9,000 farm families in Yucatan have developed small-scale beekeeping enterprises which complement subsistence maize production by providing a cash income essential for the household. They produce honey for export using the European bee, Apis mellifera, and the introduced technology of the moveable frame hive. These beekeepers supply between 5 and 10 percent of the honey traded in the international market.

The new technology was actively adopted by small-farmers with little government promotion or extension support for production. Although the technology was different from anything employed locally, it was easy for the small-farmer to adopt. The equipment had been tested and demonstrated to be successful in the region by large-scale commercial producers in the 1960s. It is relatively simple and can be made locally by village craftsmen. It is divisible so that it can be purchased in small units which allows for incremental investment of scarce cash resources. It generated high yields and the market was relatively stable and accessible to the small-farmer. This resulted in good net returns for the farm family to both labour and cash invested.

Commercial beekeeping was attractive to small farmers because it was compatible with the existing production system. The new technology's demands for resources and the factors of production---land, labour, and capital---did not conflict with those for staple food production. First, it exploited an unused resource: the flowering trees of the forest lands which abound because maize, the staple food of the region, is grown under a swidden system with long-term forest fallow. Secondly, food crop production relies primarily on land and labour, while beekeeping relies on labour and capital.

The kinds of labour constraints which were determinant in the negative examples given above do not exist in this case. Although men provide the labour for both enterprises, the production cycles complement each other well in terms of labour demands. The period of lowest activity in agriculture when the labour demands are most flexible are those with the highest labour use in beekeeping. Therefore, through the adoption of beekeeping, households can intensify farm production through the use of surplus labour without competing for labour at critical bottleneck periods in the production of staple food crops as we saw in the case of the improved cotton technology in northern Nigeria.

Commercial beekeeping was also attractive because it filled a vital role within the household economy of the small-farmers in Yucatan. Honey sales generated cash income for the household economy. This was especially important because the cash returns from the sale of surplus corn were being undermined by low guaranteed prices and declining yields resulting from inadequate fallow periods of lands within walking distances of villages.

The success of the new technology can be attributed to four basic factors which can serve as general criteria for evaluating proposed technologies developed for small-farmers. First, it was profitable under the production conditions of the small-farmers. Secondly, it engaged surplus labour and did not conflict with the production cycle or factor allocation patterns of food crop production, the primary agricultural activity of the farm families. Thirdly, the market was established and the marketing conditions were relatively favorable for the small-producer. And, finally, it met a primary goal within the household economy by providing cash income without threatening the household's ability to provision itself with staple foods.

Summary

Five general observations of factors contributing to the technology applications gap can be drawn from the case studies.

1. It is not uncommon that the objectives of researchers and development planners and their perception of farmers' needs, which structure the design of technologies transferred to small-farmers, do not correspond with those of the farm family.

2. Farmers employ social and economic criteria, as well as technical, in their evaluation of new technologies. These evaluation criteria are often different from those employed by the agricultural scientist or development planner.

3. The basic socio-economic constraints operative on the level of the small-farm are rarely taken into account as boundary conditions for the design of technology for small-farmers. Yet, they can be major impediments to successful technology transfer.

4. Misconceptions about which member of the farm family is responsible for the area targeted for intervention is a common obstacle to technology transfer.

5. Misunderstanding the role of the targeted activity within the household economy of the small-farm can lead to developing a technology which is inappropriate for the farming system or which farm families have little incentive to adopt.

These will be examined in detail in the following two chapters.

CHAPTER 2

LESSONS TO BE DRAWN FROM STUDIES OF SMALL-FARMER ADOPTION OF NEW TECHNOLOGIES

The literature on small-farmer adoption, modification, or rejection of improved technologies, while ample, is dispersed among many published and unpublished sources as well as across diverse disciplines and perspectives. It ranges from individual project case histories, to analyses of large-scale survey data, to models of farmers' decision-making with respect to specific introduced technologies. From this wide array of studies and approaches, three critical lessons on small-farmer adoption of new technologies are abstracted in this chapter. The lessons are:

1. Small-farm families are receptive to change and small-farm systems are dynamic. The concept that "traditional" agriculture is static is misleading.

2. Small-farm families are <u>selective</u> and <u>adaptive</u> in their adoption and use of recommended practices and technologies.

3. No <u>single</u> attitude, trait, factor, or farming condition explains the patterns of small-farm adoption of all new innovations.

These are valuable conceptual tools to assist agricultural scientists and development planners in better understanding the socio-economic process of technology transfer to small-farm families.

<u>Lesson 1:</u> **Small-farm families are receptive to change and small-farm systems are dynamic. The concept that "traditional" agriculture is static is misleading.**

There is a tenacious myth that small-farmers are conservative and resistant to change. This review of the literature on small-farm agriculture reveals this as a myth and nothing more. Indeed, there is ample evidence that small-farm households actively pursue economic opportunities and experiment with new technologies when they are compatible with the socio-economic organization, resource endowment and goals and needs of the farming household (Brady, 1981).

The majority of small-farmers are active experimenters both with indigenous and introduced technologies as has been documented by most investigators who have carried out in-depth analyses of small-farm systems. Brush (1977) documents considerable experimentation with potato varieties among Andean farmers. Johnson (1971, 1980) gives examples of Brazilian sharecroppers experimenting with new crops, new varieties, and new agricultural techniques. Franzel (1984) reports that a CIMMYT study in Kenya found small-farmers to be active experimenters with maize varieties. Higher-income farmers had experimented with an average of 3.7 different varieties and lower-income with an average of 2.6 varieties. In an area of Mexico stereo-typed by extension agents as very "conservative", Dewalt (1975) found that 96 percent of the farmers had experimented with chemical fertilizers in the five years since their general introduction into the region.

Gerhart (1975) documents one of the most successful cases of HYV adoption by small-farmers. Within ten years of the first introduction of hybrid maize, in two out of the three regions of Western Kenya included in the survey, the adoption rate among small-farmers was 90 to 100 percent. Moreover, the <u>rate</u> of adoption was very rapid. The mean lag time between farmers hearing of the new seed and using it was only 1.5 years, considerably faster than the five year lag time for American farmers in Iowa in the 1920s and 1930s (Gerhart 1975). Hesselmark (1975) also reports a rapid adoption rate of hybrid maize in the Central Provinces of Kenya where small-farmers predominate. The annual growth rate in its use following its introduction in 1968 to 1974 was 46 percent. Gerhart (1975:26) observes that "It would be difficult to conclude from the rapid adoption rates and short time lags between first hearing and first use that African farmers are in any way inextricably bound by tradition or unopen to change."

Brady (1981) provides a second example of small-farmers' rapid adoption of an new technology appropriate to their conditions and goals in the Iloilo province of the Philippines. Here within four years of introduction, a new, intensified, multiple cropping system based on an early maturing rice variety was being used on over 50 percent of the cultivated land of the region. This occurred despite the significant change in technology and management practices required.

Small-farmers will strive to adapt to changing economic and environment circumstances (constraints as well as opportunities) even though this often entails making major changes in their farming systems. In fact, the majority of farming systems extant are the product of a long history of change and adaptation; they are not static production systems rooted in tradition (Almy, 1979; Baum, 1968; Berry, 1975; Ewell, 1984; Guyer, 1980; Hill, 1970a; Ludwig, 1968: Merrill Sands, 1984; Norman et al., 1982; Ortiz, 1973; von Rotenhan, 1968).

There are numerous case studies of rural economies indicating that small-farmers rapidly adopt new production enterprises in response to widened economic opportunities. Several well-documented examples of small-farm innovation with limited government support or innovation are the development of the cacao industry in Ghana and Nigeria in the 1930s by small-farmers (Berry, 1975; Hill, 1970); the rapid and wide-spread adoption of commercial honey production in the small-farm sector of Yucatan, Mexico in the 1970s (Ewell and Merrill Sands, 1986; Merrill Sands, 1984); small-farm adoption of tobacco production in Brazil (Kluck, 1975) and coffee in Columbia (Ortiz, 1973); the shift from swidden agriculture to intensive small-farm irrigated tree crop and vegetable production in southern Yucatan, Mexico (Ewell, 1984); and the extensive adoption of cotton production in Sukumaland, Tanzania (von Rotenhan, 1968).

Other studies demonstrate that small-farmers have developed new practices or changed production activities in response to pressures on their farming systems from causes such as population pressure, shifting market conditions, new land tenure rules, government support of cash crops, or expansion of capitalist agricultural enterprises (Almy, 1979; Basehart, 1973; Baum, 1968; Boserup, 1965; Brush, 1977; Clay, 1979; Geertz, 1973; Haugerud, 1983; Knight, 1980; Ludwig, 1968; Netting, 1968; Norman et al., 1982; Ruthenberg, 1968; von Rotenhan, 1968).

All of these studies demonstrate that small-farm systems are dynamic; farm families respond to changes in the physical and socioeconomic environment in which they are operating. However, they also show that the responses are structured by the farming household's multiple goals, the resources and factors of production available, their perception of the riskiness of the economic opportunity or new technology, and the social organization of the household. As will be discussed in more detail below, this results in significant variability in the nature and intensity of individual household's responses and adoption of new technologies.

Lesson 2: Small-farm families are selective and adaptive in their adoption and use of recommended practices and technologies.

Small-farm families are, in general, careful decision-makers who test and select carefully among alternative technologies and production strategies and then adapt them to their particular farming conditions and needs as they endeavor to adjust to their physical, social, and economic environments (Abalu et al., 1984; Bartlett, 1980; Barlow et al., 1983; Bennett, 1969; Byerlee and Collinson, 1980; CIMMYT, 1974; Clay, 1980; Dewalt, 1975, 1979; Franzel, 1984; Gerhart, 1975; Gladwin, 1976, 1980; Gladwin and Butler, 1984; Hesselmark, 1975; Hildebrand, 1977; Horton, 1983, 1984; I[illegible], 1978; Jedlicka, 1979; Mann, 1978; Morss et al., 1976; Murphy, 19[illegible], Norman et al., 1982; Perrin and Winkelmann, 1976; Ryan and Subrahmanyam, 1975; Torte, 1984; Walker, 1981; Winkelmann, 1976).

The adoption studies show that complete technological packages are rarely adopted by small-farmers. Rather, their common conclusion is that farmers select from an array of introduced technologies and recommended practices those that are most appropriate for the specific environmental and economic conditions in which they are working.

Frequently in project analyses, however, small-farmers' selective adoption of components of a technological package or their modification of recommendations is misconstrued and they are classified as "non-adoptors". This has important implications for the study of small-farmers' responses to new technologies and the process of adoption. Defining adoption as the utilization of the complete package of recommended practices at optimum levels exaggerates the level of "non-adoption" and characterizes the small-farmer as conservative and resistant to change. Perhaps more importantly, it ignores the criteria by which farmers choose new technologies and the process by which they incorporate them into their farming systems. Yet, it is precisely this information which is of critical importance if we are to learn how to effectively design and disseminate technologies which will assist the small-farm families to increase agricultural production.

The analysis of adoption rates in the Puebla Project of Mexico, which focused on increasing small-farm rainfed maize production, provides a good illustration of this issue. When adoption was defined as use of optimum levels recommended for all three components of the package, then the adoption rate among farmers in the targeted region was only 6.7 percent, leading to justifiable frustration and discouragement among the agricultural scientists and extension agents (CIMMYT, 1974). A detailed and careful analysis of the pattern of adoption among small-farmers four years after the initiation of the project, however, revealed that in 72 percent of the parcels there was a low level of adoption of at least one of the recommended practices and in 30 percent a high level of adoption of two of the three recommended practices (Winkelmann, 1976).

The extent of adoption was actually quite successful because the third component, planting density, was shown to have negligible economic returns (Winkelmann, 1976) and the incentives to produce surplus corn were limited. The real price of maize was declining, the recommendations only resulted in about a 30 percent increase in yields (Whyte, 1977), and farming households in the region had alternative means of earning cash. Crops provided on the average only 30.4 percent of their total income (CIMMYT, 1974).

Gerhart (1975) found a similar pattern of selective adoption. among hybrid maize adopters in W. Kenya. While there was rapid uptake of HYV seed, small-farmers were more selective in their adoption of other components of the recommended package. Only large-scale commercial farmers had 100 percent adoption rates of the complete package. On small-farms, cultural practices, particularly planting in rows and weeding more than once, were more widely adopted than recommended inputs requiring cash such as commercial fertilizer or the application of insecticide on stored maize. The pattern of adoption was not homogeneous, however, and the relative rates of adoption of individual components varied among regions.

Gerhart's study is important because it clearly shows that small-farmers are not non-adopters per se, but that they evaluate each component of a package and selectively adopt technologies which they consider both economically feasible and appropriate for their farming conditions. In this case, the hybrid maize was a reliable, beneficial, and low cost technology which did not entail a major modification in their cultivation practices nor in the organization of their farming systems. Experimental trials in W. Kenya demonstrated 30 to 80 percent yield increases using hybrid seed alone (Gerhart, 1975). This pales in comparison with experimental yield increases of 300 percent from the complete package. However, from the perspective of small-farmers who had limited cash for investment, the adoption of hybrid seed alone or with several other components in the package was attractive because it generated good returns on cash and labour invested.

Mann (1978) found a similar pattern of adoption in his study of the use of high-yielding varieties of wheat in Turkey. While the complete recommended package was only used on 1 percent of the fields, the least costly component, treated seed, had been adopted in 92 percent of the parcels. Based on these findings, he proposed a model of sequential, step-wise, adoption of components of a technological package to explain small-farmers' adoption behavior. The least disruptive component, such as treated or hybrid seeds, is adopted first with other components requiring larger changes or greater investments adopted in incremental steps subsequently as experience and resources increase. On the basis of this model, he recommends that technology packages be broken into viable clusters or components which can stand alone.

Ryan and Subrahmanyam (1975) drew the same conclusion based on research in India. As in the studies mentioned above, they found that among farmers participating in the HYV program in wheat, paddy, and jowar, the adoption rate of the complete package (seed treatment, chemical fertilizer, plant protection, and inter-cultural operations) was only 9.7 percent, 16.6 percent, and 55.8 percent, for each crop respectively. Yet the adoption rate for chemical fertilizer alone was 54 percent, 61 percent, and 64 percent respectively.

Like Mann, they argue that the sequential approach to promoting practices could increase the overall adoption of modern varieties. They showed that, contrary to conventional wisdom, just switching from traditional to modern varieties in wheat could give a marginal return of between 50 to 200 percent. For paddy, the marginal returns for switching to modern varieties were much higher, ranging between 500 and 700 percent in some zones, while the ten-fold increase in returns from modern varieties of jowar were even more impressive. Obviously, high returns such as these would be attractive to small-farmers who have limited cash for investment and, thus, represent a reasonable first step in promoting technological change.

The adoption studies reviewed above clearly demonstrate that small-farmers selectively adopt improved technologies and adapt them to their specific environmental and economic conditions. With this foundation, adoption studies now need to proceed a step further to probe below the statistical patterns of behavior to determine the criteria farmers use when deciding to adopt, adapt, or reject technologies or specific components of recommended technological packages. This type of research which seeks to determine the reasons behind adoption behavior can be an important aspect of adaptive research. It generates the information necessary to help scientists define relevant research priorities and programs, to target and fine-tune technologies to local conditions, and to develop effective processes of promotion and dissemination of improved technologies.

In the vast majority of cases, there is a rational reason why small-farmers reject improved technologies or components of technology packages. In some cases the introduced technology, while biologically superior to local technologies, simply is not economically viable under the management conditions of the small-farmers. In other situations, there is a differential pattern of adoption among small-farmers reflecting the significant variation in the environmental conditions or the resource and factor endowments of individual farms. Examples from the literature on adoption studies of factors contributing to small-farmers rejecting or only partially adopting introduced "improved" technologies are given below.

The case studies presented in the preceding chapter from Peru and northern Nigeria (Cases 1 and 2) illustrate the situation where the introduced technology was simply not appropriate nor profitable for small-farm households to adopt. In another example from the Mantaro Valley Project in Peru, the International Potato Center found through analyzing data from on-farm trials and farmers' adoption patterns, that one component of the package they were promoting--- improved seed--- was undermining the viability of the whole package

(Horton, 1984). Either of the other two components---fertilizer or insect control---alone provided farmers with higher rates of return than the adoption of the complete package. Although the improved seed increased yields 15 to 20 percent, its high cost made it uneconomical for the farmer to adopt.

What is particularly interesting in this example is that the production scientists had assumed that improved seed would be the key component of the package and that they would be able to double or triple potato yields with the new technology. The results, however, were disappointing. The high-input package only increased yields on the average 50 to 60 percent over the traditional technology. Subsequent on-farm trials and interviews with farmers revealed that the researchers' assumptions about the weaknesses of the traditional technology which the new package was designed to correct were erroneous. Traditional methods of seed selection were actually quite effective, yield reducing virus diseases were not as severe a problem for native varieties as for modern, and farmers' seed management practices tended to limit the spread of the viruses.

As would be expected, few farmers adopted the improved seed component. However, adoption of other recommended practices which evolved as communication between scientists and farmers developed, was quite high. Two low cost and effective seed management practices were adopted by more than 50 percent of the farmers. These were diffused-light storage techniques which was developed in response to farmers' expressed need for reduced storage losses (Rhoades and Booth, 1982), and improved methods for selecting healthy seed. Over half of the farmers' also adopted insect control measures which had the highest returns for cash invested (Horton, 1984).

Analysis of economic returns to the technology package recommended in the Puebla project also showed that the lower levels of fertilizer application most widely adopted by farmers were more profitable than the recommended levels which were designed to maximize yields, not necessarily returns (Winkelmann, 1976). The analysis also demonstrated that farmers' rejection of recommended planting density was justified because in average years the recommended density gave no significant increase in economic returns and in poor years resulted in lower yields due to greater drought stress.

In other situations, the differential rate of adoption of recommended technology by small-farmers is most easily explained by variations in the environmental conditions under which they are working. Small-farmers often work in marginal environments marked by highly diverse micro-level agro-ecological zones. Moreover, in many areas small-farmers strive to incorporate numerous micro-zones into their production systems as a means to maintain crop diversification and minimize risk. The package of recommended practices may perform well in one micro-zone, but poorly in another despite its proximity.

In their summary review of all of the adoption studies of HYV packages disseminated by CIMMYT, Perrin and Winkelmann (1976) concluded that agro-climatic zone was the most important and consistent variable correlated with adoption patterns. "Relatively subtle agro-climatic gradients can lead to dramatic changes in farmer behavior" because in any given farming area there will be a wide variety of yield increments from a given variety and associated technology.

Agro-climatic zone was also the most significant factor correlated with non-adoption in Gerhart's (1975) study in Western Kenya. The HYV did not perform well in the lowland region where adoption was extremely low. Thirty-three percent of the farmers had tried it, but most rejected it on the basis of poor yields or high cost.

In the Mantaro Valley Project in Peru, no single package of recommended practices represented an economic optimum under the diverse farming conditions of the valley. The variability in yields from the package in on-farm trials was tremendous, ranging from 5t/ha to 40t/ha (Horton, 1984).

Similarly, an analysis of the confusing pattern of very divergent rates of adoption of HYV wheat among three neighboring villages in Turkey showed that in the village where no farmers had adopted the HYV's, the elevation was just high enough that frost problems inhibited the use of new varieties (Perrin and Winkelmann, 1976). In the village with full adoption the agro-climatic conditions were optimum for the new variety and in the village with mixed adoption, they found that the HYV did not perform well in the upper lands of the village which were light and shallow but that farmers had planted it in their plots in the lower alluvial plain.

IRRI (1978) also cited agro-climatic variablility as the critical factor determining adoption patterns in their macro-analysis of HYV rice adoption in South and Southeast Asia. In Northwest India, for example, where adoption of high-yielding varieties was very high, the total environment with favorable climatic conditions, few serious pest problems, and irrigation was ideal for the requirements of the new technology. In contrast, in eastern India yields have remained stagnant because the modern varieties do not perform well under the more difficult production conditions of the area which is subject to flooding and has high insect and disease pressures during the monsoon season. Nile Brady, former Director General of the International Rice Research Institute, comments, " To criticize the region's farmers for not adopting outside technologies which are simply not suited to their conditions is unfair" (1981:7). IRRI scientists explain the impressive widespread adoption of modern rice varieties in the Philippines, where IRRI is located, as resulting from IRRI developing varieties which are tailored to a diversity of local conditions.

Diverse economic conditions among small-farm households in terms of resource endowments and availability of the factors of production is also a factor of critical importance in determining differential rates of adoption of new technologies and recommended practices (Cancian, 1967, 1972; Dewalt, 1975; Franzel, 1984; Greenwood, 1976; Kluck, 1975; Matlon, 1977; Merrill Sands, 1983). It is also probably the factor most frequently overlooked in the analysis of differential patterns of adoption of introduced technologies by small-farmers of a given region.

Dewalt's (1975, 1979) study of adoption patterns in a Mexican ejido provides an instructive example. He found socio-economic class to be the most important factor determining the differential patterns of adoption of introduced technologies. In the case of fertilizer application on maize, the staple food of the region, the poorest and the wealthiest farmers were the major adopters, but for quite different reasons. The poor, who had the most marginal land, used fertilizer to produce enough corn to meet basic subsistence needs. The wealthy farmers with well endowed resource bases and no scarcity of cash, on the other hand, used fertilizer to increase yields sufficiently to make maize production a commercial enterprise. The intermediate farmers had the lowest adoption rates of fertilizer because they were already producing sufficient maize to meet consumption needs and had more profitable alternative investments. Thus, beneath an aggregate adoption rate of fertilizer of 67 percent, there was significant variability in which farmers adopted the technology, at what levels, and why.

The adoption pattern of fertilizer, moreover, was very different from that of another technology introduced into the region---commercial production of forage on irrigated plots. In this case, the aggregate adoption rate was only 15 percent, but when analyzed according to socio-economic class, Dewalt found a high rate of adoption of almost 50 percent among the wealthiest farm families, compared with only 14 percent among the families of intermediate group and none of the poorest. Only the wealthiest households had sufficient capital to invest in this commercial technology.

A second example comes from an ICRISAT study village in Burkina Faso (formerly Upper Volta). Here, upon cursory analysis, the adoption of introduced cotton technology appeared to be defined largely by the ethnic background of the farmers. When analyzed more carefully, however, the differential adoption pattern more precisely reflected land tenure patterns. Members of the ethnic group that moved heavily into cotton production were recent inhabitants of the region and thus had limited access to fertile lowlands were cash crops were traditionally grown. Therefore, when the opportunity to produce cotton as a cash crop on their shallower and drier upland soils became available, they adopted the new technology rapidly (Stoop, 1984).

Within this context of highly variable economic and environmental conditions which characterize small-farm agriculture, then, it is not surprising that we see differential adoption patterns among farming households and among various introduced technologies. Each farm family strives to assemble a combination of enterprises which, ideally, together will make full use of the skills, resources, and factors of production available to meet both its long- and short-term production and consumption goals. Consequently, as we have seen in the examples mentioned above, small-farm households selectively adopt introduced technologies and recommended practices that are most appropriate for their specific environmental and economic conditions.

The implication for research of these examples is that for many small-farmers an appropriate technology which can be directly transferred without adaptive research and local fine-tuning simply does not exist (Brady, 1981; Horton, 1984). Due to the high level of diversity in farming situations, small-farmers end up doing much of the fine-tuning of introduced technologies and recommended practices themselves, experimenting and adapting the technologies to meet their needs and conditions (Biggs and Clay, 1981). The kind of independent, informal, adaptive research carried out by small-farmers is clearly demonstrated by the following four examples.

In Eastern Kenya, CIMMYT conducted an investigation to determine why only 20 percent of the total maize area in the region was planted in the HYV Katumari which they had promoted as a general, widely adapted, maize variety. Franzel (1984) found that farmers had rejected Katumari as a general maize variety because they were unimpressed with its yield performance, ability to be stored, and culinary qualities. Half of the high-income farmers and almost two-thirds of the low-income farmers had, however, adopted Katumari selectively as an early-maturing crop. In this role, it served primarily as a source of much needed maize during the pre-harvest "hungry" season. It also served as an insurance crop. Farmers took advantage of the precociousness of Katumari when they were behind in planting and ninety percent of the farmers believed that Katumari gave the highest yields under drought conditions. Franzel's detailed analysis, thus, showed that despite the low total area planted in Katumari it "nevertheless plays an important role in farming systems by providing farmers with early maize at a time when their own supplies are often exhausted."

A related example of farmers adapting an introduced technology to their specific conditions comes from ICRISAT's on-farm testing of an improved sorghum variety in Burkina Faso (formerly Upper Volta). The trials revealed that local varieties were actually more widely adapted than the improved variety (E 35-1) to a broad range of regional agro-ecological conditions and that the net gain from the improved variety over such a broad variety of conditions was minimal. The introduced variety only significantly outperformed the local varieties in highly fertile fields. The following season, ICRISAT researchers found that the local farmers, based on their observations of the on-farm trials, had continued to use the local varieties in their major fields, but had selectively planted the introduced variety in the highly fertile plots near their houses which receive large amounts of organic refuse (Matlon et al., 1984).

A third example of adaptive adoption of new technology and practices comes from the Puebla Project where Gladwin (1976) using decision-tree modelling found that small-farmers adopted the recommended practice of fertilizing both at weeding and planting only under a specific set of conditions. They used the practice only in one of the two major types of soil and only then if they were planting with the beginning of the rains after the soil was thoroughly moistened. In other conditions they found the practice unprofitable.

Finally, Clay (1980) has documented the quite celebrated example of small-farmer adaptive innovation with the development of bamboo tube wells and mobile diesel pumping units in India. Farmers modified an introduced technology for irrigation so that it was less costly, more accessible due to the use of local materials, and more appropriate for their cropping system of dispersed parcels.

These four examples, taken from among many, persuasively argue the need for strengthening the adaptive research capacities of national agricultural research institutions so that modern technologies can be successfully adapted to local environmental conditions and the needs and circumstances of small-farmers. They also illustrate the potential benefits that could result from developing more effective channels for feedback from farmers to researchers so that farmers' evaluations of new technologies and the results of their experimentation are integrated into the research process (Biggs, 1982, 1983).

Lesson 3: No single attitude, trait, or factor, explains the patterns of small-farm adoption of all new innovations.

This is perhaps the most salient lesson for agricultural scientists and development planners and it carries important policy implications. Farmers apply different choice and evaluation criteria to different technologies and the criteria employed vary among farmers depending on their households' goals for production and consumption and the resources and factors of production to which they have access.

New technologies cannot be clumped together as equal and neutral innovations nor can farmers' innovative behavior e measured by their reactions to one specific technology. This approach only leads to uncritical assessments of introduced technologies and over-simplified interpretations of farmers' motivations for adoption or non-adoption.

Despite ample documentation from detailed field studies of experimentation, innovation, and technology adoption in small-farm agriculture, such as those outlined above, the myth persists in some sectors of the development and research communities that small-farmers are <u>by nature</u> conservative and resistant to change. This idea does not generate any productive insights into the process of technological and socio-economic change. It is essentially non-explanation, the product of armchair conjecture and provides nothing more than an easy means to foist the blame of failed technology development onto the shoulders of the purportedly obstinate farmers.

All of the adoption studies mentioned in this section demonstrate that mono-causal models which propose small-farmers' "attitudes" as a general explanation of (non-)adoption behavior are not supported by the literature (Whyte, 1981). What factors could possibly render small-farmers throughout the world all bearers of such personality or attitudinal traits as fatalism, resistance to change, distrust of inter-personal relations, lack of innovativeness, lack of empathy, or unable to defer gratification, as proposed by those who espouse this approach (Dillon, 1979; Foster, 1965; Rogers, 1969) ?

In the multivariable analysis of the large-scale surveys of adoption patterns carried out by the international centers, no single farmer trait, such as age or education, emerged as significantly correlated with adoption when in the presence of other variables (Gerhart, 1975; Perrin and Winkelmann, 1976).

In Berry's (1975) detailed case study of development of the cacao industry in Western Nigeria early innovators could not be distinguished by personality traits, but rather by different access to economic opportunities.

In the Tetu Rural Development Program in Kenya, the issue of whether "innovative" farmers actually adopt new technology more readily or whether adoption is higher because they are favored by extension efforts was investigated. In a pilot program with hybrid maize, extension efforts were focussed on the less progressive farmers, or "laggards". They found that nearly 100 percent of the farmers who attended the training courses adopted the hybrid and that through diffusion another 2.4 farmers for every trainee adopted the new technology. They concluded that extension efforts work as well with "laggards" as with progressive farmers; the targeting of the efforts was the issue (Morss et al., 1976).

Binswanger (1980) and Walker (1981) tested the common assertion in the literature that "risk averse attitudes" of small-farmers make them resistant to new technologies. They found that while most small-farmers demonstrated moderately to intermediately averse attitudes towards risk, there was no significant difference in attitudes between adopters and non-adopters. Walker (1981) discovered in his study of adoption of hybrid maize in El Salvador that it was farmers' perception of risk with the hybrid that was determinant of adoption. Moreover, he was able to demonstrate that in the village of non-adopters of HYV of maize the risk of drought (which impaired the yields of the hybrid) was actually considerably higher than in the village of adopters. Thus, it was not "attitudes" determining non-adoption, but farmers' evaluation of a proposed technology within their specific environmental conditions.

To understand farmers' diverse and complex criteria for evaluating technologies analyses must probe below the aggregate level of statistical correlation between adoption practices and discreet variables and test the hypothesized explanations for observed adoption behavior. These more in-depth analyses generate the kind of information that is most useful for assisting the appropriate design and promotion of new technologies.

Decision-tree modelling, although it is not the only tool available, has proved very effective at determining the specific criteria employed by farmers when evaluating specific technological recommendations (Franzel, 1984; Gladwin, 1976; Gladwin and Butler, 1984). Gladwin (1976) found in her work with the Puebla Project that farmers employed distinct criteria for evaluating the three components of the technological package recommended. In the decision to increase fertilizer, the main factor limiting adoption was lack of credit. For the recommendation to fertilize twice, the decision against adoption was based on non-profitability when the fertilizer was applied in the predominant soil type. And, for plant density, she found that the recommendation had been inaccurately communicated to farmers who rejected it basically on risk calculations. In the form that they received the recommendation, the planting density would have been much to high to withstand drought stress.

These studies represent important advances in adoption studies because they uncover the reasons behind farmers' adoption or non-adoption of specific technologies and, thus, yield information which agricultural scientists can use to modify the technologies or generate new, more appropriate ones. This approach is more useful for adaptive research than studies which generate models of small-farm behavior to fit recorded statistical behavior. Many models can provide elegant explanations of farmers' behavior without discovering the motivations which generate the behavior. Decision-making criteria applied to new technologies inferred from observed behavior can be erroneous (Cancian, 1967; Gladwin, 1980; Knight, 1980).

An example comes from the Caqueza Project in Columbia. Farmers' non-adoption of an improved maize technology was deduced to result from risk aversion because the technology required high levels of cash inputs. The project responded, therefore, by reducing the risk of adoption for the farmers with two methods. They accepted lower than optimum yields and reduced the cost of the inputs, and they devised a "risk sharing" credit program (Zulberti et al., 1979). However, this did not solve the problem because the reasons for non-adoption had been misdiagnosed (Agudelo and Crawford, 1981). The focus on farmers' assumed risk averse attitude had masked the fact that the benefits from the technology had been overestimated. Its performance in farmers fields was much lower than the estimated yields, and due to the poor culinary quality of the grain from the hybrid, it received a lower price in the market than the traditional variety. The problem, thus, was in the technology, not in the risk averse behavior of the farmers.

Summary

The lessons reveal that small-farmers are not inherently resistant to change, but that they are selective and adaptive in their adoption of new technologies.

Secondly, they indicate that technology transfer is a complex process of socio-economic change. This complexity is often not fully appreciated by those designing, developing, and disseminating new technologies.

Thirdly, they show that there is significant diversity among farming households in adoption behavior and criteria employed to evaluate distinct technologies. This diversity is a product of the broad characteristics and socio-economic organization of small-farms. It reflects the significant heterogeneity among farms resulting from the multiple goals which govern production and consumption, their differential access to resources and the factors of production, and the often marginal environmental conditions under which they are operating.

The evaluation and choice criteria determining adoption can only be understood when small-farm systems and the physical and socio-economic environment in which they operate are analyzed and farmers are integrated into the development process. This is the critical step for bridging the technology applications gap.

In the following chapter, a first approximation of a set of guidelines or conceptual tools is developed in order to assist agricultural scientists and development planners to better comprehend the situation of the small-farm household. They illustrate the possible criteria small-farms may use in evaluating improved technologies and the possible constraints they may confront in attempting to increase agricultural production. The guidelines are developed from detailed studies of small-farm economies and production systems.

CHAPTER 3

GUIDELINES FOR UNDERSTANDING TECHNOLOGY DEVELOPMENT AND TRANSFER IN THE CONTEXT OF SMALL-FARM AGRICULTURE

The technology applications gap typically arises from misconceptions or insufficient understanding of five key socio-economic factors:

1. the relevant unit of analysis for understanding farm management.

2. the goal structure of the farm family.

3. the social organization of the farm household.

4. the organization of the farm household economy.

5. the social, economic, and policy environment in which the small-farm operates.

This section examines each of these broad categories of potential socio-economic constraints to successful technology design and adoption by small-farmers in more detail. Although the distinctions imposed between the categories are somewhat artificial, they are useful for structuring the discussion. The objective is to 1) provide conceptual guidelines to generate a fuller understanding of small-farm systems; and 2) to underscore socio-economic factors which commonly impede technology transfer when they are ignored.

The Relevant Socio-Economic Unit for Understanding Small-Farm Management

In rural economies where small-farms predominate, the household, rather than the parcel, is the appropriate unit of analysis for understanding farm management and decision-making. The failure to recognize this has been a common error in agricultural economic analysis and development planning. The parcel is but one component of an integrated production system and, in turn, the farming system is often only one of several enterprises managed by the farm household (Barlow et al., 1983; Dey, 1984; Gilbert et al., 1980; Low, 1982; McDowell and Hildebrand, 1980; Merrill Sands, 1983; Murphy, 1983, 1985; Norman et al., 1982; Palerm, 1980; Shaner et al., 1982a).

Management decisions on production objectives, crop mixes, factor allocation, and the timing of operations, are made by members of the farm family within the context of both the production and consumption goals and the needs of the household. Interpreting them solely in terms of the parcel can be misleading, as was clearly demonstrated in Cases 2 and 3 presented in Chapter 1.

> The members of the farming household, in achieving a specific farming system, allocate certain quantities and qualities of basic types of inputs---land, labour, capital, and management---to three (production) processes---crops, livestock, and off-farm enterprises---in a manner which, given their knowledge, maximizes the goals they strive to reach (Norman et al., 1982:16).

The household is <u>both</u> the basic unit of production and consumption in small-farm sectors. In Latin America and Asia the household is generally a single socio-economic unit in which resources and income are pooled and the members eat from the same cookpot. Residents are generally members of a nuclear or extended family.

In sub-Saharan Africa, the household, or compound, although the basic socio-economic unit, has a more complex organization in which production and consumption overlap, but are not completely integrated into a single unit. While some of the resources, factors of production, and enterprises are organized on the level of the whole household and managed by the head of the household, there are also sub-units managed by individual wives or sons with their own granaries, purses, fields, and private enterprises (Callear, 1983; Carloni, 1983; Dey, 1984; Guyer, 1980; Hahn, 1985; Henn, 1983; Hill, 1982; Jones, 1984; Kumar, 1985). These sub-units are integrated by a system of culturally defined rights and obligations. Knowledge of organization of the sub-units within the compound is essential for understanding management decisions. Assuming that the nuclear family model of Asia and Latin America applies in sub-Saharan Africa can be misleading (Dey, 1984).

A useful model of the small-farm household economy is that of an <u>integrated system of strategies</u>, or enterprises, which the household exploits to sustain and reproduce itself (Bartlett, 1977; Bennett, 1969; Brush, 1977; Byerlee and Collinson 1980; Cancian, 1980; Cornick, 1983; Cornick and Kirkby, 1981; Dewalt, 1975; Hart, 1978; Hart, 1982; Jones, 1984; Kluck, 1975; Low, 1982; Murphy, 1983; Norman et al., 1982; Ortiz, 1973). This model provides a good framework for understanding of the context of small-farm management decisions and serves as the foundation for the more specific guidelines developed in this section.

1) It suggests that individual strategies have distinct roles and serve multiple goals operative within the household.

2) It recognizes that farming is often only one of several strategies within the household economy.

3) It focusses attention on the nature of the integration between strategies, that is, their level of interdependence, the degree of accommodation made in each in order for the household to pursue various strategies, and areas of competition between strategies as well as areas of flexibility.

4) It places the household within its natural/social/and cultural environment because it assumes that the specific combination of strategies a household exploits is largely a product of the factors of production and resources available. It thus requires a clear delineation of the institutions, rules and cultural norms, both within and outside of the community, which define a household's access to resources and the factors of production (Greenwood, 1976; Halperin and Dow, 1977) and to necessary goods not produced by the household.

5) It recognizes the farm family as the decision-making unit, thus eschewing the common bias that the male head of household is the sole decision-maker.

6) It assumes that the strategies exploited are "adaptive" in that they are designed to try to best meet the goals of the household within the limits of knowledge and resources of the household. It is not assumed that the strategies are the best potential solution, only that they represent a reasonable response to the particular set of opportunities and constraints confronting the household. The basic assumption is that there is usually a good reason why farm households do what they do and, therefore, that the reasons behind farmers' management practices should be determined through field research rather than just assumed to be "bad" and formulating solutions to farmers' problems on that premise.

By focussing on the household, rather than the parcel, the scope of analysis is broadened to include post-harvest activities and concerns which are often major factors influencing adoption and use of new technologies. Murphy (1985) reports that several of the International Agricultural Research Centers have become significantly more aware of the users' perspective in their research and technology development programs since they have focussed on the farming household as unit of analysis in constraint analysis and in evaluating technologies.

The Goal Structure of the Small-Farm Household Economy

A critical first step in problem definition and the design of possible solutions for small-farms targeted for technical and development assistance is to determine the general goal structure governing management decisions. As was evident in the case studies, too often broad assumptions are made about the goals motivating behavior in the small-farm household which turn out to be inappropriate.

Focussing on the goal structure forces us to ask four basic questions, the answers to which are fundamental to successful project design in agricultural development for small-farmers.

- What are the basic goals of the farm household and to what degree are they currently being met?
- Can we propose solutions to help the farm family to better meet specific goals?
- Is there an incentive for the farm family to adopt the proposed new technology?
- Will the adoption of the proposed technology impair their ability to attain other, more important, goals?

In-depth studies of small-farm household economies offer basic guidelines for understanding operative goal structures. It should be stressed, however, that in each situation of small-farm development, field research (drawing on these guidelines) would have to be carried out to determine the specific, dominant, goals determining management.

In most general terms, the best approximation of the overarching goal motivating behavior in the small-farm household is maximization of welfare because it recognizes that multiple goals, not just profit maximization, are pursued (Byerlee and Collinson, 1980; Chayanov, 1966; Collinson, 1972; Dey, 1984; Ewell and Merrill Sands, 1986; Gudeman, 1978; Halperin and Dow, 1977; Harwood, 1979; Hill 1970; Huang, 1984; Jodha, 1979; Merrill Sands, 1984; Moerman, 1968; Norman et al., 1982; Ortiz, 1973; Scott, 1976; Warman, 1976; Wharton, 1971). Welfare is more than food and shelter and more than profit-maximization. It is culturally defined and often incorporates such goals as status, security, prestige, comfort, stability, and leisure. We can all recognize the dominant role these goals play in our own decision-making behavior.

The small-farm should not be thought of solely as a production unit as in the case of a fully commercial farm. It is embedded in the household economy, which unites both production and consumption, and is shaped by the multiple goals operative in that sphere.

> "To farmers, the mean of livelihood, and the social and cultural welfare of the household are intimately linked and cannot be separated" (Norman et al., 1982:16).

The multiple goals govern farming decisions on resource and factor allocation, intensity of production, crop mixes, and the utility of introduced technologies. Consequently, the organization and management of the small-farm cannot be be adequately understood without at least a basic understanding of the predominant goals pursued by the farm family or by specific members.

The union of production and consumption goals within the household economy has critical implications for economic analysis of the farming system and for understanding management decisions. This organization contrasts with the assumptions of neo-classic economic analysis in which production and consumption are divided between the firm and the household with the market regulating the distribution of goods and the allocation of resources and the factors of production between the sectors. Therefore, the small-farm cannot be treated as a firm, or only as a production unit; and profit-maximization cannot be assumed to be the overarching goal motivating behavior (Chayanov, 1966; Durrenberger, 1984; Greenwood, 1976; Halperin and Dow, 1977; Merrill Sands, 1984).

Two distinct value criteria are generally operative within the household economy: "use" value and "exchange" value. The "use" value is the utilitarian value within the sphere of the household economy of an object or good produced internally. Subsistence food production designed to meet consumption goals is subject to "use" value rather than "exchange" value. "Use" value is difficult to translate into prices because the goods are not traded, or the market for them is non-existent or imperfect. "Exchange" value, on the other hand, is the value of an object determined by its exchange in the marketplace for other goods not produced by the household. The value is reflected in relative prices or bartering ratios.

Often small-farmers are producing staple food crops not because they are profitable in conventional terms but because of their "use" value. "Use" value is most apparent in decision-making about staple food crops which are usually primarily subsistence crops and, in many cases, only secondarily used as commercial crops (Bennett, 1969; Brush, 1977; Chibnick, 1978; Collinson, 1972; Huang, 1984; Low, 1982; Jones, 1984; Matlon, 1984; Merrill Sands, 1984; Moerman, 1968; Norman et al, 1982; Palerm, 1980; Scott 1976; Shanin, 1973; Warman, 1976). Cases 3 and 7 are good illustrations of this principal.

In Case 3 in northern Nigeria the "use" value of the subsistence crops was greater for the household than the "exchange" value of the cotton crop. The "use" value encompassed such unquantifiables as food security, exchange obligations, culinary preferences, and risk minimization which are not adequately represented in conventional economic analyses of cash returns per unit of land.

In Case 7 of the mixed system of commercial beekeeping and subsistence production of corn and beans, farmers did not want to abandon food production to specialize in the commercial honey production although the latter gave higher cash returns to labour and cash inputs. Their primary reasons were that: 1) the supply of corn through the market was unreliable in the rural communities; 2) the purchasing prices were erratic and often high; and 3) the culinary quality of commercial corn was poor in relation to that of local varieties. A similar situation was documented among coffee growers in Columbia. Full commercialization was not desirable nor even possible because there was no reliable supply of foodstuffs in the region (Ortiz, 1973).

There are two key issues with respect to the goal structure governing small-farm management that are important to remember in technology development and transfer. The first is that consumption goals, in addition to production goals, are major determinants of the particular mix of strategies exploited by a farming household and of the organization of production within the farming system, i.e. product mix, intensity of production, and factor allocations. The second is that "exchange" value, as reflected in calculated profitablity, is not always a relevant criteria for understanding decision-making especially in the area of staple food production (Barnett 1969; Norman 1974; Matlon 1984). As we saw in Cases 2 and 3, the goal of maximization of yields of a specific crop was not relevant, rather maximization of returns to the limiting factor of production---labour during the bottleneck period---was the critical goal governing decision-making in crop production.

Goals which have been found to frequently have high priority in small-farm household economies are discussed below. It must be emphasized, however, that while these general categories can serve as guidelines for conceptualizing small-farm management and decision-making, their relative importance will vary among farming systems and only certain goals will pertain to specific strategies. In all cases, field research should determine the relevant goals governing the farming system or specific component targeted for intervention.

<u>1) Profit maximization.</u> Profit-maximization can be operative as a goal in small-farm agricultural systems or, more commonly, in components of them. It is not realistic, however, to assume that profit maximization is the sole or even primary goal of production. Norman et al., (1982:21) argue that the assumption that profit-

maximization is the primary goal governing management decisions is only valid when the welfare of the farm family is maximized through profit-maximization. This is rarely true in rural economies of developing countries.

2) Cash maximization. More common than profit maximization in commercial strategies of small farms is cash maximization (Ewell and Merrill Sands 1985; Merrill Sands 1984). In this case, the farm family strives to get the highest cash returns to cash invested and the value of labour and land invested are irrelevant. Cash often has a distorted value in rural economies because while necessary to obtain basic needs or meet basic obligations, such as taxes or rent, it is scarce and the means available to the household to obtain cash are often limited. This goal and the decision-making behavior it generates are not predicted by conventional economic analysis. It underlies the frequent observation by field investigators in rural economies that small-farmers will stay in business when it is no longer profitable (Palerm, 1980; Warman, 1976).

3) Subsistence security. This is the most fundamental goal for small-farm households. For some small-farms in more favorable environments, the risk of not meeting basic subsistence needs is small and, thus, other goals become more important in decision-making. But for the many small-farm families operating in marginal conditions with limited resource endowments and relatively high risk in terms of yield variability and market fluctuations, it is the most critical goal (Collinson, 1972; Ewell, 1984; Harwood, 1979; Hill, 1982; Johnson, 1971; Merrill Sands, 1984; Moerman, 1968; Norman et al., 1982; Scott, 1976; Walker, 1981; Wharton, 1971).

Several mechanisms are commonly used in small-farm agriculture to assure that this goal is met. Small-farmers eschew full dependence on the market, which is often unreliable and exploitative of the small-farmer who sells cheap and buys dear, by producing at least a major portion of their food needs. In rural economies, food is often not available when needed or, if it is available, it is priced significantly above the selling price. This is especially true during periods of scarcity as in the pre-harvest hunger period. This goal causes farmers to give food crops first priority in factor allocation decisions as we saw in Case 3 (Collinson, 1972; Ewell and Merrill Sands, 1986; Matlon 1984; Norman et al, 1982).

A second common mechanism exploited to meet this goal is the maintenance of reciprocal social bonds with other households. In many rural societies, these bonds are ritually formalized and serve as sources of social and economic security in times of crisis for a household---assistance is expected and is rightfully demanded. For households living close to the margin of subsistence, these bonds are of critical importance (Mayer, 1974; Norman et al., 1982; Ortiz, 1973).

The maintenance of social bonds can have a significant influence on production. First, they often provide a means of access to critical production inputs, such as land, labour, capital, or manure or water. Second, they often require goods which the household has to either produce or purchase with cash because they are maintained through practices such as giving gifts of food, exchanging labour, ritual feasting and religious celebrations, or sharing of ritual obligations between households. Again, this goal would not be considered with common-sense assumptions about economic behavior and cannot be adequately reflected in conventional economic analysis despite the fact that it can have a major influence on production.

An excellent example of the impact that social obligations and bonds can have on farm production comes from Northern Nigeria where data collected in a large-scale regional survey in 1970-71 revealed that 18 to 20 percent of total food grain production was dispersed through gifts to other households (Norman et al., 1982). The amount of grain exchanged through non-commercial channels was roughly equivalent to that sold through commercial channels.

Implementation of practices which minimize risk is a third means by which small-farm families strive to achieve the goal of subsistence security. For example, several strategies are exploited to avoid a catastrophic impact on the household. If one fails, production or cash income of another can sustain the household at least on a short-term basis (Almy, 1979; Brush, 1977; Cornick, 1983; Corncik and Kirkby, 1981; Haugerud, 1983; Jodha, 1979; Merrill Sands, 1984; Norman, 1974; Norman et al., 1982; Ortiz, 1976; Walker et al., 1983)

In rain-fed agriculture, crop diversification with the use of drought-resistant or famine crops, varieties of different maturation periods, and mixed food crops with distinct agronomic requirements and production periods (such as cassava and maize), hedge against severe losses from irregular rainfall (Barah and Binswanger, 1982; Jodha, 1979; Walker et al., 1983). In rain-fed regions of southern India, an ICRISAT study found that crop diversification was significantly and positively correlated with stability in crop income (Walker et al., 1983). Norman (1974) in northern Nigeria also found intercropping to give more stable returns.

Planting in dispersed fields can also minimize losses from climatic irregularities (Brush, 1977; Collinson, 1972; Haugerud, 1983). Rainfall is often extremely localized; different soil types have varying capacities to hold moisture; and distinct ecological micro-zones have varying dangers or benefits for crops. Staggered planting dates is another practice implemented to reduce the risk of loss from irregular rainfall.

Collinson (1972) reports that in tests run in Sukumuland in 1962-64, the supply of grain from farmers' fields in which these various risk minimizing practices were employed was significantly more stable than those from the trial farm with fixed fields and sole stands.

The criteria of risk minimization can also emerge in crop choice. Schulter and Mant (1976, cited in Bartlett 1978)) in a study of small-holders in India expected households with the higher worker-land ratios to grow groundnuts which were more profitable and labour intensive. Instead, they found that they grew cotton which entailed less risk because households with large families to maintain and limited resources could not tolerate the higher risk levels associated with groundnuts.

The goal of subsistence security and risk minimization can have a significant impact on technology transfer. As Cases 3 and 5 illustrate, technologies which jeopardize food production by competing for resources or factors of production are likely to be resisted unless the farm family is confident that they will be able to purchase food. Small-farm families may also reject an improved technology which increases variability in yields even if the mean yield is higher since they cannot afford to fall beneath the level of subsistence in any year (Matlon, 1984; Norman, 1974; Wharton, 1971). Similarly, they may not adopt a technology which requires high inputs without stability of yields (Case 1) or which conflicts with practices employed to minimize risk such as mixed cropping, dispersed fields, or the precise timing of cultivation practices (Case 2).

Clearly, this goal, which predominates in the majority of small-farm systems, must be taken into account when designing and transferring technology. Features such as stability of yields or net returns to scarce factors of production are more relevant to the small-farmer than maximization of yields. Moderate yield increases with lower costs is probably a more realistic goal for small-farm technology than optimum yields with high-inputs. Or, compatibility with mixed cropping systems would be a desirable trait in many rain-fed agricultural systems (Norman, 1974; Jodha, 1979). Additionally, production strategies or technologies which smooth out labour bottlenecks or employ labour during low periods of demand in other activities would have a higher chance of adoption (Case 7).

Finally, it must be remembered that although many development projects strive to support technology transferred to the small-farmer with credit, inputs, extension, credit insurance, and market development, success in these areas is often uneven and the delivery of services unreliable. Moreover, corruption can make farmers' reliance on the external system very costly. From the perspective of the architect of the development plan both the security and income of the farmer would clearly increase in the project. However, from the perspective of the farmer who is actually operating in the new system, security and income could well decrease. Consequently, they are hesitant to sacrifice their autonomy.

4) Flexibility: This goal is commonly found to structure the economic organization of small-farms (Brush, 1977; Collinson, 1972; Ewell, 1984; Greenwood, 1976; Merrill Sands, 1984, Murphy, 1983; Norman et al., 1982; Ortiz, 1976; Scherr, 1983). It is closely related to that of subsistence security but can also prevail in small-farms in which the basic subsistence level is not threatened. Flexibility is attained primarily through diversification of strategies and crops and by maintaining multiple means of access to the critical factors of production.

The maintenance of flexibility protects the welfare of the household from the disruptive effects of instability in the physical, social and economic environment in which they are working. It allows them to respond to changing market conditions and reallocate factors of production (Bartlett, 1978; Ewell and Merrill Sands, 1986; Greenwood, 1976; Ortiz, 1976). During the production cycle, it permits the farm family to exercise a series of options in order to adjust to market and environmental conditions as they unfold (Collinson, 1972; Ortiz, 1973).

Towards this end, small-farm households often combine subsistence and commercial strategies which protect them against vagaries in both the market and the physical environment (Almy, 1979; Eder, 1983; Haugerud, 1983; Hill, 1970; Kluck, 1975; Merrill Sands, 1984; Moerman, 1968; Ruthenberg, 1968; Warman, 1976). Or, if they are largely integrated into the market, they cultivate numerous cash crops to buffer against fluctuations in the market (Ewell, 1984). Ortiz (1976) found that farmers would accept relatively low returns from cane production because it afforded greater flexibility within the household production system. It complemented the labour cycle of the principal cash crop, coffee, and was more profitable than temporary wage labour. Strategies or crops are often sustained even during market slumps on the assumption that they will become viable again at a later date (Merrill Sands, 1984; Warman, 1976).

5) Long-term economic stability: The goal of economic stability of the household has an important effect on production decisions although it is often not immediately apparent. It is most obviously manifested in parent-child relations. Rules of inheritance, dowry or bride-price requirements, norms for old-age care, all shape production decisions. But it is also apparent in marriage relations. Frequently, women will develop an "insurance" fund which they can draw on to maintain themselves and their dependents if the male abandons them or dies.

If access to resources and the factors of production is channeled through community institutions, long-term economic stability may also be enhanced by carefully upholding responsibilities within the community or by maintaining political and social status through gift giving, fulfilling reciprocal obligations, ritual participation, and sponsoring religious celebrations.

Small-farm households may also develop certain strategies specifically to insure long-term stability. Small holdings of livestock held basically as savings is a typical example. Financing the secondary education of a child is a second, more subtle, means used to attain this goal. For the near land-less or tenant farmers, maintaining patron-client relations, although exploitative, may be the only means for assuring a minimum of economic stability.

Summary: The preceding discussion and illustrations reveal that multiple goals motivate behavior in the small-farm household economy and that simple common-sense assumptions of a single operative goal, such as profit maximization, determining behavior or adequately approximating it, is frequently misleading. For a sufficient understanding of the small-farm situation, the primary goals which govern production decisions must be determined through field investigations. Furthermore, if the technology designed for small-farmers is to be accepted, it should enhance their ability to meet their goals.

All of the goals mentioned above can be broadly categorized as economic goals. It should be stressed in concluding this discussion on the goals governing small-farm agriculture, however, that economic goals do not always determine behavior. They may be secondary to even more fundamental goals reflecting cultural values and concepts which define what it means to be human or the relationship between humans and nature. These can conflict with pecuniary interests and defy many of our common-sense assumptions about the goals and motivations producing economic behavior (Gearing, 1970; Greenwood, 1976).

An excellent illustration of the role that "non-economic" goals can play in shaping decisions in agriculture is Greenwood's (1976) study of the causes of the demise of small-farm agriculture in a Basque region in Spain. Conventional wisdom explained the rural exodus with the assumption that farmers were maximizing economic gain and responding to the unprofitability of agriculture. Yet, through in-depth field research, Greenwood revealed a very different situation.

He demonstrated that, in fact, the Basque farms had become highly profitable through the recent process of agricultural commercialization associated with the development of the tourist industry in the region. But, people refused to stay on the farms.

"the very same economic changes that helped make the farm profitable have brought farming, as a way of life, into conflict with long-held Basque ideals about man and about the dignity of work. By migrating to the cities, they are sacrificing known economic returns in service of these ideals. Commercialization increased old stresses within the domestic group and created life situations which were intolerable for most young Basques, while simultaneously opening up urban job opportunities." (Greenwood, 1976)

The abandonment of agriculture in this situation was not something technology could solve, it was a cultural problem. The social changes that came attendant with the commercialization of agriculture were at the heart of the conflict. Greenwood argues that for the Basques to be human is to control one's destiny and have dignity and freedom. In pursuing the commercial opportunity of truck gardening, they changed from being autonomous producers to serving a capricious and wealthy tourist population. Production decisions became enslaved to consumer demand. And, the success of their enterprise was no longer a function of factors over which they had control such as their integrity and hard work. Rather external factors influencing the tourist trade such as inflation, interest rates, and international exchange rates became determinant.

In the change, the Basque ideals were compromised. The farmers are angry and humiliated. Farming has lost prestige as a social role and no young Basques want to take over the farms. Greenwood concludes that freedom and dignity are no longer possible in farming as a social role and, thus, profitable agriculture is abandoned to pursue employment which is less remunerative but does not conflict with more fundamental goals and values.

Social Organization of the Farm Household

The social organization of the household is a major determinant of production and management in small-farm agriculture. It structures:

1) the organization of family labour for production.

2) the decision-making process and distribution of authority.

3) the system of rights and obligations among members.

4) the control over production and income.

As Cases 4, 5, and 6 demonstrate, basic knowledge of the social organization of the small-farm household is fundamental for accurately targeting on-farm research, the transfer of technology and development efforts.

Organization of Labor within the Small-Farm Household

The organization of labour within the household is an important factor determining its production activities. There is often significant specialization in agricultural tasks, enterprises, or even crops, among sex and age groups. This division of labour cannot be ignored when trying to introduce technological change.

The first question that should be asked is, Who are the farmers? This may seem ridiculous, but too many case studies show that the significant role that women play in agriculture is repeatedly ignored (Achola Pala, 1980; Ashby, 1985; Barnes, 1983; Boserup, 1970; Carloni, 1983; Dey, 1984; FAO, 1984; Hahn, 1985; Henn, 1983; Kumar, 1985; Moock, 1976; Safilios-Rothschild, 1983; Staudt, 1978; Unnevehr, 1985). In most Asian countries women constitute one-third to one-half of the economically active population in agriculture; in Latin America, although the statistics are poor, one-sixth to one-quarter; and in most African countries well over one-half (Safilios-Rothschild, 1983). Moreover, in many countries women have primary responsibility for post-harvest storage and processing.

This question of Who is the farmer? is particularly relevant to Sub-Saharan Africa where women are very active in agriculture, particularly in food production, both as farm managers and as labourers. In many African countries women provide 60 to 80 percent of the labour in food production as well as a large proportion of the labour in cash crops (FAO, 1984b). In Malawi, census figures show that in 1977 approximately 66 percent of the full-time farmers and 24 percent of the part-time farmers were women (FAO, 1984). In Ghana, women farmers constitute 50 percent of the staple food and vegetable producers. In Kenya, 22 percent of the farms are managed by women (Barnes, 1983), and in regions of Western Kenya, 40 percent (Staudt, 1978). In Swaziland and Lesotho, most of the farming activities are undertaken by women because males migrate to take advantage of the higher returns of wage labour (Callear, 1983).

All too frequently, males are assumed to be the farmer and are targeted in on-farm research projects, development projects or in technical assistance services despite the fact that women are actually the farm managers or are traditionally in charge of the specific crop or activity to which the improved technology applies (Carloni, 1983; Dey, 1984; Hahn, 1985; Henn, 1983; Kumar, 1985; Moock, 1976; Staudt, 1976). The disturbing question which arises is to what degree this male bias in extension and development efforts undermines efforts to increase aggregate productivity in agriculture (Cases 4, 5, and 6).

The second basic set of questions is:

— How is the labour divided in the farm household?

— Which members are responsible for specific tasks, crops, or enterprises?

— What is the degree of specialization?

For example, in Sub-Saharan African countries the division of agricultural labour and responsibilities between members of the household is quite complex. Although the specifics vary among cultures, there is usually a clear sexual division of labour among crops or among cultivation enterprises (Cases 4 and 5). Women generally carry out most of the tasks (except land clearing and often ploughing) in food crop cultivation. Men typically are more involved in cash crops.

As we saw in Case 6, wives and husbands have complementary responsibilities in provisioning the household (Callear, 1983; Carloni, 1983; Dey, 1984; FAO, 1984; Guyer, 1980; Haugerud, 1983; Henn, 1983; Hill, 1970; Kumar, 1985). For example in the Western Sahel, the male head of household is responsible for supplying grains for the main meal of the day; the wives are responsible for furnishing the condiments, pulses, vegetables, meat, and basic cooking ingredients such as salt, sugar, oil, and tea. The items the women do not produce themselves they must purchase with surplus grain sales from their private fields (Carloni, 1983).

> "In many parts of West Africa, husbands and wives who live under the same roof and share the same cooking pot have separate farms and separate responsibilities as providers for their families" (Carloni, 1983).

What is important to remember is that not all labour in the household is equal nor interchangeable by sex and age group (Dey, 1984; FAO, 1984b; Guyer, 1980; Henn, 1983; Kumar, 1985). It is often useful, therefore, to disaggregate household labour by sex and age in order to better understand the division of labour and responsibilities and the areas of specialization. This information can be essential for accurate targeting of development intervention (Burfisher and Horenstein, 1982; Callear, 1983; Dey, 1984; FAO, 1983; Henn, 1983). Sex or age specialization in certain productive activities within the household can cause each group to evaluate proposed technological changes differently in accord with their distinct set of incentives and constraints.

Labour constraints in specialized tasks can inhibit the adoption of new technologies or limit their productivity. Or, by competing for labour, new technologies can jeopardize other spheres of the household's productive activities. A typical example is when plowing or irrigation facilities are targeted at male members of the household. The new technology allows them to either expand the area of cultivation or intensify through multiple cropping, but it often has negative repercussions on the women of the household who are responsible for labour intensive cultivation tasks such as transplanting, weeding, or harvesting (Case 5). For example, a study in Sierra Leone found that in households using primarily mechanized cultivation, women worked 50 per cent more hours than women in households using hand cultivation techniques (Spencer and Byerlee, 1976). As we saw in Cases 4 and 5, if the benefits from the introduced technological changes do not accrue to the household members who are disproportionately affected by labour demands, we can expect that they will resist the technology.

On the other hand, sex roles and the division of labour are not immutable. There are ample cases where, under conditions of socio-economic change (especially stressful ones), roles become more fluid and accommodations are made as new technologies or production strategies are incorporated into household production systems. Such changes can have varying affects, detrimental or beneficial, on different groups within the household (Barnes, 1983; Boserup, 1970; Carloni, 1983; Dey, 1984; Guyer, 1980; Henn, 1983).

A good example comes from the Volta Valley Development Authority (Kumar, 1985). An early study found that the settlement scheme had caused major changes in the organization of household production which adversely affected women. Women lost their right to land, the food crops they traditionally cultivated were not included in the scheme, and their income declined (Murphy and Spree, 1980). A study conducted five years after the settlement began, however, revealed that the organization of household production had changed even more with women regaining more control over both their labour and production. Women's unpaid work in households' common fields had declined and was increasingly replaced by hired labour; women had gained access to private grain fields, the produce of which they could control and sell for cash income; and males had assumed responsibility for many of the expenses that had traditionally been shouldered by women (McMillan, 1984).

Just as women are often the invisible farmers, children's labour in agriculture also often goes unrecognized, although time allocation studies have shown that it is substantial in many rural societies (Merrill, 1979; Nag et al., 1978). For example, children traditionally assume the task of bird-scaring which is critical for sorghum yields. Children's absence in school has reduced the farm family's total labour supply and forced other members to assume responsibility for tasks traditionally delegated to children or to neglect them. Women are frequently those who assume the extra burden.

While labour specialization among household members has the positive affect of allowing the household to pursue several activities and, thus, maintain diversification and flexibility, it can also render the household vulnerable when specific members of the household are sick or absent.

Organization of Decision-Making and Authority:

It should never be assumed that there is only one decision-maker in the farm household; the relevant decision-maker should be determined. Too frequently in agricultural research and development, it is assumed that the male head of household is the decision-maker with respect to adoption of innovations. As Case 6 illustrated, however, this assumption is often erroneous and can compromise the success of the project.

In most small-farm households, the responsibility for decisions is distributed among different members active in production, processing, and preparation of products. This creates distinct spheres of work, goals, and authority and often results in a complex process of shared decision-making. It is, therefore, important to have a basic understanding of the structure of decision-making within the farming unit so that the appropriate members are consulted about proposed technological changes.

As Cases 4, 5, and 6 illustrate, if women are the decision-makers in the targeted enterprise, the success of the project or technology transfer will be jeopardized if the male head of household is consulted and involved in the project rather than the women. Or, if women and men share responsibility for a crop or enterprise, they must both be regarded as decision-makers whose opinions and evaluations of an introduced technology will affect its adoption. Jones (1984) found in northern Camaroon that resource allocation in small-farm households was the result of a complex bargaining process between husbands and wives. This indicates that technology adoption may depend on a consensus between numerous decision-makers each with their own goals, priorities, and motivations and implies that simple assumptions of profit maximization as an overriding goal guiding agricultural decisions may not accurately reflect the decision-making process (Unnevehr, 1985).

While the primary decision-maker is often the person who carries out the activity or is responsible for certain crops, this cannot be assumed and has to be determined through field investigations. In some instances, the authority for decision-making on the timing or quantity of critical inputs may lie with the head of household or farm manager who allocates responsibility for certain activites to other household members. This can be a particularly difficult problem for agricultural development in societies where the male head of household retains authority for decision-making on the farm despite prolonged absences in migrant wage labour.

The System of Rights and Obligations

Members of the farming household are bound together by a complex system of rights and obligations. This system is an important factor organizing production and consumption within the household. It structures the hierarchy of goals operative in the household. It determines the number of cookpots and who shares them; the combination of private and household fields and enterprises; the degree to which resources, assets, and the factors of production are pooled among members; and the disposal of the household's products and income. It also influences planning decisions and the long-term viability of the household.

As we have seen, frequently individual members have complementary responsibilities in provisioning the household. These determine their goals and their choice of enterprises, their product mix, their priorities for certain crops or animals, and their factor allocation decisions.

The system of rights and obligations also determines the individual member's access to and control over household labour, assets, inputs, resources. It cannot be assumed that household members pool and share these equally nor that they are all working towards a common goal (Callear, 1983; Carloni, 1983; Dey, 1984; Guyer, 1980; Henn, 1983; Hill, 1982; Kumar, 1985). Private and household fields may be managed very differently (Norman et al., 1982). For example, Ancey (1975) found in West Africa that the head of household emphasized food self-sufficiency and inter-annual security in his production decisions, while the younger men of the household emphasized market production and net cash income in their private fields.

There are generally two critical, and often quite complex, dynamics operative in the system of rights and obligations. The first is that between husbands and wives and revolves around the degree to which they are integrated into a single economic unit. In most Sub-Saharan African households the head of the household does not control all of his wives' labour nor all of their resources or product. When introduced technology increases the demands for women's labour in men's crops, it is not unusual that the men will have to pay their wives for the labour which goes beyond the traditional obligations (Dey, 1984; Kumar, 1985). Similarly, it cannot be assumed that women farmers will have access to their husband's resources or assets (Dey, 1984; Guyer, 1980; Henn, 1983). Cases 4 and 5 provide good illustrations of this principal.

The second is that between the head of household and adult children revolving around the issues of inheritance, labour demands, and children's autonomy. If there is a need for labour in production, the parental household strives to retain the labour services of its adult children, while the adult children struggle to assemble sufficient resources to marry and establish an autonomous household. The strength of the household can depend on finding a balance between these two conflicting goals (Ancey, 1975; Greenwood, 1976; Hill, 1982).

A good example comes from the gandu in Huasaland Nigeria (Hill, 1982). Married sons living in their father's compound are obligated to work on his fields and, in turn, the head of the household has to provide them with the main meal of the day during the farming season. The father does not have to provide food during the dry season. The sons have sufficient free time to earn their own livelihood with private plots or in non-farm activities. In its ideal form this arrangement is beneficial for both. The sons can build up an economic base while under the security of their father's compound and the father benefits from their labour and the delay in dividing up the limited property of the household.

The system of rights and obligations can influence the success of technology transfer. Technology which threatens the balance of rights and obligations within the household may not be adopted or may not be feasible when household resources are not pooled. Case 5 provides a good example of this with respect to husbands and wives. Another manifestation is that if the head of household has to pay for wives' or sons' labour because it falls outside of traditional obligations, than a new technology may be rejected because it is not economical. Yet, thinking in terms of pooled family labour and resources, development planners may have calculated the returns to the technology as profitable (Dey, 1984).

An example from Senegal illustrates how the system of rights and obligations between fathers and sons affected the adoption of introduced technology. The French found that farmers were not adopting post-harvest ploughing which they had recommended to restore the organic matter of the soil. The primary reason was a labour constraint: the young men of the household were free from obligations to their elders with the harvest and thus were not available to do the ploughing. A similar problem impeded the adoption of the practice of de-stumping. Since these tasks were not included within the traditional system of obligations, young men had to be paid and credit had to be provided to the farmers (Elliot, 1977).

A further implication is that if the system of rights and obligations is ignored, as in Case 5, agricultural development can increase inequity between men and women (Achola Pala, 1980; Boserup, 1970; Burfisher and Horenstein, 1982; Carloni, 1983; Dey, 1984; FAO, 1984b; Henn, 1983; Spencer and Byerlee, 1976).

"...modernization in agriculture has tended to concentrate lands, assets, and cash earning opportunities in male hands at the expense of women, thereby making it difficult for them to fulfill their traditional roles as producers" (Carloni, 1983:71).

In areas where women are the primary food farmers this has serious implications for the well-being of the society at large. Limited access to cash and land constrains their ability to increase production through improved technology. The implication for agricultural development is that women's resources have to be increased (eg. through higher prices for their products) if new technology is to be adopted and food production increased (Henn, 1983).

Control over Production and Income

The organization of control over the disposal of household production and income is closely related to the system of rights and obligations. It is important to understand in the process of technology transfer because it influences whether the decision-maker or principal actor in the targeted activity will have an incentive for adopting the proposed technology (Dey, 1984). Cases 4 and 5 showed how the productivity of irrigated projects was compromised because the women, who were the workers, had no incentive to increase output. Their husbands controlled the product of their labour and they received no personal benefit.

Summary: This discussion has demonstrated some of the many ways in which social organization of the household can influence the management of a farming system and decisions affecting technology transfer to small-farmers. It has also illustrated that the introduction of a technology can have varying effects on production and the welfare of members of farming households depending on the social organization of the production unit (Guyer, 1980). The major points of the discussion can best be summarized by seven basic questions which should be addressed during the course of problem formulation and research and project design.

--- Who are the farmers?

--- How is labour organ_ed within the household?

--- Do the members of the household have common goals?, and Will all of those active in the targeted area have an incentive to adopt the proposed technology?

--- Which members of the household are responsible for or have the most knowledge about the production area targeted for intervention?

--- Which members are the relevant decision-makers for a proposed technological change?

--- Who will benefit from the proposed change?

--- Will other members of the household be adversely affected by the technology change?

Organization of the Farm Household Economy

Many of the salient features of the economic organization of the small-farm have already been discussed: the household as the relevant unit of analysis; the multiple goal structure; the division of labour among sex and age groups; the system of rights and obligations; and control over resources, products, and income. There remain, however, three key points to address.

1) The economic organization of the household is structured by an integrated system of diverse production strategies.

2) The relative availability of the factors of production---land, labour, capital, and management---in the rural economy is a major factor shaping production systems.

3) The particular combination of strategies a household exploits is largely a product of the resources and factors of production it is able to assemble.

1. The economic organization of the household is structured by the integrated system of diverse strategies it exploits. The various agricultural enterprises in the farming system usually represent distinct strategies and they are generally supplemented by others such as trade, wage labour, or food processing.

An important first step in analyzing a small-farm system with the view to introducing improved technology is to determine the role and objectives of the targeted agricultural activity in the household economy. The second is to examine its linkages and degree of interdependence with the other strategies in the system. Both of these are determinant in management decisions, factor allocation patterns, and areas of constraint and flexibility within the strategy and the production system (Barlow et al., 1983; Cornick, 1983; Hart, 1982; McDowell and Hildebrand, 1980; Merrill Sands, 1984).

As was mentioned above, specific strategies serve specific goals within the household. These can be obvious such as food provisioning or cash generation, or more subtle such as the production of goods to be exchanged in barter or accumulated for dowries, bride prices, or ritual obligations. The strategies are, therefore, often not interchangeable nor their respective products comparable (Cases 3 and 7). It is essential to know the objective of the strategy targeted for intervention in order to develop and evaluate technologies which will help the farm family to better meet its goals. For example, if the staple food crop is not a profitable commercial crop, as is often the case under government "cheap food" policies, and is being grown for its "use" value, then there is little incentive for the farmer to increase production beyond his calculated average subsistence needs.

This has important implications for technology design and transfer. When subsistence needs are being met with the existing technology, it is not likely that the farm family will adopt improved technologies which require increased investments of labour or cash despite higher yields (Lang and Cantrell, 1984). They may however adopt low cost improvements, such as improved seed, in order to enhance food security or free land and labour for other enterprises as the examples of rapid adoption of hybrid corn seed given above demonstrate (Gerhart, 1975; Low, 1982).

On the other hand, if subsistence needs are not being met or stores are depleted after several consecutive poor production years, then the farm family may invest generously on the basis of the "use" value of the staple food. These behaviors are hard to predict with conventional economic analysis where regional or government prices do not adequately reflect the "use" value of the commodity within the household economy.

Low (1982) provides a pertinent example from Lesotho and Swaziland. Although small-farm families have money to buy corn and it is available in the market, they grow it because it costs them three times more to purchase than to produce it. In this case, when the government promoted hybrid maize to encourage the commercialization of agriculture through surplus maize production or expanded areas of cash crop production, the results were not those desired. Farmers rapidly adopted hybrid maize, but only to more completely meet their subsistence needs. They invested their surplus labour in more lucrative wage employment.

The degree of interdependence of the household's strategies is also relevant to technology transfer. Interdependence can be in terms of production inputs, availability of factors of production, the production cycle, or mutually beneficial agronomic affects. Changes induced by a new technology in one strategy can have negative repercussions in another which will cause farmers to reject the technology (Cases 3, 4, and 5).

For example, in many mixed crop-animal production systems, each strategy depends on the other for critical production inputs. Field cultivation requires animal traction and crop productivity relies on animal manure. In turn, animals feed on crops or crop residues. While this type of tight integration between strategies results in an efficient use of scarce resources, it also means that production decisions within each strategy are more complex (Cornick, 1983; Cornick and Kirkby, 1981; Harwood, 1979; McDowell and Hildebrand 1980). If a high-yielding variety increases grain yields but has stalks or leaves that are inadequate as animal stover, then farmers may well not adopt it.

A less obvious example is the impact of the strategy of male migrant wage labour on productivity in small-farm agriculture. The effects are variable, but should always be considered. If remittances are received, those who are left to tend the farm can hire young men to perform the heavy agricultural tasks of clearing the land or plowing, or invest in labour-saving inputs. In this situation, migration can, in fact, increase productivity in the agricultural sector if there is not a significant loss of management skills as well. In the Upper Wedza region of Zimbabwe, the substantial income from male migrants' remittances allowed women farmers to expand maize production which required input costs of hybrid seeds and fertilizer (Callear, 1983).

It is not uncommon, however, for productivity and the general welfare of the farming household to decline when males migrate (Barnes, 1983). Even if the household receives money from the absent head of household, they may not have the authority to invest it in agriculture or males may not be available for hire. When they do not receive any remittances, they have to adjust farm management to compensate for the decline in available family labour. They may resort to clearing low secondary bush, but suffer from poor yields due to the reduced fallow period. Or they may switch to less labour intensive crops (FAO, 1984b).

An example of this interaction comes from southeast Ghana. When men migrated and women were left with the responsibility of maintaining the family alone, they changed from planting yams to cassava. The latter have a higher caloric return to labour invested and have better storage qualities. The impact on the general welfare of the household, however, was negative. The new cropping system was less nutritional; cassava is lower in protein and is not intercropped with vegetables and pulses (Bukh, 1979).

On a more general level, the integration of multiple strategies into a diversified production system places constraints on the degree to which any one strategy can be commercialized or intensified (Cornick, 1983; Cornick and Kirkby, 1981; Ewell 1984; Gudeman 1978; Mallon 1984; Merrill Sands 1984; Ortiz 1973). The resources and the factors of production controlled by the peasant household are limited and have to be carefully allocated among strategies within the context of the system and in accord with the consumption and exchange criteria of the household.

Case 3 illustrated this principal well. Clayton (1968) also provides a second good example from Eastern Africa in which the production cycles of coffee and maize conflict. Farmers give priority to the timely pruning and harvesting of coffee which generates much higher returns and accept the lower yields of maize resulting from the delay in weeding.

By opting for the enhanced economic stability, food security, and flexibility provided by the diversified production system, small-farm households are accepting a limit to the degree to which the productivity in any one strategy can be developed. Yields in each strategy may not be maximized, but the combined production better serves the needs and the goals of the household.

2. The availability of the respective factors of production---land, labour, capital, and management---within the rural economy is a major factor shaping the organization of the farming system and management decisions and objectives.

Limiting factors of production must be taken into account when designing new technologies. Improved technologies should 1) help the farm household to maximize the returns to its available resources; and 2) be feasible to adopt. Cases 2 and 3 from N. Nigeria illustrate this point. The traditional technology maximized returns to the limiting factor of production---labour. The proposed technology ignored this constraint and was not adopted.

The relative availability of the factors of production varies among rural situations and should be determined in each case. Some conditions are quite widespread, however, and can serve as basic guidelines.

In general in the small-farm situation, productive capital and cash are chronically scarce and the means to obtain them limited. Furthermore, they are subject to complex allocation decisions within the household where production needs are weighed against consumption and saving priorities.

Pressing consumption demands can erode capital for investment in production or limit the availability of cash to purchase necessary inputs. This conflict can become acute in the pre-harvest "hungry" season. The household is buying food because its stores are depleted, but this is also the busiest time in agriculture when it needs cash to buy inputs and hire labour. Productivity can suffer because farmers are weak or because they have to hire themselves out as wage labourers to earn cash to buy food and, consequently, delay planting in their own fields (Norman et al., 1982).

An extreme example of this problem comes from Senegal during the aftermath of the Sahel drought. Small-farmers participating in a resettlement scheme were desperate to buy food in the pre-harvest season because they had no stores. They resolved the conflict by purchasing machinery and inputs on credit from the project and then promptly reselling them for about 25 percent of their value in order to obtain cash to buy food (Rocheteau, 1984).

The general scarcity of cash and its dual purpose in both consumption and production tends to make small-farm households invest cash conservatively because they cannot afford a major loss. It also makes them tend to invest incrementally because they are rarely able to accumulate large amounts. This is one of the principal reasons for the typical step-wise pattern of adoption of components of a technology package noted in Chapter 2. Additionally, small-farm households often try to maximize returns to cash invested and will discount the value of family labour to do so (Cases 1 and 7).

Labour can also be a limiting factor of production (Bartlett, 1978; Boserup, 1965; Brush, 1977; Chayanov, 1966; Clayton, 1968; Collinson, 1972; Kumar, 1985; Matlon, 1984; Norman et al., 1982). When time allocation studies are executed in rural economies, the myth of the idle peasant is shattered (Brush, 1977; FAO, 1983; Henn, 1983; Merrill, 1979; Morss et al., 1976). Small-farm families work long hours with considerable drudgery. Technologies which are based on the assumption of rural underemployment in many cases are, therefore, not desirable unless land is the limiting factor of production or the returns generated are sufficient to enable hiring labour (Case 4).

Family labour is generally the small-farm household's primary productive input. It is also the one over which they have most control and can allocate with greatest flexibility. It must, therefore, be carefully managed in order to maximize the welfare of the household.

The reliance on family labour can create seasonal bottlenecks as several of the case studies illustrate. Labour constraints are particularly onerous for households in the early stage of their development cycle when there are many small children to feed and only one or two adults to carry the work burden. As the household develops and the ratio producers to consumers increases the organization of the farming system will change. If land is not a major constraint, the household will pursue more strategies or exploit the existing ones more intensively (Bartlett, 1978; Chayanov, 1966; Jorian, 1984; Kluck, 1975; Merrill Sands, 1983).

Labour bottlenecks can often be ameliorated by hiring labour, but the distinction between the value of family and hired labour from the farmer's perspective must be born in mind. The cost of the family labour is rarely imputed because they have to be fed whether they work or not. Hired labour, on the other hand, represents an additional production cost because it requires the expenditure of scarce cash or products. Moreover, labour is not always available for hire during the bottleneck periods in the production cycle.

Introduced technologies, if they are to be adopted, should not aggravate existing bottlenecks (Cases 2, 3, 5). Case 7 of beekeeping in Mexico illustrates a positive case in which the labour demanded by the new technology complemented that of the agricultural cycle and was able to more fully employ household labour. Farmers also use intercropping to spread out the peak demand for labour and, thus, maximize total production through the fuller utilization of household labour (Jodha, 1979; Norman, 1974).

Finally, an aspect of labour in small-farms to which researchers and development planners often do not pay sufficient attention is the integral relationship between labour power, food, health, and productivity. Farm families, however, are acutely aware of this relationship. They know that their survival (both in the long- and short-term) is dependent on their ability to labour. They, therefore, strive to conserve their strength and manage their labour expenditures judiciously. Production beyond subsistence requirements will be curtailed if it threatens to deplete the strength or jeopardize the health of the household's workers.

In many parts of Africa, this relationship is most obvious during the "hungry" season when it is a major constraint to productivity (Matlon 1977; Norman et al., 1982, Rocheteau, 1984). The period of the most concentrated and critical labour demands in agriculture coincides with that of shortest food supply. People are hungary when they most need their strength. Resolution of this problem should be a primary focus in areas where the "hungry" season is acute. Possible solutions are early maturing food crops, improved storage, or consumption credit.

In areas of high population density, the availability of land is usually the limiting factor to production and primary determinant of family welfare (Bartlett, 1978; Boserup, 1965; Geertz, 1973; Hill, 1982). von Rotenhan's (1968) study in Sukumuland, Tanzania, found that whereas in areas of low population density family income was tied directly to family labour resources, when population density rose and land became sufficiently scarce to limit the productivity of labour, the relationship declined in importance.

At this point returns to land become more important than returns to labour (Boserup, 1965; Ruthenberg, 1968). Under population pressure, the farm household is forced to accept declining marginal returns to labour in order to intensify production in a process Geertz (1973) has aptly termed "agricultural involution." Rural underemployment may exist in these situations because households do not command sufficient resources to fully employ family labour (Hill, 1982) and technologies which increase yields to land with intensified investment of labour would be appropriate.

3. The particular combination of strategies a household exploits is largely a product of the resources (e.g. manure or water for irrigation) and factors of production (land, labour, capital, and management) it can assemble (Bartlett, 1978; Berry, 1975; Brush, 1977; Clay, 1979; Dewalt, 1975; Dey, 1984; Greenwood, 1976; Halperin and Dow, 1977; Haugerud, 1983; Hill, 1970; Huang, 1984; Kumar, 1985; Mayer, 1974; McGough, 1984; Merrill Sands, 1983; Merrill Sands, 1984; Murphy, 1983). Small-farm households employ multiple means to gain access to the necessary production inputs and the particular channels they employ shape the production system (Greenwood, 1976). These channels are often quite flexible and change over time (Bartlett, 1978; Clay, 1979; Ewell and Merrill Sands, 1986; Greenwood, 1976; Murphy, 1983).

In most rural economies, other institutions besides the market have important roles in determining access to and distribution of resources and factors of production among households (Berry, 1975; Greenwood, 1976; Halperin and Dow, 1977; Haugerud, 1983; Hill, 1970a, 1970b; Kumar, 1985). Knowledge of these channels---means of access---is basic to understanding the organization, dynamics, and areas of constraint and flexibility within the farming system. It also elucidates a primary source of variability between farming systems within a specific region.

The primary means of access may differ among strategies. For example, inheritance may be the primary means of access to lands which have been improved or planted in tree crops, while flexible usufruct rights prevail for lands more distant from the villages which are cultivated under an extensive swidden system (Netting, 1968). Knowledge of the means of access to the factors of production required for a production activity targeted for technology transfer can help prescreen the acceptability of the technology.

Common means of access to resources and the factors of production operative in small-farm sectors include the following (Greenwood, 1976; Merrill Sands, 1984):

Purchase - land, labour, and capital.

Production - includes altering land to make it cultivatable, having children which is the primary means of access to labour in most rural economies, and the production of capital goods such as tools, seed, or animals.

Rent - primarily applicable to land and tools.

Inheritance - a primary means of access to land and capital in many rural societies.

Reciprocity - a common means of access to scarce resources and factors of production in small-farm agriculture through which resources are shared or exchanged among households. Includes arrangements such as exchanging lands in different ecological zones, reciprocal labour obligations, sharing equipment and animals, or exchanging labour for access to land, capital inputs, or technological knowledge. Reciprocal relationships are most common within kin groups and the acceptance of mutual obligation is generally formalized through ritual.

Marriage - can provide access to land either through ownership or usufruct rights; to labour both in terms of the division of labour between the sexes and in terms of opening channels for reciprocal labour exchanges; and to capital through bride prices or dowries.

Kin Group or Tribal Affiliation - an important channel for access to land in many African societies; can also structure access to labour and to critical resources such as watering holes for animals or wells for irrigation.

Gift - these usually occur between close kin or households tied through formalized ritual or social bonds.

Appropriation - this includes stealing of capital goods or seizing of lands.

Once the means of access are understood, it is then possible to see how farming households exploit these various channels, their effect on the organization of the farming system and management decisions, and possible areas of constraint and flexibility with respect to the availability of factors of production and critical resources. Furthermore, we can more accurately estimate the feasibility of a technological change within the context of the existing means of access to the factors of production. Several examples will serve to illustrate this point.

In situations of land scarcity, the means by which farmers procure land has a significant influence on the farming system. In a region of Costa Rica, the amount of land the household controlled was the primary determinant of the crop options it could exploit (Bartlett, 1978). Landless households or those which had not yet received their inheritance were limited to annuals since they had to renegotiate for a land parcel each year. Among the households which had land, they all planted annual subsistence crops and then with increasing amounts of land, tobacco, coffee, and pasture are successively added to the product mix.

Greenwood's study (1976) among the Basque, where access to land was limited basically to inheritance, revealed that the type of land farm families owned was the principal determinant of whether they engaged in cattle/dairy production or more lucrative truck farming.

In the Andes where households strive to exploit multiple ecological zones in order to fully meet their consumption needs, sharecropping or exchange of land parcels are the primary means of obtaining this objective (Brush, 1977; Mayer, 1979).

A more complicated example comes from the Philippines (Takahashi, 1970, cited in Bartlett, 1978). Here tenancy as the primary means of access to land resulted in severe constraints on productivity and adoption of improved technologies. Tenant farmers were heavily in debt to their landlords, but they were not interested in investing labour or cash to increase productivity on the land because most of the benefits would accrue to the landlord. Instead, their strategy was to hire labour for their own plots, the cost of which the landlord was obligated to pay half, and work as wage labourers for others because the landlord could not seize any of their cash income for loan repayment. The result was poor farm management and lack of incentives to increase agricultural production.

In rural societies where land is not as scarce, the means of access to labour and cash are more important. In Yucatan, Mexico, (Case 7) beekeepers with active reciprocal labour arrangements who did not have to hire labour were able to more successfully attain the objective of the strategy—— maximizing net cash returns. Berry (1975) found that pioneer cacao farmers in Nigeria relied on kin groups and home community networks, which were a source of labour, support, and services, as the primary means to mobilize capital to initiate production in the frontier forest zones.

Among the Paez Indians in Columbia, households have to ensure that they grow sufficient food crops in order to be able to prepare the meal required for reciprocal labour exchanges in coffee production. This is the means by which they procure a large number of workers to complete a task quickly (Ortiz, 1973). This occurs in the Peruvian Andes as well (Mayer, 1974). Similarly, in the hills of Nigeria, farmers need to allocate land to grow surplus millet because beer made from millet is the just recompense for labour contributed under reciprocal exchange arrangements (Netting, 1968).

Changes in the means of access to the factors of production or critical inputs within the rural economy can have major repercussions on the organization and viability of the farming system. Achola Pala (1980) shows the negative impact on women's ability to meet their household obligations with changes in land tenure among the Joluo in Kenya. Land reform, which gave men individual ownership of land, eliminated women's usufruct rights to land within the patrilineage for their private fields.

In the case of the Basque described above, constriction of the means of access to land caused by commercialization aggravated existing pressure points within the domestic unit which resulted in the demise of farming in the region (Greenwood 1976).

Haugerud (1983) provides an interesting example from the Central Highlands of Kenya of the tenacity of traditional institutions in providing means of access to the factors of production. Here the state instituted land reform in order to create consolidated landholdings with single ownership with the objective of commercializing small-holder agriculture. Twenty-five years later, the legal form of land ownership was still widely contravened as households continued to use traditional means of access --- lending, multiple parcel ownership, and exchange --- as a way to maintain diversified production systems and exploit multiple ecological zones.

Changes in disposal channels and the means by which households procure basic necessities for household consumption also influence the organization of the farming system and the choice of product mixes. The expansion of market opportunities is an obvious example of this, but this will be discussed in the next section on the linkages between the farm and the larger society of which it is a part.

<u>Summary:</u> The analysis of the organization of the farm household economy places the farming system within the context of an integrated system of strategies which the members of the household exploit in order to maximize their welfare. The discussion raises several basic questions which can serve as guidelines for planning improved technologies for small-farmers.

--- What are the enterprises exploited by the household and what role does farming, or the targeted activity, have within the household economy?

--- Does the household have an incentive to increase yields in the targeted crop?

--- What are the principal constraints affecting production?

--- What are the principal constraints on consumption?

--- What are the principal areas of flexibility in the economic system of the household?

--- What channels do households use to gain access to the factors of production and critical resources? What is the most limiting factor of production

--- How will the farm family benefit from the proposed change?

--- What could be the possible negative repercussions of the introduced technology on other strategies in the household production system? Would these prevent adoption of the technology?

Socio-Economic and Policy Environment of the Small-Farm

In the process of technology design and transfer, it should not be forgotten that the small-farm is embedded in a larger socio-economic and policy environment which also shapes the farming system and its potential productivity. It is, therefore, necessary to examine the linkages between the small-farm and the community, region, and nation-state in which it operates. These linkages can function as major sources of constraint or flexibility for the farming system and household economy (Blustain, 1985; Collinson, 1972; Ewell and Merrill Sands, 1986; Hardaker et al., 1984; ISNAR, 1984; Low, 1982; Merrill Sands, 1984; Mintz, 1974; Morss et al., 1976; Norman et al., 1982; Orlove, 1977; Palerm, 1980; Scherr, 1983; Stavenhagen, 1976; Warman 1976).

On the community level, these linkages include: inter-household labour exchange or wage opportunities, rules regulating household access to communal land or resources (such as irrigation water), community labour obligations or taxation, ritual or social obligations, systems of political power and social status, and mechanisms or institutions for collective action.

National level linkages include: market channels for farmers products as well as for agricultural inputs and consumer goods, government pricing policies, credit institutions, agricultural extension and development agencies, agricultural research systems, agricultural services, communication and transportation infrastructure, taxation, laws regulating land ownership, education facilities, and political organizations.

Analysis of the impact on small-farm management and productivity of off-farm social, economic, and political constraints and opportunities, particularly those operative at the national level, has been a major focus of the literature on agricultural development. The topic, therefore, receives only a cursory treatment in this review which intends to summarize the literature on on-farm constraints to technology adoption and application. The point to be made is that the linkages which define the social, economic, and political environment in which the small-farm operates must be borne in mind when designing, developing, evaluating, and adapting new technologies. As Case 1 illustrates, the benefit of yield increases is dissipated if the price for the product is weak or the inputs are too costly or not available when needed.

Although the importance of these linkages in defining farmers' management strategies is obvious and has been commented on extensively in writings on agricultural development, it is not uncommon that such external social, economic, and political conditions are overlooked during the design and development phase of "improved" technologies when yields are the primary yardstick for measuring success. Often it is not until researchers or development planners are puzzled by the lack of adoption of what they have considered to be an improved technology that they assess the impact of external socio-economic conditions on the viability of the technology.

Goodell's study (1982, 1984) of constraints to farmers' adoption of an integrated pest management technology for rice production in Southeast Asia provides a good example of the too common tendency in technology design and development of divorcing the technology from the socio-economic conditions in which it is to be used until the final evaluation stage. In this case, collective action by farmers who were field neighbors was integral to the success of the technology which relied on synchronous planting and pest management over an extensive area of approximately 1000 ha. Yet, despite the importance of farmers' collective action to the technology, the feasibility of farmers organizing to work together on such a large scale was not considered until the final stage of technology evaluation. It was merely assumed that the social institutions would be developed to meet the needs of the technology.

When scientists began to test the technology on farmers fields, however, they discovered that the development of effective farmer organizations is a long and complex process in itself. Farmers have to believe that cooperation is beneficial; institutions to support collective action for a common interest have to be built or existing institutions have to be mobilized to direct collective action towards the new objective; and skills for working in groups and making group management decisions have to be developed. Eventually, as scientists came to realize the difficulties of organizing large numbers of farmers whose only relation with one another was that they had contiguous fields, they began to seriously reexamine the basic assumptions under which the technology had been designed. "What the entire team expected to be the final stage of technology development turned out to be the beginning of the process instead" (Goodell, 1982:39).

A similar situation occured with the development of ICRISAT's technology for water management units to be used in the deep Vertisol soils in India (Walker, 1982). Again, the technology depended on collective action by farmers, but little socio-economic analysis was carried out during the design and development stage of the technology to see if collective action was feasible. It was assumed farmers could be organized and socio-economic factors could be manipulated as required by the technology. Not surprisingly, when on-farm testing began, there was a major problem with farmers' continued participation in the project.

Unfortunately, examples abound of sound technologies being rejected because farmers could not count on timely delivery of critical inputs or credit; or because they could not find stable and adequate markets for the surplus production generated by the "improved" technology; or the potential returns to the farmer from an improved technology were dissipated by the profit-taking of intermediaries. A related problem is that of low government prices for food crops which serve to maintain low wages in urban areas but are a strong disincentive for surplus production in the small-farm sector.

In many cases these external socio-economic constraints are disregarded on the assumption that they can be adjusted to provide more favorable conditions to the small-farmer once the more intractable technical constraints are removed. Social and economic engineering, however, is usually a much more difficult process than imagined. The French experience with the Unités Expérimentales in West Africa and the disappointing results of numerous large-scale integrated rural development projects (Ewell and Poleman, 1980; Palerm, 1980; Warman, 1976) provide ample evidence of this point. Social policy is fraught with conflicting interests, priorities, and objectives in which the small-farmer usually has little voice or power. Instituting policy or economic changes for the benefit of small-farm families, therefore, can be as complicated and difficult as developing technologies to alleviate physical constraints within the farming system. Equal weight should be given to both processes.

CHAPTER 4

RECOMMENDATIONS FOR BRIDGING THE TECHNOLOGY APPLICATIONS GAP

The case studies and analysis of the patterns of small-farm adoption of introduced technologies teach us two fundamental lessons: 1) that we must recognize that agricultural development and the transfer of improved technologies to small-farmers is a complex process of socio-economic change, and 2) that we must allow for this complexity in research, technology design and project implementation. This is clearly not a new insight for anyone working in agricultural research or rural development. Yet, the frustration of having technology transfer and development projects fail because the importance of critical social and economic dimensions were underestimated is also far too familiar.

The examples presented in the review illustrate clearly that technology is not neutral. Technology transfer cannot be accomplished as a surgical operation in which weak organs are simply replaced by new, more efficient ones, although this is the common model employed. It takes place within a social and economic system which bestows upon the technology numerous dimensions and determines its eventual viability in meeting specified goals. Furthermore, an introduced technology often has multiple repercussions within the system. These can only be predicted with a thorough knowledge of the system into which the technology is being introduced. Even then, results are sometimes not those anticipated.

Due to time and monetary constraints on research and project development and the need to meet macro-level policy goals, adequate recognition of complexity and attention to specific regional conditions is often sacrificed. Problem definition and proposed solutions are generated on the basis of broad assumptions and general national policy objectives, rather than knowledge drawn from investigations in the field with the small-farmers the project is designed to benefit.

While this conflict may never be fully resolved, there are ways to ameliorate it. It is most important to narrow the knowledge gap between the actors in the process and to bring the "voice" of the small-farmer---the technology user---into the research and development process (Abalu, 1984; Alverson, 1984; Ashby, 1984; Biggs, 1982, 1983; Biggs and Clay, 1981; Byerlee and Collinson, 1980; Chambers, 1983; Chambers and Ghildyal 1985; Collinson, 1982; Dewalt, 1975; Gilbert et al., 1980; Goodell, 1982; Goodell et al., 1984; Harwood, 1979; Hildebrand, 1978; Horton, 1984; Howes, 1980; Matlon et al., 1984; Morss et al., 1976; Murphy, 1985; Norman, 1980; Norman et al., 1982; Rhoades and Booth, 1982; Rhoades et al., 1983; Russell, 1984; Shaner et al., 1982; Sheridan, 1981; Tripp, 1985; Vierich, 1984; Walker, 1982; Whyte, 1977, 1981).

In any technology design and transfer project, an on-going dialogue should be established between small-farm families and the agricultural scientists and project designers. The farm families are experts on their physical, economic, and social environment and their farming system (Biggs, 1983; Biggs and Clay, 1981; Brush, 1977; Brokenshaw et al., 1980; Chambers, 1983; Chambers and Ghildyal, 1985; Collinson, 1979; Gilbert et al., 1980; Goodell, 1984; Goodell et al., 1982; Harwood, 1979; Howes, 1980; Horton, 1984; Johnson, 1980; Matlon, 1985; Mayer, 1979; Murphy, 1983; Norman, 1980; Norman et al., 1982; Rhoades and Booth, 1982; Richards, 1980; Russell, 1984; Sheridan, 1981; Whyte, 1981). They know the goals they are trying to meet, the resources and factors or production they have available, and the critical constraints and pressure points affecting production. In addition, they have evaluated the results of experiments and adjustments they have already made within their production systems in response to changing economic and environmental conditions. Finally, the farm family has the local knowledge base for anticipating and evaluating some of the possible social and economic impacts of introducing a new technology.

The agricultural scientists and project designers, on the other hand, are experts in the array of potential solutions to agricultural problems and constraints, in testing and adapting technologies within specific environments, and in evaluating the feasibility of instituting specific technological innovations within the context of the national society. The union of these two systems of knowledge and experience provides a more adequate context in which to develop technology which will be viable and beneficial within the small-farm system while at the same time conforming with national policy objectives (Biggs, 1982, 1983; Biggs and Clay, 1981; Chambers, 1983; Horton, 1984; Howes, 1980; Rhoades et al., 1983; Norman et al., 1982; Sheridan, 1981; Whyte 1981).

Uniting the two knowledge systems is not an easy task and the mechanisms for integrating the small-farmer into the process of technology design are still experimental. However, if technology transfer is accepted as a complex process of socio-economic change, then there is no other real alternative.

This objective can be reached in four basic steps, each of increasing specificity and approximation of the small-farmers' voice. While the integration of all four is the ideal, the use of any one of the steps would enhance our ability to reach the small-farm family more effectively.

Step 1: Learning About the Client: Who is the Small-Farmer?

The first step is to help the agricultural scientists---who are developing technology for small-farmers---and development planners---who are designing projects to transfer the technology---know who their client is. They need a set of guidelines and conceptual tools, such as those developed in Chapter 3, which will enable them to better comprehend the situation of the small-farm family, the possible socio-economic constraints they may confront in attempting to increase agricultural production, and the socio-economic factors which typically influence the transfer of technology.

Methods: (general to more specific tools)

1. Make secondary information more accessible

   a) Publish reviews of technology applications gap.

   b) Publish several detailed case studies of positive examples in which socio-economic factors were taken into account in technology design and transfer to small-farmers operating in marginal environments (cf. Biggs, 1982, 1983; Matlon et al., 1984; Rhoades and Booth, 1982).

2. Organize seminars and workshops on the technology applications gap.

3. Develop training materials and workshops

   The training materials and workshops would be designed for development planners, agricultural scientists, and project administrators working with small-scale, resource-poor, farmers. The objective of training would be to heighten awareness of the small-farm situation and to replace common sense assumptions with a set of guidelines more appropriate for understanding agricultural production in the context of the socio-economic organization of small-farms. This type of training would also provide a common frame of reference which would facilitate and enhance interdisciplinary research and collaboration.

   Objectives:

   a) Analyze the types of critical social, economic and environmental factors affecting agricultural production in resource-poor conditions.

   b) Confront common misconceptions about small-farm agriculture.

c) Point out typical pitfalls in technology design and transfer resulting from an inadequate understanding of the organization of small-farms and socio-economic factors and constraints.

d) Review lessons from studies of small-farm adoption or rejection of improved technologies

e) Outline the critical minimum of information that should be controlled for problem definition and project design.

Training Tools:

a) Case studies of technology design and transfer projects to illustrate common problems and misconceptions as well as approaches yielding positive results.

b) Seminars to develop basic conceptual guidelines for understanding the small-farm situation and critical factors influencing technology adoption. These will draw on key principles extracted from existing analyses of small-farm systems.

c) An interactive dynamic computer model of a small-farm system which would place the participants in the management situation of a small-farmer. The model, which continues through numerous production cycles, requires the participants to make decisions that normally confront the small-farm family. These include: the household's production and consumption goals, mechanisms to cope with environmental risk, the enterprise and cropping mix, obtaining and allocating resources and factors of production, and experimenting with introduced improved technologies. The model is dynamic and interactive so that the participants see the results of their decisions and have to respond to changing internal and external conditions each cycle. This experiential "gaming" approach is one of the most effective ways to illustrate and communicate to the participants the principles of the small-farm situation developed in the workshop.

Step 2: Integration of the Small-Farm Family's Circumstances into the Project Process

The second step is to recognize that there is a basic picture of the small-farm that ought to be assembled for problem definition and the design of research and technology development and transfer projects. Attention must be given to socio-economic as well as technical and environmental factors. The required actions include the following.

1. Develop a checklist of essential socio-economic questions and issues for professionals to consider and evaluate in problem definition, and in project design, monitoring, and evaluation. This provides a way of pre-screening possible technological changes (Byerlee and Collinson, 1980). Some sample questions are:

   - What are the principal agro-ecological zones in the targeted region and how do they affect the organization of the small-farms?

   - What are the enterprises (on- and off-farm) exploited by small-farm families in the region and what role does farming, or the particular agricultural activity targeted for intervention, have within the household economy?

   - Who is the farmer?, e.g., Which members of the household are responsible for the targeted activity?

   - Do the farmers and researchers share the same conception of the problem ?

   - Does the proposed intervention correspond with the goals of the farm family; e.g., Do they have an incentive to adopt the technology or participate in the project?

   - What are the principal constraints affecting production? What are the critical resources?

   - What are the areas of flexibility?

   - How does the farming household assemble resources and the factors of production and what is their respective availability?

   - What is the most limiting factor of production or resource?

   - What is the degree of variability among the farming systems in the region?

   - Are there positive technological or management changes that have been made by some farmers which could be reinforced through the project or with modification of the technology?

- What changes will the farm family have to make in order adopt the new technology and will they be feasible?

- How will the farm family benefit from the proposed technological change? Will all members benefit equally? What could be the possible negative repercussions?

- Are there existing village-level mechanisms or institutions for collective action which might facilitate technology adoption?

2. Develop and Evaluate Methods to Efficiently Collect the Information Necessary for Understanding Small-Farm Circumstances.

The case studies and examples presented in this review argue that a comprehensive descriptive and diagnostic phase of research, carried out by an interdisciplinary team of technical agricultural scientists and social scientists, is a prerequisite for relevant problem definition and design of potentially viable solutions. Sufficient time, money, and priority should be allocated to preliminary research to ensure that the basic questions, such as those outlined above, can be answered before launching the design stage of generating improved technologies. This is the first step in the dialogue with the small-farm family.

The basic rule of thumb is the more time spent in the field in contact with small-farm families the better. This applies to technical agricultural scientists as well as social scientists. A three-pronged approach is recommended for large-scale research or development projects.

a) Full use of secondary information in order to not waste field time "reinventing the wheel."

b) A descriptive and diagnostic regional reconnaissance made by an interdisciplinary team comprised of both technical agricultural scientists and social scientists trained in small-farm agriculture.

c) Two or three short-term, focussed, studies in representative communities which would serve to test or examine in more depth the hypotheses generated the regional reconnaissance and would permit relevant socio-economic factors to be sufficiently understood. The community studies can also be used to monitor and analyze the changes incurred in production systems when they are perturbed by new technologies.

These three complementary approaches are discussed in more detail below.

Secondary Information.

One of the main criticisms of farming systems research and participatory technology development models is their high cost due to regional specificity (Gilbert et al., 1980; McIntire, 1984; Norman, 1980). A major step towards reducing this cost is the full utilization of secondary sources of regional information and data so that funds are not squandered on "reinventing the wheel" (Byerlee and Collinson, 1980; Gilbert et al., 1980).

Review of the secondary material should be completed before conducting field research so that the questions framed for field reconnaissance are appropriate. Professionals' time in the field ought to be devoted to dialogue with farm families.

Secondary information and data varies in quality and quantity between countries and regions. Attention should be given to climatic, economic, demographic, and statistical data on agriculture, as well as in-depth studies of farming systems, communities, or environmental features of the region. The accuracy of census data should be treated with some caution when applied to the regional or subregional level (Hill, 1982).

The amount of time devoted to reviewing the secondary material will vary but should not exceed one month. Support staff should be used to pull as much of the material together for the team as possible.

Descriptive and Diagnostic Regional Reconnaissance

This is the first stage of research in the field with farmers. It is an informal or exploratory (Collinson, 1979, 1982) approach emphasizing qualitative rather than quantitative information. The primary tools are interviewing and observation. With this method, a lot of information can be collected in a short amount of time (Byerlee and Collinson, 1980; Collinson, 1982; Hildebrand, 1978; Gilbert et al., 1980; Shaner et al., 1982a). The regional reconnaissance provides the interdisciplinary research team with first-hand knowledge of farming systems in the targeted area and initiates their dialogue with the small-farmers.

A team of three to four members is recommended, including one or two agricultural scientists of specialities relevant to the region, an agricultural economist, rural sociologist, or economic anthropologist, and a member of the local extension service who knows the region and the language of the farmers.

The primary goals of regional reconnaissance should be to:

a) initiate dialogue with the farmers so that their needs and priorities are incorporated into the initial stage of the technology development process.

b) develop an overview of the physical, economic, social, and political environment in which the small-farmer operates.

c) describe the major farming systems in the region and develop criteria for dividing them into more or less homogeneous types with similar needs, constraints and areas of flexibility.

d) generate hypotheses of principal constraints to increased productivity for each type.

The team should use a checklist of necessary information such as that described above for structuring their field investigation. The checklist is continuously refined during the research process beginning with the review of secondary information. Team members should work together, sharing impressions, insights, questions, and information. Efficiency is enhanced if each team member is responsible for writing a specific section of the reconnaissance report (Hildebrand, 1978).

It is usually easiest to start with interviews with professionals familiar with the targeted region such as government officials, extension personnel, merchants dealing with farmers' products and supplies, local agricultural scientists, and political leaders. They can often focus attention on key problem areas in the small-farm sector, but their hypotheses should be tested in interviews with farmers.

Attention is then turned to the small-farm families. Methods for contacting farmers will vary between societies and cultures and a flexible approach has to be maintained. The team should be careful to enlist the farmers' cooperation and knowledge, not simply demand information. It should always be borne in mind that this is the first step in a dialogue, not an interrogation. Often it is necessary to first contact village leaders and secure their support and guidance for the most effective means of meeting with farm families. It may be necessary to begin interviewing small-farm families informally during their times of leisure. From that initial contact, arrangements usually can be made to visit farmers' fields. In talking with small-farmers, a judicious balance ought to be struck between breadth of contact and the quality and detail of information collected.

The regional reconnaissance is a critical phase in the research process because it is the period in which problems are initially defined and research priorities established. Yet, it is also often the most vulnerable to funding constraints because the pressure for producing concrete results as quickly as possible is so strong. In response to this conflict, some Farming System Research and Development teams have limited the descriptive and diagnostic phase to one or two weeks (Byerlee and Collinson, 1980; Hildebrand, 1978). While this is better than nothing, under most situations it is too little time to collect the kind of information that the case studies and examples developed in this review indicate are necessary for accurate problem definition and pre-screening technological solutions (McIntire, 1984; Vierich, 1984)

Short-Term Studies in Representative Communities

Effective problem definition at the beginning of the project will conserve resources in later phases. It is therefore, not a reasonable area for trimming the budget. In fact, it is recommended that if salient socio-economic factors are to be fully incorporated into the process of technology development, than the regional reconnaissance should be supplemented with several short-term, focused, community studies (Dewalt and Dewalt, 1982; Goodell et al., 1982; Hernandez X. et al., 1980; Hill, 1982; Lang and Cantrell, 1984; Matlon, 1984; McIntire, 1984; Merrill Sands, 1984; Scherr 1983).

The communities are selected during the regional reconnaissance and should be representative of the region or of distinct agro-ecological or economic sub-regions. The community studies yield a tremendous amount of information per man-hour invested. They permit sufficient time and contact with farmers to:

a) develop rapport and effective channels of communications with farmers.

b) permit researchers opportunities to observe and work with farmers in their fields.

c) collect the necessary information on socio-economic factors shaping the farming systems.

d) test hypotheses on areas of constraint and flexibility within the farming system and household economy.

e) determine the degree of variability among farming systems.

In terms of methodology, the emphasis on short-term community studies represents the shift from the analytic focus of the parcel to that of the farming household recommended in this review. It is only with this approach that good rapport with farm families can be developed and information on important features of the small-farm households determinant in their farming systems, such as those outlined in Chapter 3, can be discerned.

This is not information which can be adequately captured in a single-visit formal survey nor during the regional reconnaissance, but, as we have seen above, it is the information critical to adequate problem definition and technology design. Information given publically before rapport is developed, in response to a survey for example, is often superficial or a stereo-typed response which can be misleading. Observation and working with farmers, in addition to communication, is important since interviewees often verbalize norms about behavior in response to survey questions, while their actions, which respond to a dynamic agricultural situation, may be quite different (Dyson-Hudson, 1972; Goodell et al., 1982; Johnson, 1980; Matlon, 1984; Vierich, 1984).

It is ideal if the community studies are executed by a two-person team including a social scientist and technical agricultural scientist. They can be carried out by young professionals as a method for field training, with the team members making frequent site visits. Both qualitative and quantitative data collection methods are used. The community studies need only last a few months, but they require at least part-time residence in the community. The relationships established with farm families during this phase in the research can be built on in the next step of on-farm testing and evaluation of proposed technologies.

3. Develop Institutional Mechanisms to Ensure that The Information Collected and Analyzed During this Step Does Get Incorporated into the Research or Project Design Process.

Step 3: Small-Farm Family Participation

The third step follows on the diagnostic phase and fully integrates representative small-farm families into the development process. They are involved in problem definition, the design of possible solutions, and evaluation of proposed technological solutions. Full participation of small-farmers in the development processes not only enhances the design of appropriate technology, but also enables farmers to sustain the changes after the project or research program has been formally terminated (Ashby, 1984; Biggs, 1983; Byerlee and Collinson, 1980; Chambers and Ghildyal, 1985; Collinson, 1982; Goodell et al., 1982; Horton, 1984; Howes, 1980; Matlon et al., 1984; Morss et al., 1976; Murphy, 1985; Norman, 1980; Norman et al., 1982; Rockefeller Foundation and ISNAR, 1985; Rhoades and Booth 1982; Rhoades et al., 1983; Russell, 1984; Shaner et al., 1982a; Sheridan, 1981; Whyte 1977, 1981)

In recent years, evaluations of the results and productivity of on-farm research projects which have promoted farmer participation have begun to appear in the literature. While this mode of research is still in an experimental stage, the results to date are very encouraging and clearly indicate the need to continue to develop effective means for integrating the "voice" of the small-farm family into the research process. Case 3 of the refinement of improved cotton technology in northern Nigeria is a good example of how farmer participation in technology development can significantly minimize the technology applications gap. Biggs (1983) has documented a similar case of a maize research program in northern India in which on-farm research and active farmer participation made research and technology design more relevant to farmers' needs and priorities. And, in a review of AID projects, Morss et al. (1976) found that local participation was a major ingredient for project success. Three other brief examples will serve to further illustrate this point.

Farmers' participation in research carried out by the International Potato Center in the Mantaro Valley of Peru to improve potato storage led to the development of a technology which was relevant to farmers' needs and widely adopted (Horton, 1984; Rhoades and Booth, 1982; Rhoades et al., 1982; Rhoades et al., 1983). Soon after the dialogue between farmers and scientists began, it became apparent that they held different concepts of storage losses and definitions of problems to be addressed in research. Scientists were concerned with minimizing pathological and physiological losses, a problem important in the United States and Europe; farmers, on the other hand, did not regard shrivelled or spoiled potato as losses since they could be fed to animals or immediately consumed. Farmers were, however, concerned about losses of seed potatoes and the time needed to desprout potatoes before planting. They considered this to be a major constraint to increased agricultural productivity.

Thus, with the problem of storage and the needs of farmers more specifically defined, scientists began research on a diffused-light storage system for seed potatoes which would minimize sprouting and losses. Once a proto-type was developed, farmers again became actively involved in testing and evaluating the technology. Eventually, joint experimentation by scientists and farmers resulted in a design for an effective, low-cost seed store which was made from local materials, fitted within the architecture of the Andean farmhouse, and met the needs of the farmers.

The integration of farmers' perspectives and knowledge has also assisted ICRISAT to more clearly define priorities for research and technology development in West Africa (Matlon, 1984). A good example comes from Burkina Faso (formerly Upper Volta). Scientists designed experiments to maximize aggregate productivity of a cowpea-sorghum intercropped system through increased planting densities of cowpea. Farmers participated in on-farm trials and their evaluation of the technology was actively solicited by scientists. Farmers concluded that the increased aggregate production and possible higher financial returns did not compensate for changes that the technology would bring about in the farming system. Risk of animal damage was considerably greater at high cowpea densities; labour requirements for weeding increased substantially at a time when labour was scarce; animal traction for weeding and ridging could not be used; and the accompanying reduction in yields of sorghum (the staple food crop and priority component of the mixture) was unacceptable. As a result of the farmers' input, ICRISAT scientists abandoned further research to increase cowpea densities and were able to concentrate their efforts on research to intensify production in sorghum-groundnut systems for which farmers had demonstrated considerably more interest.

The case mentioned above of the development process of an integrated pest management technology in the Philippines illustrates how the efficiency of the technology development process could have been significantly enhanced if farmers had been involved in the earlier design stage of the research (Goodell et al., 1982). Major changes in the technology were precipitated when farmers were finally involved in the research process at what scientists had thought would be the final stage of on-farm testing.

First, through discussions between scientists and farmers it became apparent that pests other than those anticipated by the technology designers were major causes of infestation and damage. Second, scientists learned that they had made some incorrect assumptions about farmers' understanding of the interactions between pests, types of damage, treatments, and crop losses. Farmers' had problems in identifying discrete pest entities, in associating specific types of damage with specific pests, and in distinguishing among the multitude of pesticides available in the market. This led scientists to begin to try and understand how farmers conceptualized pest problems and to generate more general recommendations for pesticide use and estimations of levels of pest infestation which made sense in terms of how farmers' conceived of the problem. Third, when the scientists realized the problems inherent to organizing farmers into large management groups as required by the technology, they began to reevaluate what had been considered a fundamental parameter in the technology design---the need for consolidating fields into large-scale management units.

While it is now becoming more widely recognized that agricultural research and technology development can benefit significantly from the participation of farm families, the specific mechanisms for integrating their participation into the research process are still being experimented with and evaluated (Chambers and Ghildyal, 1985; Matlon et al., 1984). Farming Systems Research (FSR) in the "downstream" sense, has emerged as a quite effective means to incorporate the participation of small-farm families in technology design and development (Gilbert et al., 1980). The "downstream" FSR approach emphasizes:

a) on-going farmer participation in the research process.

b) interdisciplinary research and technology development.

c) a systems perspective of the small-farm encompassing both its technical and socio-economic aspects.

d) moderate and incremental technological changes through adaptive research with new technologies under the management conditions of small-farms.

It is an iterative research process with backward linkages to the farmer which strives to develop technologies which both help small-farm families better meet their goals as well as conform with national policy objectives (Byerlee and Collinson, 1980; Collinson, 1982; Gilbert et al., 1980; Merrill Sands, 1986; Norman, 1980; Rhoades and Booth, 1982; Tripp, 1985). Farming systems research is adaptive research which is designed to complement mainstream commodity-oriented agricultural research, it is not an alternative to it (Gilbert et al., 1980; Merrill Sands, 1986; Norman, 1980). It should be thought of as a flexible approach to be integrated into existing agricultural research organizations which links on-station and on-farm research (Biggs, 1982, 1983; CIMMYT and ISNAR, 1984; Harwood, 1979). It should not be formalized into a rigid procedure or fixed package of tools nor isolated in a separate bureaucratic niche as has occurred in some agricultural research programs.

The methodology for this approach is only briefly summarized in this review because it has been laid out in detail in numerous papers (Byerlee and Collinson, 1980; Collinson, 1982; Gilbert et al., 1980; Harwood, 1979; Norman, 1980; Shaner et al., 1982a). The principal elements are (Gilbert et al., 1980):

1. selection of target area.

2. exploratory survey for problem diagnosis (usually an abbreviated version of regional reconnaissance described above).

3. definition of "recommendation domains" or types of farming systems that are relatively homogeneous and have the same basic problems or constraints and can benefit from the same technological solution(s).

4. description of small-farm systems in recommendation domains

5. design of several possible technological solutions on-station.

6. prompt experimentation with proposed solution in on-farm trials in collaboration with farmer but managed by the research team.

7. farmer-managed trials for testing and evaluation of technology.

8. modification and refinement of technology if necessary.

9. dissemination through extension.

10. monitoring and evaluation of adoption and adaptation of technology by small-farmers.

The weakest components to date in most FSR programs are steps 2, 3, 4. The methods recommended for these phases are usually too cursory to capture the quality and quantity of information they claim to obtain or to adequately integrate the farmers' perception of priorities for research. The three-pronged approach laid out in Step 2 would do this more effectively.

Step 4: Analysis and Evaluation of Adoption of Introduced Technologies

This step is too often abandoned. The examples developed in Chapter 2 illustrate that much can be learned about technology transfer if adoption patterns are analyzed and farmers' experimentation with and adaptation of the technology to their specific conditions are documented and evaluated (Barlow et al., 1983; Franzel, 1984; Gladwin, 1976; Horton 1984; Rhoades and Booth, 1982).

If this information is not collected it is very difficult to evaluate the success of technology development and transfer projects. Evaluation criteria for technology development, thus, remain those of the scientific community, such as yield maximization, or those of the development institution, such as number of projects launched, rather than the ability of the project or research organization to meet farmers' needs. This perpetuates the technology applications gap.

Several methods for collecting data on farmers' adoption, adaptation, and evaluation of introduced technologies have been examined in this review. These include:

1. Formal surveys designed to determine frequency and patterns of adoption of new technologies (CIMMYT, 1974; Gerhart, 1975; Mann, 1978; Winkelmann, 1976). Statistical analysis is used to discern the important factors determining variability in adoption rates. These analyses generate hypotheses of causal factors of adoption rates, but they are only correlations and do not necessarily explain farmers' reasons for adopting or rejecting technologies.

2. In-depth interviews with small-farmers to obtain their evaluation criteria and reasons for adoption of specific technologies (Horton, 1984; Rhoades and Booth, 1982; Matlon, 1984; Vierich, 1984). These are very effective when used to test the hypotheses generated by the formal survey method (Cancian, 1980; Dewalt, 1975; Merrill Sands, 1984).

3. Decision-tree modelling (Franzel, 1984; Gladwin, 1976). This is a more formal method with which to elicit the specific criteria and structure of decision-making employed by farmers regarding the adoption of a proposed technology.

With a full participation approach such as that proposed in Step 3. the farmers' evaluation of technology is incorporated into the development process so that *ex post* studies of non-adoption are not relevant. However, once the tested technology has been turned over to extension for full dissemination, follow-up studies using methods such as those suggested above should be carried out.

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ANNOTATED BIBLIOGRAPHY OF SELECTED REFERENCES PERTINENT TO UNDERSTANDING THE TECHNOLOGY APPLICATIONS GAP

Reference Categories

I. Detailed Case Studies of Small-Farm Production Systems and Agricultural Development.

II. Economics of Small-Farm Households and Production Systems

III. Social Organization of Small-Farm Households and the Organization and Management of Production Systems

IV. Small-Farm Decision-Making and the Adoption of New Technology

V. Design and Development of Technology Appropriate for Small-Farm Production Systems

I. DETAILED CASE STUDIES OF SMALL-FARM PRODUCTION SYSTEMS AND AGRICULTURAL DEVELOPMENT

Baum, E.

1968 "Land Use in the Kilombero Valley: from Shifting Cultivation towards Peasant Farming." In Smallholder Farming and Smallholder Development in Tanzania, H. Rutenberg, ed., pp. 21-50. Munchen: Weltform Verlag.

This paper analyses small-farm shifting cultivation in a relatively isolated area of Tanzania. It challenges the stereotype of "traditional" agriculture as static by showing how agriculture in the region has changed significantly since the turn of the century in response to population pressure, the development of external labor opportunities and infrastructure, and the introduction of new technologies and crops. Baum explains the lack of commercialization of agriculture in the region (despite a clear propensity of farmers to innovate) as caused by labor scarcity in the household units, conflicts in the production cycle between subsistence and cash crops, and inadequate returns to labor and capital investments from the available cash crops.

Bennett, J.

1969 Northern Plainsmen. Chicago: Aldine Press.

This study analyzes the alternative means four groups with distinct social and cultural traditions developed to exploit the natural, social, and economic resources of a frontier region of the Great Plains of North America. It documents clearly how the social organization and cultural values of the different groups --- ranchers, farmers, Hutterites, and American Indians --- led to very different patterns of resource use within a common environment. It is a classic work of the school of cultural ecology which views human behavior as adaptive to an enviroment defined by social and cultural, as well as natural, parameters. It is highly recommended for its theoretical and methodological framework. The clear policy implication from this study is that social, cultural, and economic factors cannot be ignored in any process of development.

Brush, S.

1977 Mountain, Field, and Stream: The Economy and Human Ecology of an Andean Valley. Philadelphia: University of Pennsylvania Press.

Brush develops a comprehensive analysis of a diversified, farming system in the Peruvian Andes which has evolved in response to the complex physical, social, and economic conditions of that environment. It is an excellent case study of how farming systems reflect the economic and social goals and organization of farming households as well as households' means of access to the factors of production. By showing the prominent role that kinship plays in regulating the distribution of goods, resources, and factors of production among households and communities, the study presents a strong argument against the assumption that small-farms in developing countries operate under the same principles and with the same goals as commercial farms in developed countries.

Cancian, F.

1972 Change and Uncertainty in a Peasant Economy: The Mayan Corn Farmers of Zinacantan. Stanford, CA: Stanford University Press.

This classic study demonstrates that differential patterns of response by small-farm households to new economic opportunities provided by government development programs in Chiapas, Mexico correlated with their socio-economic rank, but not in a directly linear relationship as is often assumed in development planning. Cancian proposes a modified middle-class conservatism model as a means to predict small-farmer responses to innovation under conditions of uncertainty. Households of the lower middle-class rank, because they are interested in upward social mobility, are more willing to take risks than those of the upper middle-class rank. This was one of the first studies illustrating the need to take local socio-economic heterogeneity into account when analyzing technology adoption and innovation among small-farmers.

Ewell, P.

1984 The Intensification of Peasant Farming in Yucatan. Ithaca, NY: Cornell University, International Agricultural Economics Study, A.E. Research No. 84-4.

This is a well-documented and clearly presented case history of small-farmer innovation and successful agricultural development in Yucatan, Mexico. Ewell records the transition over a 40 year period from subsistence slash-and-burn agriculture to intensive small-farm commercial production of fruits and vegetables under irrigation. Government involvement was limited to constructing simple, small-scale, irrigation facilities and farmers retained the freedom to adapt and develop their traditional technology and management strategies to the more advantageous conditions created by the improved infrastructure. Ewell emphasizes the dynamic and flexible nature of small-farmer management strategies and shows how cropping arrangements, factor allocation decisions, and levels of investment all reflect the farm family's priority of securing a steady and reliable income throughout the year, rather than profit-maximization. This is a rational and successful response to the marginal environment of Yucatan characterized by high variablity and uncertainty in the economic and physical environments. Ewell's study concludes with lessons pertinent to the technology applications gap when he contrasts the successful development of the semi-autonomous, small-holder, irrigated parcels to the failure of the more recent, large-scale, technically complex and rigidly structured, government managed irrigation projects in the same region.

Greenwood, D.

1976 Unrewarding Wealth: The Commercialization and Collapse of Agriculture in a Spanish Basque Town. Cambridge: Cambridge University Press.

This is an outstanding, but disturbing, case study of the demise of small-farm agriculture in a Basque community which provides a powerful and well-documented example of how the profit motive is not always a useful model for explaining or predicting human behavior. Greenwood combines farm management economics with an anthropological analysis of cultural values to build a strong refutation of the conventional wisdom that the rural exodus from the Basque community was caused by declining profits on the farms. He demonstrates that the farms were indeed very profitable. Yet, the shifting political and economic relations in the region created by a burgeoning tourist industry and the commercialization of agriculture itself had brought farming as a way of life into conflict with basic Basque values of work, dignity, and self. The unsettling conclusion is that regional economic development precipitated the demise of agriculture as farm families forsook profit able farming enterprises to emigrate to urban areas where they believed their self-esteem would be less severely challenged.

Gudeman, S.

1978 The Demise of the Rural Economy: from Subsistence to Capitalism in a Latin American Village. London and Boston: Routledge, Kegan Paul.

An interesting case study from Panama documenting the transformation of a rural economy organized around small, diversified, subsistence farms to a state-run, plantation-type, economy based on sugar cane production. Small-farmers eagerly adopted sugar cane as a cash crop to supplement subsistence production when the mill first opened. However, the mill's dependence on high volume and a steady supply of cane for profitability led it to increasingly acquire control over production. When the State took over control of the mills, the area became an experiment in state socialism with the mill assuming all management decisions. Farmers lost all control over production and became a rural proletariat. The material wealth of the farmers increased in the short-term, but at the cost of inherent instability over the long term due to extensive environmental degradation and total dependence on the mills and sugar cane export economy for their livelihood. Gudeman presents a useful analytic method for resolving the problems of comparing returns in subsistence and commercial agriculture by evaluating them in terms of returns to labor.

Hill, P.

1970 The Migrant Cacao-Farmers of Northern Ghana. Cambridge: Cambridge University Press.

This economic history documents autonomous small-farmer innovation in Ghana with the indigenous development of commercial cacao-farming within a complex farming system without government intervention or support. The study dispels the myth of the "traditional" peasant or small-farmer, backward and resistant to change. In response to an expanding international market, men from small-farm households formed corporations, based on kin groups, in order to finance the long-term capital investment required to buy suitable lands distant from their communities and bring the cacao trees into production. Subsistence production was carried out by women in the home villages to maintain the household. A fascinating finding was that two very different forms of organization evolved for the land owning units which reflected distinct types of kinship ties (matrilineal or patrilineal) among the members. Hill's is an exemplary study of a rural economy. It is based on detailed and meticulous field research unencumbered by preconceptions or untested assumptions of small-farm economic behavior and organization.

Kluck, P.

1975 Decision-Making Among Descendents of European Farmers in Rio Grande do Zul, Brazil. Ithaca, NY: Cornell University Latin American Studies Program Dissertation Series, #61.

Kluck presents an interesting and thoroughly researched case study of the success of small-farm agriculture in southern Brazil. It supports the desirability of developing small-farm agriculture and questions the assumption that economies of scale are inherent in "modern" agriculture. Kluck shows that the diversified small-farm production systems, which incorporated subsistence and commercial crops, provided households with economic stability and the flexibility to both respond to a variety of economic opportunities and withstand economic downturns in the market. She suggests that the necessary elements for the successful development of small-farm agriculture are: diversified production systems; minimal marketing infrastructure; secure land tenure; and access to improved inputs at affordable prices.

Ludwig, H.

1968 "Permanent Farming on Ukara." In Smallholder Farming and Smallholder Development in Tanzania, H. Rutenberg, ed., pp. 87-135. Munchen: Weltform Verlag.

Ludwig presents an interesting study of intensive small-farm agriculture on the small, population-dense, island of Ukara in Lake Victoria. It documents one of the few autochthonous farming systems in sub-Saharan Africa in which manuring, fodder-growing, and erosion control measures, such as terracing, contour cultivation, and controlled water flows, have been developed within a complex farming system to maintain soil-fertility. It provides a good example of the common pattern in small-farm agriculture of labor intensification in reponse to population pressure and land shortages. While returns per unit of land are high relative to neighboring mainland farming systems, the returns to labor are very low.

Mayer, E.

1974 Reciprocity, Self-Sufficiency, and Market Relations in a Contemporary Community in the Central Andes of Peru. Ph.D. Dissertation, Anthropology, Cornell University, Ithaca, NY.

A compelling case study of an agrarian community in the highlands of Peru. It demonstrates how institutionalized reciprocal exchange relationships, rather than the market, organize production, consumption, and exchange within households, between households in the community, and among communities in the region. Reciprocal exchange relationships, which are both social and economic relationships, are the primary means of households' access to resources and the factors of production and they are, thus, key to understanding the organization and management of farming systems in the region.

Merrill Sands, D.

1984 The Mixed Subsistence-Commercial Production System in the Peasant Economy of Yucatan, Mexico: A Study in Commercial Beekeeping. Ph.D. Dissertation, Anthropology, Cornell University, Ithaca, N.Y.

This study is the basis for Case Study 7 presented in this monograph. Employing both regional and household levels of analysis, the study documents the successful development of small-farm agriculture in Yucatan, Mexico through the evolution of a farming system integrating subsistence production of corn and beans under a swidden system with the commercial production of honey for export. The author argues that the subsistence-commercial mixed production system is a viable model for agricultural development. Diversification into commercial production strategies, without sacrificing subsistence autonomy, protects small-farm households from extreme vulnerability to the vagaries of both the market economy and the natural environment. The analysis shows that this particular product mix was successful because the strategies were complementary in their production cycles, goals, and demands on available factors of production and resources.

Netting, R.

1968 Hill Farmers of Nigeria: Cultural Ecology of the Kofyar of the Jos Plateau. Seattle and London: University of Washington Press.

This excellent analysis of the highly productive, intensive and complex crop-animal farming system of the Kofyar in the hill lands of Northern Nigeria is highly recommended. Under conditions of relatively high population density, the Kofyar use terracing and tie-ridging; practices of manuring, incorporation of crop residues, crop rotations and cropping mixes, and fastidious exploitation of micro-ecological zones to intensify production on limited lands surrounding their homesteads. With increasing integration into the market economy, Kofyar households have employed extensive slash-and-burn agriculture in the more distant forest lands to grow surplus crops for sale. Due to the different ecological zones and crops, the production cycles of the two agricultural systems are complementary and have allowed households to increase their labor productivity. Netting places the analysis of the farming system within the context of the socio-economic organization of the Kofyar.

Norman, D.; Simmons, E; Mays H.

1982 Farming Systems in the Nigerian Savannah: Research Strategies for Development. Boulder, Colorado: Westview Press.

This book summarizes the findings of almost twenty years of socioeconomic research on evolving farming systems and constaints to technology adoption in the northern Nigerian Savannah. The authors not only provide a detailed case study of small-farm agriculture in Africa, but they move beyond description to conclude with two chapters analyzing the implications of the findings for agricultural research and development in the region. The book is highly recommended, especially for those interested in how farming systems in Africa have responded to conditions of increasing population pressure and economic change.

Ortiz, S.

1973 Uncertainties in Peasant Farming: A Columbian Case. London: University of London - The Athlone Press.

This impressive study of small-farm agriculture among the Paez Indians of Columbia was one of the first to deal comprehensively with small-farmers' response to risk and uncertainty in their environments. The study presents an excellent analysis of the multiple goals operative in the diversified farming system which combines the production of multiple food crops with commercial production of coffee. The mixed subsistence-commercial system is maintained as a buffer against household vulnerability to an uncertain physical and economic environment. Farm families regard the subsistence and commercial operations as two separate spheres with distinct goals, priorities, constraints, and distribution networks. The subsistence sphere is organized by kinship, reciprocity, barter, and the overriding goal is food security both for the household and the community. The commercial sphere is organized by the market (albeit imperfect), cash transactions, relations with traders, and the goal of profit maximization as long as subsistence production is not jeopardized. Ortiz argues that Paez farmers' agricultural decisions and management strategies are rational when understood within the context of the specific social, economic, and political environment in which they operate.

Ruthenberg, H.

1968 "Coffee-Banana Farms at Mt. Kilmanjaro." In Smallholder Farming and Smallholder Development in Tanzania, H. Rutenberg, ed., pp. 213-218. Munchen: Weltform Verlag.

A brief, but rich, case study of a highly integrated, intensively managed, mixed small-farm system in Tanzania which has developed autochthonously in response to increased population pressure. The system integrates mixed cropping of the cash crops of coffee and bananas, with subsistence maize production, and small-scale, but intensive, animal production. The study demonstrates the importance of the interactions and interdependencies between crop and animal strategies within the farming system and household economy.

Scherr, S.

1983 Resolving the Agriculture-Petroleum Conflict: The Experience of Cacao Holders in Mexico. Ithaca, NY: Cornell University, International Agricultural Economics Study, A.E. Research, No. 83-33.

This is a fascinating study, with voluminous documentation, demonstrating that small-scale family farms in Tabasco, Mexico had greater flexibility and stability than capitalist farms in the face of major social, economic, and environmental disruptions precipitated by the petroleum boom in the late 1970's. Production on the large-scale capitalist farms followed the typical scenario of agricultural collapse in regions of petroleum development, but due to the stability of small-farm agriculture, the total production of commercial crops in the region reached unprecedented levels. Focussing on the cacao sector, Scherr shows that the resource structure, farm costs, and flexible use of household labor both on and off-farm, permitted small-farms to withstand the economic pressures of the petroleum economy. The story challenges the stereotype of small-farm inefficiency and resistance to change and illustrates the important role small-farms can play in the process of economic development. The study is exemplary because it unites a comprehensive regional economic analysis with a micro-level analysis of household economy and small-farm management strategies to explain the anomolous Tabasco situation. The detailed research of a local situation is used to draw broad theoretical and policy implications.

von Rotenhan, D.

1968 "Cotton Farming in Sukumaland: Cash Cropping and its Implications." In Smallholder Farming and Smallholder Development in Tanzania, H. Rutenberg, ed., pp. 51-86. Munchen: Weltform Verlag.

This is an interesting analysis of the transition from swidden to semi-permanent or permanent agriculture among small-farmers in Sukumaland, Tanzania caused by increasing population pressure. Changes are seen in the dramatic expansion of cotton as a cash crop and the substitution of more productive cassava for tastier maize as a subsistence crop. The expansion of cotton production brought a short-term rise in prosperity, but has also created significant long-term agricultural problems which are exacerbated by increased population pressure. These include soil degradation through erosion, exploitation of all available lands, shortened fallow cycles and lower soil fertility, and the degeneration of the cattle economy on small-farms. The author concludes that the long-term problems could cause agricultural stagnation and eventual involution with declining production per capita. The study is a good data source on diversified small-farm agriculture in Eastern Africa with information on farmers' goals, constraints, management strategies, labor investment patterns, and land-use and cropping choices.

II. ECONOMICS OF SMALL-FARM HOUSEHOLDS AND PRODUCTION SYSTEMS

Almy, S.

1979 "Response of Agricultural Systems to Natural Increase: The History of a High-Potential Region in Kenya". In Changing Agricultural Systems in Africa, E. Moran, ed. Williamsburg, V.A.: College of William and Mary, Studies in Third World Societies, No. 8.

Almy provides a fascinating case study which documents how the Imenti in Eastern Kenya successfully intensified their agricultural system in response to external forces of change which included increased population pressure, land reform, and the development of external markets. In the 1950's Imenti households, composed of an extended family, exploited the three major ecological zones on the eastern slope of Mt. Kenya through a diversified production system of dispersed plots. With increasing population pressure and Colonial land reform, the production unit broke down into nuclear family units working single consolidated plots in only one of the three zones. What is striking is that despite the radical changes in the organization of the production systems, the goals of production, which reflected the traditional division of authority, status, and obligations among the sexes, remained the same.

Bartlett, P.

1975 Agricultural Change in Paso: The Structure of Decision-Making in a Costa Rican Peasant Community. Ph.D. Dissertation, Columbia University, New York, N.Y.

This case study from Costa Rica documents the dramatic changes in land-use patterns and labor intensification which resulted from small-farm households' responses to environmental degradation and population pressure. Bartlett found that the significant heterogeneity in the cropping options chosen by households was largely determined by the amount of land available to the household and the permanence of tenure. Land availablity was shown to be a more important predictor of cropping options than labor availability as expressed in family size or structure.

Bartlett, P.

1977 "The Structure of Decision-Making in Paso." American Ethnologist, 4 (2): 285-308.

The land resources available to farming households emerges as the primary determinant of the kinds of crops and amount of land planted by small-farmers in a Costa Rican community. The distinct choices of tobacco or pasture are discussed in terms of their long-term effects on the community and the natural resource base.

Berry, S.

1975 Cacao, Custom, and Socio-Economic Change in Rural Western Nigeria. Oxford: Clarendon Press.

Berry presents an excellent case study documenting how traditional institutions facilitated the rapid adoption and development of cacao production in the small-farm sector of Western Nigeria. Institutions which fostered reciprocal responsibilities for services and support among members of kin groups and communities provided the means for small-farmers to mobilize capital and incur the risks of moving to uninhabited forest lands distant from their communities and investing in an unfamiliar crop with a long gestation period. The study demonstrates the "price responsiveness" of African farmers, but by documenting the important role of non-market institutions in mobilizing resources, Berry is also able to explain why farmers continued to expand production even when prices were low. She concludes from the case study that information on market costs and returns cannot be expected to fully explain patterns of investment and output in the small-farm sector.

Chibnick, M.

1978 "The Value of Subsistence Production." Journal of Anthropological Research: 34 (4): 561-576.

Chibnick proposes that the value of subsistence crops should be calculated at the price farmers would have to buy them if they did not produce them. This is the most realistic approximization when employing a standard unit of value to analyze subsistence (use-value) and commercial production (exchange-value) in small-farm agriculture or endeavoring to understand factor allocation decisions within small-farm systems integrating subsistence and commercial production.

Clayton, E.

1968 "Opportunity Costs and Decision-Making in Peasant Agriculture." Netherlands Journal of Agricultural Science, 16: 243-252.

Clayton provides an excellent discussion of opportunity costs in small-farm agriculture which, although different from those in large-scale commercial agriculture, are positive and often substantial. Adopting a farming systems perspective, he analyzes the impact of opportunity costs on farmers' decision-making in evaluating new technologies and on management practices, such as staggered planting, choice of crops, timeliness of cultivation operations, and the allocation of resources and factors of production between cash and subsistence crops.

Collinson, M.

1972 Farm Management in Peasant Agriculture: A Handbook for Rural Development in Africa. New York: Praeger Publishers.

This book, based on Collinson's extensive field work in small-farm agriculture in Africa, remains the prominent work on methods for on-farm research in Africa. Part 1 describes the management conditions under which small-farms operate in Africa and outlines an approach to farm management appropriate to those conditions. Part 2 lays out research methods appropriate for analyzing small-farm systems in Africa. Part 3 discusses how research data can be used to devise appropriate and relevant programs for agricultural development. This is a basic reference book for researchers and development planners working with small-farmers in Africa.

Cornick, T.

1983 The Social Organization of Production in Quimas, Ecuador: A Case Study of Small-Farmer Production Systems in the Highland Andes. Ph.D. Dissertation, Department of Rural Sociology, Cornell Univeristy, Ithaca, N.Y.

Cornick employs a farming systems approach to analyze mixed crop-animal small-farm agriculture in Ecuador. The study generates insights which are very relevant to understanding the technology applications gap. The central thesis is that the high degree of variability found among small-farm systems in the region results from farming households' different resource bases, production and consumption goals, and access to the factors of production. The analysis shows that the more marginal the resouce base of the farming system, the more interdependent the separate components of the farming system. The level of interdependence between components determines management strategies. A high degree of interdependence limits the degree to which productivity can be increased in any single component of the system; commercially-oriented production goals and strategies only emerge when the constraining effect of the integrated system is sufficiently reduced to allow a component to be treated as a separate sub-system.

Dewalt, B.

1979 Modernization in a Mexican Ejido: A Study in Economic Adaptation. Cambridge: Cambridge University Press.

Dewalt analyzes the heterogeneity in farming households' responses to innovations in Central Mexico with the view to demonstrate that socio-economic change with "modernization" is a complex process and that the assumed dichotomy between "innovators" and "traditionalists" in agricultural development is misleading. Through sophisticated statistical analysis, he shows that small-farm households selectively adopt clusters of innovations according to various criteria. Adoption depends on the nature of the innovation and on factors such as the household's resources, access to the factors of production, socio-economic rank, and the organization of their farming systems. A finding of great significance to the technology applications gap was that the patterns of adoption among households of different socio-economic ranks varied according to the nature of the specific technology, i.e. socio-economic rank and willingness to innovate are not uniformly correlated.

Fleuret, P.

1985 "The Social Organization of Water Control in the Taita Hills, Kenya." American Ethnologist, 12 (1): 103-118.

A case study of a small-scale, indigenous, irrigation system in Kenya which illustrates pointedly how the patrilineal social organization of the Taita determines the physical layout of irrigation canals, households' access to the fields they serve, the organization of canal maintenance, and management and distribution of irrigation water among farms. The social organization provides the rules and norms which structure cooperative use of a scarce resource in a way that is reliable and requires minimal organizational effort. The implications of the case study for development programs of land reform and agricultural modernization which too frequently ignore indigenous forms of social and economic organization are analyzed.

Halperin, R. and Dow, J. (eds.)

1977 *Peasant Livelihood: Studies in Economic Anthropology and Cultural Ecology.* New York: St. Martin's Press.

This volume contains sixteen papers examing the variety of institutional arrangements that structure economic life in rural societies. The studies and theoretical discussions draw attention to the important role that institutions, other than the market economy, have in organizing and integrating production, consumption, and distribution of goods, resources, and the factors of production in rural economies. The papers are of varying quality, but it a useful source book.

Hart, G.

1978 *Strategies of Labor Allocation in Rural Javenese Households.* Ph.D Dissertation, Agricultural Economics, Cornell University, Ithaca, NY.

This study provides a comprehensive analysis of the different strategies for allocating family labor in farming households of distinct socio-economic ranks in rural Java. Inter-rank differences were most marked in the labor investment of women and children, both in quality and quantity of labor. Hart uses the analysis to argue that macro-analysis or models of labor force behavior must take into account local heterogeneity in households' access to the factors of production and the decision-making process on labor allocation operative at the household level. The study represents an effective and exemplary unification of macro and micro analysis.

Haugerud, A.

1983 "The Consequences of Land Tenure Reform among Smallholders in the Kenya Highlands." *Rural Africana*, 15/16: 65-89.

This is an interesting study documenting the persistence of indigenous institutions in regulating farming households' access to land in Kenya despite land tenure reform designed to help commercialize smallholder farming. Informal relations based on systems of patronage, friendship, and kinship widely contravene the legal system of land ownership recognized by the government. The traditional institutions continue because they provide farming households with access to multiple ecological zones necessary for maintaining a diversified farming system.

Hill, P.

1970 Studies in Rural Capitalism in West Africa. Cambridge: Cambridge University Press.

This is an interesting collection of six brief case studies drawn from Polly Hill's extensive research on rural economies in West Africa. The case studies illustrate how traditional institutions have served to facilitate capital formation and investment leading to economic growth and development. They also demonstrate the diversity and complexity of rural economies and underscore the need for studying the organization of a specific rural economy before attempting to institute changes for economic development.

Huang, S.

1984 "Market and Non-Market Factors in Taiwanese Peasant Economy." In Chayanov, Peasants, and Economic Anthropology, E. Durrneberger, ed. New York: Academic Press, pp. 167-181.

This is a good study of small-farm agriculture in a Taiwanese community which illustrates the common priority operative in small-farm agriculture of subsistence security. It argues that other institutions besides the market regulate the distribution of rice and labor within the community and shows the importance of intra-household linkages as a means for assembling the labor necessary for intensive rice cultivation.

Jodha, N.

1979 "Intercropping in Traditional Farming Systems." Andhra Pradesh, India: ICRISAT, Economics Program Progress Report #3.

This paper reports the findings of a study on intercropping in six villages of the semi-arid tropics of India. It shows that intercropping is a key component of small, unirrigated, farming systems. Farmers employ intercropping primarily to: 1) spread out peak labor requirements; 2) meet the multiple subsistence and commercial production objectives of farming households; and 3) to minimize risk. Jodha argues that given the importance of intercropping in small-farm agriculture, research directed towards small-farms must concentrate on developing intercropping systems which satisfy at least the key objectives of profitability and stability.

Johnson, A.

1971 "Security and Risk-Taking Among Poor Peasantry." In Studies in Economic Anthropology, G. Dalton, ed. Washington, D.C.: American Anthropological Association. Anthropological Study, #7, pp 144-151.

Today a standard reference, this was one of the first studies to argue that management strategies in small-farm agriculture were motivated by the goal of risk minimization rather than solely by profit maximization. Based on field work in Brazil, the study employs the analytic framework of cultural ecology which views agricultural behavior as the product of adaptive strategies developed by farm families to cope with the natural, social, and economic environment in which they operate.

Low, A.

1982 "From Farm-Homestead Theory to Rural Development Policy in Lesotho and Swaziland." In Labor, Migration, and Agricultural Development in Southern Africa, F. de Vletter, ed., pp. 67-78. Rome, Italy: FAO

This is an excellent study which employs the model of the farm household economy to analyze the interactions between off-farm employment, small-farm agriculture, and farmer responses to introduced technologies. In Swaziland, small-farm households rapidly adopted hybrid maize seed that was promoted by the government with the view to commercialize small-farm agriculture. However, aggregate maize production did not increase. Low discovered that, contrary to government expectations, households used the higher yielding maize only to more adequately meet subsistence needs, not to produce a surplus. Freed labor was invested in the more remunerative strategy of migrant wage labor.

Mayer, E.

1979 Land Use in the Andes: Ecology and Agriculture in the Mantaro Valley of Peru with Special Reference to Potatoes. Lima, Peru: International Potato Center, Social Science Unit.

This is an exemplary study of land-use patterns in a valley of Peru. It presents detailed maps of major land-use zones in which potatoes are grown with their ecological characteristics, land tenure patterns, and farming system types. The approach integrates the analysis of census data and aerial photographs with short periods of intensive field work. The monograph is highly recommended. The study provides a good model for the kind of descriptive and diagnostic regional analysis and classification of farming systems which should serve as the basis for planning agricultural development projects.

McDowell, R. and Hildebrand, P.

1980 "Integrated Crop and Animal Production: Making the Most of Resources Available to Small Farms in Developing Countries." Working Papers - The Rockefeller Foundation. New York: The Rockefeller Foundation.

This short monograph is designed to underscore the importance of recognizing the interrelationships between crop and animal components of farming systems when analyzing small-farm agriculture and/or developing technologies to improve the productivity and efficiency of these systems. Crop and animal components are not only interdependent with respect to inputs, but also have complementary roles within the farm household economy. The monograph presents a general discussion of crop-animal interactions in a selected number of farming systems characteristic of distinct agro-ecological zones throughout the developing world as well as a detailed, quantified, analysis of a specific farming system from the highlands of Guatemala.

Moerman, M.

1968 Agricultural Change and Peasant Choice in a Thai Village. Berkeley and Los Angeles: University of California Press.

In this case study of small-farm rice production in Thailand, Moerman analyzes agricultural management strategies in terms of the social and economic organization of the household, production and consumption goals, and the rules that structure decision-making. Of particular interest to the technology applications gap is the finding that households employed very different management practices in their commercial rice crop than in their subsistence rice crop where the "subsistence first" principle prevailed. With the commercial rice crop, little attention was given to maximizing yields because yields were less certain and regarded as a "windfall". The commercial rice crop was planted in distant fields with limited water control using tractor cultivation, broadcast planting, and wage labor. In contrast, rice for subsistence was intensively managed to both maximize and secure yields. It was planted first in specially prepared seedbeds and then transplanted to plowed, irrigated, fields near the village, relying on family labor or labor exchange between households.

Murphy, J.

1983 "Farming Households' Perceptions of Alternate Production Strategies." Paper presented at USAID, Workshop on Dryland Agriculture, November 21-22.

This paper argues that a major cause of the technology applications gap is development experts' failure to recognize the farming household (in its social and economic dimensions) as the relevant unit of analysis for understanding decision-making with respect to technology adoption and choices between alternative production strategies. The paper includes two examples from the Near East of how the social and economic organization of households determined their responses to technology adoption and their choices between alternative production strategies.

Norman, D.

1974 "Rationalizing Mixed Cropping under Indigenous Conditions: the example of Northern Nigeria." Journal of Development Studies, 11: 3-21.

Norman employs farmers' economic criteria and goals to explain their resistance to agricultural scientists' recommendations to plant sole stands in Northern Nigeria. While yields of individual crops may not be maximized in mixed stands, net returns per unit of land and returns to labor invested during the labor bottleneck period are maximized.

Orlove, B.

1977 Alpacas, Sheep, and Men: The Wool Export Economy and Regional Society of Southern Peru. New York: Academic Press.

This was a pathbreaking study in anthropology because it placed the analysis of production within the context of the political economy of the region, nation, and the world wool market. Ample attention is given to analyzing the agricultural system as a response to the ecological conditions of the Andean environment, but the study is unusual in the emphasis given to viewing the farming system as a product of its social, economic, and political linkages with the region and world economy as well. The wool production sector, including peasant farms, haciendas, wool traders, and international marketing agents, is the unit of analysis, rather than the community or the household as is typical of most anthropological studies. The book is recommended as an

example of the kind of regional production and market analysis that could significantly enhance the effectiveness of agricultural development planning.

Scott, J.

1976 The Moral Economy of the Peasant: Rebellions and Subsistence in South East Asia. New Haven and London: Yale University Press.

This is one of the first, and best, studies arguing that the goal of subsistence security is paramount in peasant, or small-farm, agriculture and that the subsistence ethic, or the right to subsist, defines the moral structure of the peasantry. Drawing on agrarian history from lower Burma and Vietnam, Scott shows how these two basic values shape the "moral economy" of the peasantry and influence their economic and political behavior. Small-farmers will emphasize stability of yields over maximization; will prefer taxes or rents calculated on shares of production rather than fixed rates which may push them below the subsistence threshold in years of low yields; and may accept onerous rental agreements if the landlord guarantees subsistence in times of crop failure. Scott argues that peasant uprisings occur when peasants believe that their subsistence is threatened. This often occurs with the intrusion of capitalism or the development of nation-states when external demands on the product of small-farmers increase at the expense of the subsistence ration of the household.

Walker, T.; Singh, R.; Jodha N.

1983 "Dimensions of Farm-Level Diversification in the Semi-Arid Tropics of Rural South India." Andhra Pradesh, India: ICRISAT, Economics Program Report, No. #51.

The paper argues that diversification across crops and fields is a primary means by which farmers combat instability in crop income in dry land areas. Analyzing data from ICRISAT's village level studies, the authors found that crop diversification was more prevalent in rainfed regions than in irrigated and that it was strongly correlated with the availability of bullocks and farm size.

Wharton, C.

1971 "Risk, Uncertainty, and the Subsistence Farmer." In Economic Development and Social Change. G. Dalton, ed. Garden City, New York: Natural History Press, pp. 566-574.

Wharton's is a classic paper on the subject of risk and technology adoption by small-farmers. Wharton was among the first to argue that small-farmers' resistance to new technologies (especially in subsistence production) often derived from uncertainty about the performance of the new technology and the risk of being forced below the minimum subsistence level if the technology failed. For small-farmers the degree of variability in yields is often as important as the average yield when evaluating new varieties or technologies. Wharton predicts that farmers will be more conservative with innovations the closer they are to the minimum subsistence level and the more unfamiliar the innovation.

Cross References

Author	Year	Section
Bartlett, P	1978	IV
Bartlett, P., ed.	1980	IV
Baum, E.	1968	I
Bennett, J.	1969	I
Brush, S.	1977	I
Cancian, F.	1972	I
Chayanov, A.	1966	III
Dove, M.	1984	III
Durrenberger, E., ed.	1984	III
Ewell, P.	1984	I
Gladwin, C.	1980	IV
Greenwood, D.	1976	I
Gudeman, S.	1978	I
Guyer, J.	1980	III
Harwood, R.	1979	V
Hill, P.	1970	I
Hill, P.	1982	I
Horton, D.	1983	V
Horton, D.	1984	V
Kluck, P.	1975	I
Ludwig, H.	1968	I
Matlon, P.	1984	V
Mayer, E.	1974	I
McGough, J.	1984	III
Merrill Sands, D.	1984	I

Norman, D.; et. al.	1982	I
Ortiz, S.	1973	I
Ruthenberg, H., ed.	1968	I
Scherr, S	1983	I
Shaner, W,m et. al.	1982	V
von Rotenhan, D.	1968	I
Walker, T.	1981	IV
Winkelmann, D.	1976	IV

III. SOCIAL ORGANIZATION OF SMALL-FARM HOUSEHOLDS AND THE ORGANIZATION AND MANAGEMENT OF THEIR PRODUCTION SYSTEMS

Barnes, C.

1983 **Differentiation by Sex among Small-Scale Farming Households in Kenya." Rural Africana, 15/16: 41-63.**

This paper presents an historical analysis of the changes that have occurred in rural households and the gender-based division of adult labour, specifically the emergence of female-headed households, with economic transformation in Kenya. The four major factors contributing to the change in the traditional division of labour by sex were: 1) an increased absence of men from the homestead with greater time spent in wage employment; 2) men's employment on estates where they performed all agricultural tasks, even those traditionally performed by women; 3) the introduction of cash crops as men's crops by the colonial adminstration; and 4) the decline in importance of livestock production, traditionally an economic activity for men, leading to the increased involvement of men in the production of food crops as cash crops. Today, no precise division of adult labour by sex occurs in crop and livestock activities in the small-farm sector; the primary division of labour is that men migrate for wage employment leaving their wives as de facto heads of rural households. Of the farm households in the 1978-79 national survey, 22 percent were headed by women.

Boserup, E.

1970 **Women's Role in Economic Development. New York: St. Martin's Press.**

This is a classic work in development literature because it was the first to systematically address the pervasive neglect of the role of women in development planning and policies. Boserup uses macro-level analysis to demonstrate how economic development changes the division of labour among the sexes and explores the implications this has for development planning and policies. A substantial section of the book is dedicated to documenting the predominant role of women in the farming systems of Africa and the disruptive effect that male-biased agricultural development policies have had in marginalizing women producers as well as food production for which women are largely responsible. In general, the impact of agricultural development on women has been to lower their status, rights, labor productivity, and ability to generate income to maintain their families.

Callear, D.

1983 "Women and Course Grain Production in Africa." Paper presented at the Expert Consultation on Women in Food Production, ESH:WIFP/83/14. Economics and Social Policy Department, Food and Agriculture Organization of the United Nations, Rome, Italy.

The paper focusses on major role of women in food crop production in sub-Saharan Africa, emphasizing the social organization of the household and the division by sex of not only labor, but enterprises, crops, household obligations, and resources. It presents data from field investigations in Zimbabwe showing women farmers to respond to economic opportunities and to be active adopters of hybrid maize seed. Callear argues that development projects must recognize that opportunity costs of the acceptance of new crops and technologies are usually different between men and women. For women, returns to labor and ability to meet family food obligations are crucial factors in evaluating new technologies.

Chayanov, A.

1966 The Theory of Peasant Economy. D. Thorner, B. Kerbley, and R. Smith, eds. Homewood, Illinois: Richard D. Irwin, Inc., published for the American Economic Association.

This 1925 study of Russian peasant farming and household economy, translated for the first time into English in 1966, is a major theoretical work in the study of peasant economy. Its fundamental argument is that the economic organization of peasant farms is determined by the structure and composition of the domestic unit. He argues that economic principles and analytic methods relevant to capitalist farming are not applicable to peasant farming because peasant farms rely on family labor as the critical factor of production, rather than land and capital, and because profit maximization is not the primary goal of production. The organization of the farming system and the intensity of production in peasant farming will vary with the changing structure and composition of the farming household, the ratio of consumers to producers, the productivity of the labor, and the balance between the drudgery of the labor and the desired consumption levels of the household.

Dey, J.

1984 Women in Rice-Farming Systems, Focus: sub-Saharan Africa. Rome, Italy: Food and Agriculture Organization of the United Nations, Women in Agricultural Production and Rural Development Service, Women in Agriculture Series, No. 2.

This monograph is highly recommended because it provides some striking examples of the technology applications gap resulting from development planners' inadequate understanding of the social organization of the farming household and the major role that women play in rice cultivation in many parts of sub-Saharan Africa. The analysis reveals the complex interactions between the social organization of the household, the household economy, and the structure and management of the farming system. Dey's study breaks new ground because she challenges the applicability of the concept of the family farm with a single household purse, typical of Latin America and Asia, to farming households in most parts of Africa. She demonstrates that technology adoption and management within the farming system is not only influenced by the division of labor among sex and age groups within the household, but also by the division of obligations and control over resources, factors of production, distribution of products, and income from the sale of products. The study rests on a strong theoretical foundation and is supported by ample documentation from field investigations. It is a valuable data source on the role of women in agriculture in sub-Saharan Africa and presents thoughtful recommendations for more appropriate design and development of technology for women rice cultivators in the region.

Dove, M.

1984 "The Chayanov Slope in a Swidden Society: Household Demography and Extensive Agriculture in Western Kalimantan". In Chayanov, Peasants, and Economic Anthropology, E. Durrenberger, ed. New York: Academic Press, pp 97-132.

This study is a good example of the influence of household social organization on agricultural productivity and factor allocation decisions. Drawing on field data on shifting cultivation among the Kantu in Indonesia, Dove shows that, as predicted by Chayanov, the household economy is organized by consumption demands and that the intensity of family labor expenditure in agriculture reflects the demographic structure of the household. He argues further that wage labor is used to meet peak labor demands so that household labor investment is maximized throughout the entire production cycle. Households with high producer to consumer ratios use hired labor as a means to attain a larger total product of crops.

Those with low producer to consumer ratios deintensify family labor in their own plots and hire out labor.

Durrenberger, E., (ed.)

1984 Chayanov, Peasants, and Economic Anthropology. New York: Academic Press.

Ten papers are presented which employ a Chaynovian theoretical framework to analyze peasant economies in diverse parts of the world. Chayanov's main theoretical contribution was the idea that the intensity of peasant production is determined by the interaction of the demographic structure of the household, the producer to consumer ratio, the productivity of labor and the corresponding level of drudgery, and the desired consumption level. The papers analyze the relevancy of Chayanov's theory to understanding and predicting economic behavior in small-farm agriculture. The papers are of unequal quality, but some provide useful analyses on the interaction between the social organization of household units and the economic organization and behavior within farming systems. The papers most relevant to the technology applications gap are annotated separately.

Food and Agriculture Organization, Food Policy and Nutrition Division

1983 "Time Allocation Survey: A Tool for Anthropologists, Economists, and Nutritionists." Paper presented at the Expert Consultation on Women in Food Production, ESH:WIFP/83/17. Economics and Social Policy Department, Food and Agriculture Organization of the United Nations, Rome, Italy.

The paper argues that time allocation surveys provide a much more accurate description of labor allocation patterns by sex and age than surveys which rely on traditional definitions of "economically active" behavior. The latter, which generally only capture activities which can be readily measured in monetary terms, consistently undervalue women's and children's work burden and lead to false assumptions in rural development about free time which could be invested in productive activities. The paper, which emphasizes measuring the productive activites of women in Third World countries, includes good reference material summarizing findings from time allocation surveys.

Food and Agriculture Organization of the United Nations

1984 The Role of Women in Agricultural Production. Rome, Italy: The Food and Agriculture Organization of the United Nations, Women in Agricultural Production and Rural Development Service, Women in Development Series, No. 1.

This is a very good introductory work which summarizes the key issues pertaining to the role of women in agricultural production, food processing, storage, and marketing, and livestock production in Third World countries. The implications this has for agricultural development planning and project development are explored. The paper includes a comprehensive bibliography.

Food and Agriculture Organization of the United Nations

1984b "Women in Food Production and Security". Paper prepared for the Government Consultation on the Role of Women in Food Production and Food Security, July 10-13, 1984, Harawe, Zimbabwe. Rome, Italy: Food and Agriculture Organization of the United Nations.

This policy paper focusses attention on the important, yet too frequently neglected, role of women in agriculture, with particular attention to Sub-Saharan Africa. It advocates the need to more effectively involve women in agricultural development if the goal of food security is to be achieved. A good summary is provided of the types of constraints affecting women farmers and their ability to increase productivity through the adoption of new technologies.

Guyer, J.

1980 "Food, Cacao, and the Division of Labour in Two West African Societies." Comparative Studies in Society and History, 22: 355-373.

This article is a comparative analysis of changes in the gender-based division of labour that occurred in two different rural economies (that of the Yoruba in W. Nigeria and the Beti of South-Central Camaroon) with the integration of cacoa as an export crop. Before cacao the two societies had very different division of labour by sex: among the Beti farming was largely women's work; among the Yoruba farming was largely men's work. The integration of cacao reinforced the traditional division of labour in both societies. In both areas, cacao production became men's work and women's traditional obligation to supply harvest, processing, and transport labour was extended to cacao. The Beti women's work in food production intensified in order to maintain full subsistence production. In contrast, among the Yoruba, men continued to supply most of the labour in food farming, but the share of subsistence met by household production declined significantly. Reliance on trade, largely an economic activity of women, for food increased. Guyer concludes that the introduction of cacao production had a very different impact on the productive roles of women in the two societies: it expanded the economic opportunities for Yoruba women while, in contrast, it put pressure on the Beti women to remain in subsistence production.

Henn, J.

1983 "Feeding the Cities and Feeding the Peasants: What Role for Africa's Women Farmers?" World Development 11 (12): 1043-1055.

Henn argues that women farmers are key to alleviating the food crisis in Africa. Drawing on detailed case studies farming systems of the Beti in Southern Cameroon and the Haya in Tanzania, Henn documents the predominance of women in food production: the Haya women spend more than twice as many hours in food production than men and the Beti women more than five times the number of hours. Henn argues that the principal constraints to increasing food production in Africa are 1) women's heavy work burden and low labour productivity which leaves little room for expanding production without labour saving technologies; and 2) women's traditionally limited access to land and capital which impedes investment in improved technology. For agricultural development efforts to be successful in increasing food production, women farmers and professionals will have to be incorporated more fully into the research and development process.

Jorian, P.

1984 "Chayanov Should Be Right: Testing Chayanov's Rule in a French Fishing Community." In Chayanov, Peasants, and Economic Anthropology, E. Durrneberger, ed. New York: Academic Press, pp. 71-96.

Jorian gives a solid analysis of the interrelationship between the demographic cycle and structure of the household and its economic behavior. Analysis of data from small-scale fishing enterprises supports Chayanov's theory that the intensity of labor per worker in the household increases in direct relation to the ratio of producers to consumers. Jorian also demonstrates a strong correlation between the demographic structure of households and the labor demands of the economic enterprises they pursue.

McGough, J.

1984 "The Domestic Mode of Production and Peasant Social Organization: The Chinese Case." In Chayanov, Peasants, and Economic Anthropology, E. Durrneberger, ed. New York: Academic Press, pp. 183-201.

This is an excellent analysis of the interaction between the social organization of the household and its economic behavior and potential in agricultural production. Based on a Chaynovian analysis, McGough argues that the "anomolous" patterns of marriage and adoption observed in Chinese households can be seen as a means by which households compensate for imbalances in their producer to consumer ratios. Within the labor-intensive agricultural system, the kinship system functions as a means for labor recruitment and utilization when the labor resources of the biological family are inadequate to meet consumption demands of the household.

Moock, P.

1976 "The Efficiency of Women as Farm Managers: Kenya." American Journal of Agricultural Economics, (December 1976): 831-835.

This study compares the possesion and access to relevant knowledge for maize production of male and female farm managers in a district in western Kenya where 38% of the farms are managed by women. Moock found that male managers had greater access to extension services and credit which resulted in higher technical efficiency than female managers.

Rockefeller Foundation and ISNAR.

1985 Women and Agricultural Technology: Relevance for Research. The Hague, Netherlands: ISNAR, 2 volumes.

This report from the CGIAR Inter-Center Seminar on Women and Agricultural Technology is an excellent collection of papers addressing the technology applications gap with specific reference to women as technology users. Volume I is a summary of analyses and conclusions from the seminar. It includes six papers of which two, those by J. Murphy and M.S. Swaminathan are particularly recommended (that of J. Murphy summarizing IARC's experiences is annotated separately). Volume II contains papers from each of the International Agricultural Research Centers summarizing their experiences with incorporating the perspective of women as users of technology into the research and the technology generation process. It also contains three very useful papers summarizing the relevant literature on women and agricultural production and technology in Africa, Asia, and Latin America. The final paper by U. Lele is a general analysis of women's participation in agricultural development and the extent to which and circumstances under which gender affects economic behavior.

Roodkowsky, M.

1983 "Information Note on Women in Agriculture." Rome, Italy: Food and Agriculture Organization of the United Nations, Information Division.

A concise, well-written, review of the important role that women play in food production in Third World countries and the implications this has for designing effective agricultural research and development strategies. It is recommended as introductory reading on the topic.

Cross References

Author	Year	Section
Almy, S.	1977	II
Barlett, P., ed.	1980	IV
Carloni, A.	1983	V
Fleuret, P.	1985	II
Greenwood, D.	1976	I
Halperin, R. and Dow, J., eds.	1977	II
Hart, G.	1978	II
Hill, P.	1970	I
Hill, P.	1982	I
Huang, S,	1984	II
Kluck, P.	1975	I
Low, A.	1982	II
Mayer, E.	1974	I
Murphy, J.	1985	V
Netting, R.	1968	I
Norman, D; et. al.	1982	I
herr, S.	1983	I
staudt, K.	1978	V

IV. SMALL-FARM DECISION-MAKING AND THE ADOPTION OF TECHNOLOGY

Bartlett, P.

1978 "What Shall We Grow? A Critical Survey of the Literature on Farmers' Decision-Making." Paper prepared for the Civic Participation Division, Bureau of Program and Policy Coordination, Agency for International Development, Washington, D.C.

Bartlett presents a good review of the literature (written in English) on the interaction between conditions in the natural, economic, and social environments and decision-making in small-farm households. The review focusses on how households' access to the factors of production (land, labor and capital) shape the organization, management, and agricultural options of their farming system. Small-farm decision-making about land-use options is emphasized and the paper includes a very useful annotated bibliography of selected works in this area.

Bartlett, P. ed.

1980 Agricultural Decision-Making: Anthropological Contributions to Rural Development. New York: Academic Press

This book contains an excellent collection of papers on decision-making in small-farm agriculture. The contributions demonstrate the kinds of analytic contributions anthropologists can make to agricultural research, and development planning and programs. Nine papers discuss theoretical and methodological issues in studying decision-making, all drawing on conclusions formed from field research. Three papers analyze the types of factors that cause differential patterns of adoption of technologies or different management strategies among small-farmers in specific communities. The final two papers discuss the implications of research on decision-making for agricultural development policy and program planning.

CIMMYT

1974 "The Puebla Project: seven years of experience, 1967-1973." El Batan, Mexico: CIMMYT.

This paper summarizes CIMMYT's data on adoption patterns of recommended technological packages in Plan Puebla. It presents clear evidence of farmers' selective adoption of individual components of technological packages. CIMMYT interprets low levels of adoption as caused by insufficient technical assistance; the technology itself is not questioned. Other studies of Plan Puebla have seriously questioned the viability and profitability of the proposed recommendations (see Winkelmann 1976 and Gladwin 1976).

Dewalt, B.

1975 "Inequalities in Wealth, Adoption of Technology, and Production in a Mexican Ejido." American Ethnologist, 2 (1): 149-167.

This article presents data from a Mexican ejido to show that there is significant variation by wealth in adoption of new technologies among small-farm households. Statistical analysis of the paterns of adoption of two specific technologies---fodder crops and fertilizer--reveals distinct patterns of correlation between wealth and adoption with respect to each technology. The findings indicate that the relationship between wealth and adoption will vary depending on the technology introduced and the socio-economic constraints and incentives present.

Franzel, S.

1984 "Modeling Farmers' Decisions in a Farming Systems Research Exercise: the Adoption of an Improved Maize Variety in Kirinyaga District, Kenya." Human Organization. 43 (3): 199-204.

This article, extensively discussed in the text, provides an excellent example of how patterns of adoption of introduced technologies can be understood through constructing models of farmers' decision-making processes with respect to the new technology. The paper is recommended both as a case study on farmers' selective adoption and adaptation of an introduced technology to the specific needs and conditions of their farming systems, and as a good review of a valuable research tool for on-farm research and technology development.

Gerhart, J.

1975 The Diffusion of Hybrid Maize in Kenya. Abridged. Mexico City: Centro Internacional de Mejoramiento de Maiz y Trigo.

This monograph summarizes findings of a large-scale survey on the adoption of hybrid maize seed and associated practices among small-farmers in Western Kenya. It documents very high and rapid rates of adoption of hybrid seed, which alone gave yield increases of 30% to 80%. Adoption of associated recommended practices was more selective and varied with each component which was judged on its own merit. Adoption of the complete recommended package only occurred on commercial farms.

Gladwin, C.

1976 "A View of Plan Puebla: An Application of Hierarchal Decision Models." American Journal of Agricultural Economics, 58 (5): 881-887.

1980 "Cognitive Strategies and Adoption Decisions: A Case Study of Non-Adoption of an Agronomic Recommendation." In Indigneous Knowledge Systems and Development, D. Brokenshaw, D. Warren, and O. Werner, eds. Lanham, Maryland: University Press of America, pp 9-28.

These papers demonstrate the utility of decision-making models for understanding small-farmers' responses to introduced technologies and adoption patterns. Based on an exemplary analysis of the decision-making process of a sample of farmers in the Plan Puebla project in Mexico, Gladwin was able to identify the factors limiting adoption of recommended practices. Of particular relevance to the technology applications gap was the finding that the critical factor determing farmers' decision to adopt or not adopt differed among the specific components of the recommended package of practices. No single trait, such as risk aversion or profit maximization, could adequately explain farmers' decision-making behavior.

Johnson, A.

1972 "Individuality and Experimentation in Traditional Agriculture." Human Ecology, 1 (2): 149-159.

This is a classic article which was among the first to refute the conventional wisdom that peasant farmers were resistant to change due to deep-rooted conservatism. Based on research in Brazil and a review of the literature, Johnson puts forth two very important principles relevant to understanding small-farm systems and technological change. The first is that the assumption of homogeneity among small-farmers in a given region is misleading. The second is that small-farmers typically demonstrate a significant level of experimentation, rather than traditionalism, in their farming practices. The latter frequently leads to indigenous technical and socio-economic change and can be tapped as a resource for agricultural development if farmers are involved in the process.

Mann, C.

1978 "Package of Practices: A Step at a Time with Clusters." <u>Studies in Development</u>, 21: 73-82. Turkey: Middle East Technical University.

Mann documents Turkish wheat farmers' selective and sequential adoption of components of a recommended package of practices. He concludes that farmers adopt practices in an agronomically and economically logical sequence and recommends that improved technologies not be introduced as packages, but broken down into clusters of practices which can be adopted in a step-wise fashion in accord with farmers' resources and experience with the technology.

Perrin, R. and Winkelman, D.

1976 "Impediments to Technical Progress on Small versus Large Farms." <u>American Journal of Agricultural Economics</u>, 58 (5): 888-894.

This article summarizes the findings of CIMMYT's farm-level studies of adoption of improved maize and wheat varieties. The authors conclude that farm size is not a particularly significant variable influencing adoption. Although small farms lag behind large farms in adoption rates in the early stages of technology introduction, they catch up after several years. Agro-climatic zone emerged in the multi-variate analysis as the most important and consistent factor influencing adoption.

Ryan, J. and Subrahmanyam, K.

1975 "An Appraisal of the Package of Practices Approach in the Adoption of Modern Varieties." Hyderbad, India: ICRISAT, Economics Department Occasional Paper, No. 11.

This paper analyzes patterns of adoption of a technological packages centered on high yielding varieties in India. Results show limited adoption of the complete package, but high levels of adoption of selective components. Based on the analysis, the authors propose that a sequential approach to promoting new practices and technologies is more viable for resource-poor farmers than the technological package approach.

Walker, T.

1981 "Risk and Adoption of Hybrid Maize in El Salvador." Food Research Institute Studies, 18 (1): 59-85.

This is an excellent study challenging the a priori assumption that small-farmers are risk averse and, thus, are resistant to technological change. By comparing samples of farmers from a community which had adopted a recommended technology and one which had not, Walker demonstrates that their respective attitudes towards risk were not different, but that it was their perceptions of the risk entailed that led to differential adoption patterns. Farmers in the non-adoption community experienced a higher incidence of drought and perceived the new maize variety as less drought resistant. The study argues that the concept of risk aversion is used too loosely to explain lack of technology adoption and often clouds the fact that the technologies may not perform well under the specific agroclimatic or socio-economic conditions in which farmers operate.

Winkelmann, D.

1976 "The Adoption of New Maize Technology in Plan Puebla, Mexico." Mexico City, Mexico: CIMMYT.

Winkelmann generates an insightful analysis of the reasons behind the selective adoption patterns of recommended technological packages in Plan Puebla. Dismissing the standard argument of insufficient technical assistance, Winkelmann demonstrates that the recommended levels for plant density and fertilizer application were unprofitable and resulted in high risk for farmers, eg. the technology was not appropriate. In response, farmers adopted intermediate levels which Winkelmann shows had the highest economic returns under farmers' conditions.

<u>Cross References</u>

Author	Year	Section
Bartlett, P.	1975	II
Bartlett, P.	1977	II
Berry, S.	1975	II
Cancian, F	1972	I
Callear, D.	1983	III
Clayton, E.	1968	II
Dewalt, B.	1979	II
Dey, J.	1984	III
Ewell, P.	1984	I
Henn, J.	1983	III
Hill, P.	1970	I
Horton, D.	1984	V
Kluck, P.	1975	I
Matlon, P.	1984	V
Mayer, E.	1979	II
Merrill Sands, D.	1984	I
Moerman, M.	1968	II
Murphy, J.	1983	II
Ortiz, S.	1973	I
Rhoades, R, and Booth, R.	1982	V
Rhoades et al.	1983	V
Sheridan, M.	1981	V
Wharton, C.	1971	II

V. DESIGN AND DEVELOPMENT OF TECHNOLOGY APPROPRIATE FOR SMALL-FARM PRODUCTION SYSTEMS

Alverson, H.

1984 "The Wisdom of Tradition in the Development of Dry-land Farming: Botswana." Human Organization, 43 (1): 1-8.

Using conventional economic analysis of returns to land and labor, Alverson compares the profitability of a traditional smallholder farming system in Botswana with that of an "improved" farming system promoted by the government under a national plan to achieve selfsufficiency in the late 1970's. At current market prices, the returns to both land and labour from the traditional farming system were significantly higher than those of the improved farming system. The unprofitability of the "improved" system resulted primarily from large capital expenditures for plowing equipment which were not scale-neutral, and from the significantly higher labor investment required. The increase in yields attained with the new technology, given the low market price for cereals, was not sufficient to offset the higher cash expenditures required. Farmers were soon disenchanted with the project and rejected the technology. Alverson argues that that significant yield increases could be attained through moderate adjustments in the management practices of the traditional system which would not entail such drastic technological and socio-economic change within the farming systems. The theme is, again, that drawing on farmer's existing resources and knowledge is often a stronger foundation for agricultural development than the imposition of entirely new farming systems which have not been tested nor developed under local conditions.

Biggs, S.

1982 "Generating Agricultural Technology: Triticale for the Himalyan hills". Food Policy, (Feb.): 69-82.

This case study of a triticale improvement program in India documents how information generated by on-farm trials and surveys was successfully integrated into the process of research priority-setting and programming to make research more relevant to the problems of farmer client groups.

Biggs, S.

1983 "Monitoring and Control in Agricultural Research Systems: Maize in Northern India". Research Policy, 12: 37-59.

This is one of the few articles available in the literature which documents in detail the way in which an on-farm research program influenced the priorities and programming of a commodity improvement program. The case study comes from a maize research program in Northern India. The analysis focusses on the dynamic nature of the feed-back linkage from on-farm to on-station research. It documents how information generated through the on-farm research program deepened scientists' understanding of farmers' problems and influenced programming over the course of four years to make research more relevant to farmers' priority problems. The on-farm research program also helped to generate more appropriate recommendations for agricultural extension. The article is highly recommended.

Blustain, H.

1985 "The Political Context of Soil Conservation Programs in Jamaica." Human Organization. 44 (2): 124-131.

A case study of the technology applications gap based on a soil conservation project from Jamaica. Factors contributing to the failure of the project to achieve its goals are diagnosed as: 1) the prohibitive cost for farmers to maintain the conservation technology; 2) the social unit engaged in the project was inappropriate for the efficient use and maintenance of the technology; 3) the incentives (one-time subsidies for introducing conservation technology) offered to farmers to participate did not foster a commitment to soil conservation nor the success of the project; and 4) the impact of the project and technology could not be sustained because the project served primarily as a short-term vehicle to build patron-client relationships between politicians and farmers rather than to ensure long-term soil conservation. The case study is an excellent example of how the hidden political agenda of development projects frequently undermines their potential to attain development in the long term.

Byerlee, D. and Collinson, M.

1980 Planning Technologies Appropriate to Farmers: Concepts and Procedures. El Batan, Mexico: CIMMYT.

This is a comprehensive, well-written, and very useful reference for applied research on small-farm systems leading to technology

development, evaluation, and transfer. It explains the basic concepts underlying the Farming Systems Research approach and presents in detail the methodology that has been developed by the CIMMYT Economics Program for conducting on-farm research with a farming systems perspective.

Carloni, A.

1983 "Integrating Women in Agricultural Projects: Case Studies in Ten FAO Assisted Field Projects." Rome, Italy: Food and Agriculture Organization of the United Nations.

This paper presenting ten detailed cases studies of FAO field projects is highly recommended. The objective of the paper is to: 1) assess the degree to which FAO has taken rural women into account in project design and implementation; 2) evaluate the consequences of overlooking women; and 3) generate recommendations for project design which would facilitate the effective incorporation of women. The critical review of the project histories furnishes excellent examples of the technology applications gap resulting from development planners' insufficient understanding of the social and economic organization of the farming household. The paper provides an insightful summary of common misconceptions about women in agriculture as well as useful recommendations for more effectively incorporating rural women into project design and development.

Collinson, M.

1982 Farming Systems Research in Eastern Africa: The Experience of CIMMYT and Some National Agricultural Research Services, 1976-81. East Lansing, Michigan: Michigan State University, MSU International Development Paper, No.3.

This paper includes a recapitulation of the FSR procedures developed by CIMMYT for adaptive research, but its principal contribution is that it is one of the few published papers which reports on the results of research and training in FSR at the national level. It summarizes CIMMYT's experiences in developing national research capacity in FSR in four East African countries. This paper is an early contribution to the "second generation" of FSR literature which critically evaluates the approach based on several years of extensive field experience.

Ewell, P. and Poleman, T.

1980 Uxpanapa: Agricultural Development in the Mexican Tropics. New York: Pergamon Press.

This study is a probing analysis of a controversial resettlement and integrated rural development project in the humid tropics of Mexico. Based on research carried out five years after the initiation of the project, the study critically examines Mexican policy towards development of the tropical rain forests, in particular the "top-down" approach which treated farmers as laborers, rather than managers, and resulted in many serious technical failures due to lack of experience and knowledge of the region, poor management, and inappropriate objectives. This case study of agricultural development in the tropics provides a wealth of information, insight, and lessons on the complex problems inherent to developing the humid tropics through large-scale projects which are predicated on assumptions of the feasibility of massive technical and social engineering.

Gilbert, E.; Norman, D.; and Winch, F.

1980 Farming Systems Research: A Critical Appraisal. East Lansing, Michigan: Michigan State University, Department of Agricultural Economics, Rural Development Paper, No. 6.

This is an excellent review paper on Farming Systems Research incorporating a critical evaluation of the utility of FSR as an approach to agricultural research, a description of FSR methodology, an analysis of the linkages between FSR and agricultural development, and a set of three appendices appraising specific FSR programs in selected international, regional, and national institutes.

Goodell, G.; Kenmore, P.; Latsinger, J.; Bandong, J.; Dela Cruz, C.; and Lumban, M.

1982 "Rice Insect Pest Management Technology and its Transfer to Small-Scale Farmers in the Philippines." In The Report of an Exploratory Workshop on the Role of Anthropologists and Other Social Scientists in Interdisciplinary Teams Developing Improved Food Production Technology. Los Banos, Philippines: International Rice Research Institute.

Goodell presents a very useful discussion of the technology applications gap based on her work at IRRI with the development and extension of integrated pest management technology to Philippine farmers. To be successful, the technology required collective action by farmers. Yet, this integral aspect of the technology was never addressed nor tested until the "fine-tuning" stage when scientists were ready to evaluate the technology in farmers' fields. The scientists had assumed that the social conditions could be adjusted to meet the needs of the technology. The result was that the technology, as originally, designed was poorly received by farmers. It was only after 2 1/2 years of intensive interaction between farmers and scientists as well as of research on indigenous forms of organization by the anthropologist that an IPM technology was finally developed which was appropriate to the farmers' needs and farming conditions. Goodell uses the case history to stress the importance of including farmers throughout all stages of the technology development process.

Greenwood, D.

1980 Community-Level Research, Local-Regional-Governmental Interactions, and Development Planning: A Strategy for Baseline Studies. Ithaca, NY: Cornell University, Center for International Studies, Rural Development Committee Occasional Papers, No. 9.

This paper is highly recommended for those working in rural and agricultural research and development. The first section abstracts six major lessons relevant to development planning from recent social science studies on local communities and local-regional-national linkages. The six lessons coalesce into a general argument for the importance of good quality base-line data collection for effective problem identification and planning in development. The second section presents several methodologies from social science research which successfully link household and community levels of analysis with the more macro regional and national levels of analysis.

Harwood, R.

1979 Small-Farm Development: Understanding and Improving Farming Systems in the Humid Tropics. Boulder, Colorado: Westview Press.

This book is designed to help agriculturalists and development experts understand the organization and management of small-farm systems in the humid tropics so that they can more adequately develop technologies and transfer mechanisms that are appropriate for the conditions of small-farmers. The orientation is heavily agronomic, rather than socio-economic, and emphasis is placed on the complexity of cropping systems and the implications this has for agricultural research and development. The analysis focusses on several key aspects of small-farm production systems that promote efficiency in conditions of limited resources and which serve as critical leverage points for improving productivity. This book is basic reading for anyone interested in small-farm development.

Horton, D.

1983 "Potato Farming in the Andes: Some Lessons from On-Farm Research in Peru's Mantaro Valley." Agricultural Systems, 12: 171-184.

Horton documents a classic example of the technology applications gap through the case history of the Mantaro Valley Project in Peru which involved the International Potato Centre and the Peruvian national agricultural research service. He shows how the conventional wisdom of the agricultural researchers and extension agents on constraints in small-farm potato production were erroneous and led to the development of technologies which were unprofitable and inappropriate for farmers' needs and circumstances. The article builds a strong argument for the need for on-farm research and dialogue between farmers and researchers in order to generate relevant and useful technologies. It presents a methodology for on-farm research suitable for constraint analysis and the prescreening of potential technological solutions.

Horton, D.

1984 Social Scientists in Agricultural Research: Lessons from the Mantaro Valley Project in Peru. Ottawa, Canada: IDRC.

This excellent study provided the material for Case Study 1 in this monograph. It abstracts lessons from the International Potato Center's experience in developing interdisciplinary on-farm research methods for the analysis of constraints to potato production and post-harvest technology in the Mantaro Valley of Peru. The research methodology is presented, the empirical results reviewed, the contribution of social scientists evaluated, and the difficulties and benefits of on-farm interdisciplinary research are analyzed. The importance of interdisciplinary on-farm research for successful technology development and transfer is strongly substantiated by this case study.

Howes, M.

1980 "The Use of Indigenous Technical Knowledge in Development." In Indigenous Knowledge and Development, D. Brokenshaw, D. Warren, and O. Werner, eds. Lanham, Maryland: University Press of America, pp. 341-359.

This is a good review article on the potential of the contribution that indigenous knowledge of local environments and socio-economic conditions can make to agricultural research and development when it is effectively integrated through active farmer participation. Howes argues that research directed towards the development of technologies for a targeted group of farmers will be most successful when it draws on both indigenous and scientific knowledge systems.

Johnson, A.

1980 "Ethnoecology and Planting Practices in a Swidden Agricultural System." In Indigenous Knowledge Systems and Development, B. Brokenshaw, D. Warren, and O. Werner, eds. Lanham, Michigan: University Press of America, pp 49-66.

Johnson argues that ethnoecologists working to define the cognitive models farmers use in agriculture must supplement the analysis with the observation of actual behavior if their research is to be useful for understanding farmers' practices and applied to the development of appropriate strategies for agricultural development.

Matlon, P.

1984 "Technology Evaluation: Five Case Studies from West Africa." In Coming Full Circle: Farmers' Particpation in the Development of Technology. P. Matlon, R. Cantrell, D. King, and M. Benoit-Cattin, eds. Ottawa, Ont.: IDRC., pp. 95-118

In this excellent paper, Matlon develops a useful analytic framework which distinguishes six types of on-farm research with distinct objectives, methods, problems, products, and roles in the research process. The types are organized along a continuum from researcher-managed trials to farmer-managed trials with each reflecting increasing levels of farmer participation. Drawing on ICRISAT's experience in West Africa, Matlon analyzes the role that farmers can play in diagnosing constraints and in testing and evaluating technologies in the various types of on-farm research. Matlon provides some insightful examples of how farmer participation helped ICRISAT to focus research more effectively on the problems and objectives that farmers regarded of critical importance. The paper concludes with a critical discussion of the principal constraints to on-farm research: high variance in trials, bias, and staffing and supervision problems.

Matlon, P.; Cantrell, R.; King, D.; and Benoit-Cattin, M.; eds.

1984 Coming Full Circle: Farmers' Participation in the Development of Technology. Ottawa, Ont.: IDRC.

This volume contains eleven papers with commentaries (originally presented at a conference in Ouagadougou, Burkina Faso in 1983) which summarize and critically evaluate recent efforts to stimulate farmer participation in agricultural research in developing countries. The collection is highly recommended since it is probably the most comprehensive and current synthesis available of research institutions' experiences with integrating the perspective of small farmers more fully into the technology generation process. The papers, largely based on research in West Africa, are of varying quality and scope, but all reflect experiences with on-farm research and are directly relevant to the technology applications gap. Some use case materials to document the need for integrating the farmers' perspective into the research process. Others record how farmers' participation influenced the evolution of specific research projects and resulted in technology more closely adapted to farmers' environments and needs. Others, finally, deal with important methodological and institutional issues related to on-farm research. As a collection, the volume is strongest in justifying the need for farmer participation in research and in confronting the scientific and methodological problems of carrying out on-farm research. It is weakest in terms of addressing the social, cultural, and economic issues involved in organizing effective farmer participation; on-farm research does not necessarily result in farmer participation. Selected papers most relevant to this review are annotated separately.

Morss, E.; Hatch, J.; Mickelwait D.; and Sweet, C.

1976 Strategies for Small Farmer Development: An Empirical Study of Rural Development. 2 vols. Boulder, Colorado: Westview Press.

This study analyzes 36 rural development projects targeting small-farmers in 11 African and Latin American countries with the view to generate guidelines for the design and execution of projects aimed towards increasing the productivity of small-farms and the welfare of farming households. The primary conclusion of relevance to the technology applications gap is that project success is maximized with farmer involvement in the project process and when farmers make a resource commitment to the project. This is a good reference book which pulls together material from project histories to abstract relevant lessons and propose effective strategies for small-farm development. Volume 1 summarizes the study's general findings. Volume 2 presents the project case studies with a brief analysis of factors influencing their relative success or failure.

Murphy, J.

1985 "User-Oriented Research: a Synthesis of the IARC's Experience." In Women and Agricultural Technology: Relevance for Research. The Rockefeller Foundation and ISNAR. The Hague, Netherlands: ISNAR. Vol. 1, pp. 41-49.

This paper is a useful synthesis of the experiences of the International Agricultural Research Centers (IARC's) with integrating the users' perspective (particularly that of women as technology users) into agricultural research and technology development as a means for overcoming the technology applications gap. The discussion is organized around four key issues: 1) the need in research to place agricultural production into a broader context which comprises not only the farm, but also the household (on the micro level) and the region or nation (on the macro level) as relevant units of analysis; 2) the need for data on decision-making processes within the household with respect to agricultural production, consumption, marketing, and technology use and adoption; 3) the pivotal role of social scientists in incorporating the users' perspective into agricultural research; and 4) the need for collaborative relationships between IARC's and national research programs, which conduct more location-specific research, as a primary means for integrating the users' perspective into research and technology development in the IARC's.

Norman, D.

1980 The Farming Systems Approach: Relevancy for the Small Farmer. East Lansing, Michigan: Michigan State University, Department of Agricultural Economics, Rural Development Paper, No. 5.

This paper is particularly valuable for the four concrete examples it gives of the technology applications gap and the analysis provided of contributing factors. It provided source material for Cases 2 and 3 presented in this monogrpah. The paper illustrates quite persuasively how the farming systems approach to agricultural research can significantly minimize the problems leading to the technology applications gap.

Rhoades, R. and Booth, R.

1982 "Farmer-Back-to-Farmer: A Model for Generating Acceptable Agricultural Technology." Lima, Peru: International Potato Center, Social Science Department Working Paper, 1982-1.

By documenting the evolution of a research project aimed at improving post-harvest technology for potatoes in Peru, the authors develop a strong case for the need to involve farmers in all stages of the research process if the technology developed is to be relevant and widely adopted. The article provides a useful model for stimulating farmer participation in technology research and development.

Rhoades, R.; Booth, R.; and Potts, M.

1983 "Farmer Acceptance of Improved Potato Storage Practices in Developing Countries". _Outlook on Agriculture_, 12 (1): 12-15.

This paper describes the diffusion of low-cost potato storage practices among Philippine farmers. The principles for diffused-light stores for seed potatoes were first developed through intensive collaboration with farmers in the Peruvian Andes in a research program of the International Potato Center. This article documents the process by which the potato seed store technology was adapted to the local conditions of the main vegtable growing province of the Philippines through the active participation of local farmers. As occurred in the Andes, farmers rarely accepted the precise model for storage presented by agricultural technicians, but took the principles of the technology and adapted them through informal research to conform to their specfic needs and resource conditions.

Russell, N.

1984 "Tapping the Wisdom of Farmers." _World Agriculture_, 33 (9/10): 7-8.

A brief summary of the benefits accrued to agricultural research on root crops in Cameroon through actively involving farmers in the research process.

Shaner, W.; Philipp, P.; Schmehl, W.

1981 Farming Systems Research and Development: Guidelines for Developing Countries. Boulder, Colorado: Westview Press.

This is a comprehensive training manual on farming systems research designed for researchers in national systems. The principles underlying the approach are reviewed. A broad compendium of research methods are described in detail and supported with examples and case study material. It is highly recommended as a reference and "how-to" manual on FSR.

Sheridan, M.

1981 Peasant Innovation and Diffusion of Agricultural Technology in China. Ithaca, N.Y.: Cornell University, Center for International Studies, Rural Development Committee, Special Series on Agricultural Research and Extension, No. 4.

Sheridan provides a well-documented summary of small-farmer innovation and participation in agricultural research and development in the People's Republic of China based on the author's extensive field work in China in the 1970's. She argues that China's concerted effort to involve small-farmers in agricultural development and to foster an environment which stimulates farmer experimentation, innovation, and dissemination of ideas has been a key factor contributing to Post-Revolutionary China's considerable success in increasing agricultural production and meeting the rural population's basic needs. She uses the China model of "walking on two legs" to demonstrate the importance of fully integrating small-farmers into the process of agricultural research, development, and technology diffusion. Incremental innovation based on small-farmer experimentation can serve as a complementary and enabling strategy to large-scale technology innovation and development. Modest innovations, when applied on a large-scale, can significantly boost agricultural productivity. At the same time, they facilitate major innovation by supporting peasant involvement and by building a scientific and technical foundation to support change.

Simmonds, N.

1984 "The State of the Art of Farming Systems Research." Washington D.C.: World Bank, Agriculture and Rural Development Department.

A comprehensive review of the Farming Systems Research which develops a typology of the major types of research included under the general category of FSR.

Staudt, K.

1978 "Agricultural Productivity Gaps: A Case Study of Male Preference in Government Policy Implementation." Development and Change, 9 (3): 439-458.

This article analyzes male bias in agricultural services in Western Kenya where 40% of the farms were managed by females. Based on a sample of 212 households, Staudt found that, even controlling for the level of innovative behavior and economic resources, the difference between female-managed farms and jointly-managed farms with a male present in terms of attention from agricultural services was statistically significant. Staudt argues that systematic neglect of female farmers will eventually lead to a decline in productivity in relation to male farmers who are receiving a disproportional share of services and information. In areas where women play an important role in farming such a male biased policy will not only foster inequality, but could also contribute to an aggregate decline in agricultural productivity and thus thwart national goals for agricultural development.

Tripp, R.

1985 "Anthropology and On-Farm Research." Human Organization, 44 (2): 114-124.

This is a good article on the role that anthropologists can play in farming systems research. Tripp argues that social scientists should be active participants throughout all phases of the research process. He emphasizes that on-farm research is an iterative process with knowledge of farmers' production systems and potential areas for technical intervention increasing as farmer-researcher interaction grows. Anthropologists can play a key role in developing effective research tools and methods for technically trained national agricultural researchers so that they can promote farmer participation and conduct on-farm research which includes social and economic dimensions as well as

agronomic. The article summarizes the history and results of an on-farm research project in Ecuador.

Valdes, A.; Scobie, G.; and Dillon, J.

1979 Economics and the Design of Small-Farmer Technology. Ames Iowa: Iowa State University Press.

A moderately useful collection of articles on key issues pertaining to the design of technology appropriate for small-farmers. Emphasis is placed on the issue of the importance of taking risk into account when developing technologies for small-farmers and on designing economic models to predict farmers' decision-making.

Vierich, H.

1984 "Accomodation or Participation? Communication problems." In Coming Full Circle: Farmers' Particpation in the Development of Technology. P. Matlon, R. Cantrell, D. King, and M. Benoit-Cattin, eds. Ottawa, Ont.: IDRC.

Vierich gets to the heart of the issue of integrating the farmers' perspective into agricultural research by confronting the communication problems between farmers and researchers which frequently arise from the different paradigms each employs when observing phenomena and developing an explanation for its occurence. When farmers and scientists are of different cultural traditions, their distinct conceptual models of reality can render incomprehensible researchers' explanations for how a technology works or its potential utility to farmers' production systems. Similarly, farmers' answers to researchers' questions may be useful and meaningful, but Vierich cautions that researchers should not assume that the underlying model generating the answers is the same as theirs. Vierich's basic argument is that effective communication between farmers and researchers can only be built up as mutual knowledge and understanding develop through interaction over time.

Whyte, W.

1977 "Towards a New Strategy for Research and Development Agriculture: Helping Small Farmers in Developing Countries." Desarrollo Rural en las Americas, 9 (1-2): 51-62.

This article argues that a conceptual change in agricultural research and development targeting small-farmers has taken place. An organizational model which depends on farmer participation and

interdisciplinary research involving social scientists has emerged. The paper provides a good analysis of the lessons learned from Plan Puebla in Mexico which Whyte characterizes as a "transitional model".

Whyte, W.

1981 Participatory Approaches to Agricultural Research and Development: A State of the Art Paper. Ithaca, NY: Cornell University, Center for International Studies, Rural Development Committee, Special Series on Agricultural Research and Extension, No. 1.

This monograph is a comprehensive review of the evolution of the farming systems research approach in agricultural research including several detailed case studies of research projects based on farmer participation and on-farm testing of technologies. The paper constructs a strong and convincing argument for the need for farmer organization and participation if agricultural research is to lead to successful agricultural development.

Cross References

Author	Year	Section
Bartlett, P.	1980	IV
Collinson, M.	1972	II
Dey, J.	1984	III
Ewell	1984	I
Franzel, S.	1984	IV
Gladwin, C.	1980	IV
Henn, J.	1983	III
Jodha, N.	1979	II
Mann, C.	1978	IV
Mayer, E.	1979	II
McDowell, R. and Hildebrand, P.	1980	II
Merrill Sands, D.	1984	I
Moock, P.	1976	III
Norman, D.	1974	II
Norman, D.; et. al.	1982	I
Rockefeller Foundation and ISNAR	1985	III
Ryan, J. and Subrahmanyan, K.	1975	IV