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John M. Staatz and Richard H. Bernsten[1]

How do new technologies developed under the CRSPs affect household food security? The answer to this question depends on how we view household food security. This paper examines recent research findings on the determinants of household food security, particularly in Africa, and discusses their implications for the organization and goals of technology development research under the CRSPs. We stress the collaborative role of social and technical scientists in that process.

Part I of the paper introduces the concept of food security and discusses how the concept has evolved in recent years. Part II briefly describes the diversity of strategies that households follow to help assure their food security. Part III analyzes the implications of these diverse strategies for technology development under the CRSPs. Part IV discusses the implications of the preceding discussion for how the CRSPs organize themselves to produce and evaluate new technologies aimed at improving food security and how social scientists can contribute to that process.

The analysis presented here draws heavily on our experience working on food security issues in Africa. Some of the food security challenges in Asia and Latin America differ from those described here. A central challenge, however, to improving food security throughout the

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world is the need to drive down the real cost of food to poor rural and urban consumers. Achieving this cost reduction requires technical and institutional innovations throughout the food system. The CRSPs can make a major contribution to this process of innovation.

I. THE CONCEPT OF FOOD SECURITY

The concept of food security has evolved markedly since the mid 1970s, when Congress passed the Title XII legislation giving birth to the CRSPs. The term "food security" first came to prominence during the World Food Conference in Rome in 1975. At that time, crop failures in Asia and the Soviet Union combined with low carry-over stocks in major grain-exporting countries to lead to rapidly rising world food prices. Many observers felt that the planet was teetering at a precipice, and that small reductions in food production could trigger widespread famines. The conference therefore endorsed a two-pronged approach to improve global food security. The first element involved efforts to increase food production in food-deficit countries so the food supply would at least keep pace with the burgeoning population. This has been the main focus of the CRSPs. The second element called for establishing national and international emergency reserve stocks to deal with temporary local food shortages.

Since 1975 the world food situation has changed dramatically, and with it the perception of food security. Food production per capita in developing countries increased by 12% between 1974/76 and 1987/89, despite a population increase in those countries of nearly a billion people (FAO). Increases in food production and per capita incomes were greatest in Asia, the area of most concern during the World Food Conference. Yet while per capita food availability increased throughout most of the world during the 1980s, Africa was living out the fears of 1975. Widespread drought and civil disruption led to severe famines in several parts of the continent, and in many countries per capita food production stagnated or fell. The world witnessed the terrible paradox of Africans starving when world food prices were at an all-time low and farmers in food-exporting countries were going bankrupt because they could not sell their crops at remunerative prices.

Even in Asia, however, it became apparent that increased per capita food availability did not solve all the problems of hunger. For example, India became a net exporter of foodgrains during the 1980s (even sending emergency food aid to Ethiopia in 1985), although many Indians still went hungry.

These changes led to growing recognition that improving food security involves more than just increasing the supply of food. It also requires that poor nations and individuals have access to that aggregate supply. This changing view of the food security problem is reflected in the definitions of food security that came into widespread use during the 1980s.

Defining Food Security

An individual is food secure if he or she has access to a diet that is adequate to ensure a healthy and active life. The individual's access to food is in turn determined by the supply of food available locally and the individual's claim on that food (what Sen refers to as the individual's "food entitlement"). Whether the diet is "adequate" for a healthy and active life depends on the individual's ability to utilize the food. For example, chronic diarrhea caused by bad water supplies limit the individual's physiological capacity to absorb nutrients. Hence, underlying conditions affecting health strongly influence food security (Mellor et al., 1992).

The food security of a household, country or region reflects the degree to which the residents of that group or area are food secure. Most formal definitions of food security have focused on food security at the more aggregate levels of country or region. As explained below, one of the challenges in food security research involves analyzing the relationships between food security at the regional or national level and that at the individual and household levels.

The World Bank has defined food security as "access by all people at all times to enough food for an active and healthy life." A similar but more detailed definition has guided much of the work under Michigan State University's Food Security in Africa Cooperative Agreement:

> "Food security is the ability of a country or region to assure, on a long-term basis, that its food system provides the total population with a timely, reliable, and nutritionally adequate supply of food." (Eicher and Staatz, 1986, p.216)

These definitions have several implications for how one develops policies and technologies to improve food security.[2]

Implications of the Definition

1. Access is as Important as Availability.

Improving food security requires not only increasing food availability (or supply), but also the poor's access to food (or, to use the economist's term, their effective demand for food). A person can gain access to food through producing it herself, by using money earned in other activities to purchase food, or through gifts and transfers from others. It became evident by the mid 1980s that lack of purchasing power was a major cause of food insecurity in many African countries that experienced widespread hunger while world markets were awash with grain.

Viewing food security as a question of access, as well as availability, helps make clear the distinction between food security and food self-sufficiency. Food self-sufficiency refers to the capacity of a country, region, community, or household to produce directly all the food it consumes. In contrast, food security refers to having access to an adequate supply of food, which may come from own production, purchases, or gifts. Food self-sufficiency is thus a much more restrictive concept than food security. A country such as India may be food self-sufficient, in the sense that it produces more grain than can be sold domestically at prevailing prices, and yet not be entirely food secure. On the other hand, a country such as Singapore may be largely

[2]For a more detailed discussion of the various implications, see Eicher and Staatz, 1986.

food secure without even having an agricultural sector. Such a country relies on its earnings from other sectors to import an adequate supply of food. Similarly, households or individuals may be food secure even if they are not food self-sufficient. Such households and individuals typically have either diversified income sources that allow them to obtain food through the market or social ties that give them claims to food through non-market channels.

Even for largely agrarian countries, the single-minded pursuit of food self-sufficiency may not be the most effective way of assuring food security. It may be more efficient, from the point of view of both the country and the individual farm family, to devote some resources to other activities, such as producing cash crops or non-agricultural goods, and use the money thus earned to buy food. In effect, such a strategy involves producing one's own food, but indirectly, by using resources to produce other goods that are then traded for food. The strategic question facing both the individual farmer and the nation is which use of resources is the least costly (most efficient) and most reliable way of getting one's food. An integrated food security strategy thus needs to consider more than just domestic food crop production.

2. Need for a Food Systems Approach.

Food security depends on the ability of the entire food system to provide access to an adequate supply of food. By food system we mean the entire set of actors and institutions involved in input supply, farming, and the processing and distribution of agricultural products (including their links with international trade). Improving the ability of the food system to deliver food at low cost to consumers requires increasing the efficiency at each level of the system and improving the coordination among the various levels. Thus, while developing higher-yielding or more stable-yield crop varieties for farmers is one important step in strengthening food security, it is not enough in and of itself. Efforts to improve the reliability of food markets (e.g., through technologies aimed at improving the storability of commodities as well as policies making it easier for farmers and private traders to operate) represent other crucial activities to improve food security.

Taking a food systems or subsector approach is particularly important if one wants to try to improve food security through encouraging specialization and trade. It makes little sense for a farmer to produce cotton or non-agricultural products to sell for food if she cannot rely on the market to make food available when needed at reasonable cost.

3. Food Security at What Level?

Food security can be analyzed at many different levels of aggregation, such as:

- o The regional or subregional level, such as for the Sahel as a whole;
- o The national level;
- o The level of a zone or district within a country;
- o The village level;
- o The household level; or
- o The level of the individual.

The focus of this paper is food security at the household level. During the 1980s researchers increasingly shifted their attention from analysis of food security only at the national level towards food security problems at more disaggregated levels, such as the village, household, and individual. A common finding of much of this research was that there exists much greater heterogeneity than previously thought in the level of food security among rural households and in the strategies they follow to gain access to food. One of the key roles for social scientists in the CRSPs is to describe this heterogeneity and analyze its implications for technology development.

In particular, key steps in food security analysis involve analyzing who the food insecure are, what they eat, and how they secure access to food (what Sen refers to as their "food entitlement mapping." See also Timmer, Falcon, and Pearson.) Another key step is analyzing how recent or potential changes in technologies, institutions, and policies affect the poor's access to food. For example, how would the development of a grain variety that matured two weeks earlier than current varieties affect the access of food-insecure small farmers to basic staples? Without this type of disaggregated information, it is impossible to trace through the impact of improved technologies on the food security of the poor.

Agricultural research contributes to both sides of "the food security equation" (availability and access). Technical research that drives down unit costs of production lowers the real cost of food for consumers, including farm families. Furthermore, new technologies have the potential to raise farm incomes. In the short-run, costs may fall more quickly than prices, leading to higher farm profits for early adopters of the technology. Increased productivity in food-crop production also may permit farm households to assure their own food needs with fewer resources, thereby releasing resources for other income-earning activities. Higher incomes allow increased access to a larger and more varied diet as well as improved health care and sanitation, all of which strengthen household food security. In addition, higher farmer incomes translate into increased demand for other goods and services produced in other parts of the economy, stimulating economic growth and employment more broadly.

Nonetheless, most technology development work, including that of the CRSPs, has focused primarily on the supply dimension of food security. The implicit assumption has been that increased supplies would increase urban food security by driving down real prices to consumers. For rural areas, the implicit assumption, at least for Africa, was that most farmers were self-sufficient or net sellers of grain, or at least aspired to be (Staatz, 1991). Therefore, the most direct way to increase rural household food security was to increase the rural households' home production of food.

II. HOUSEHOLD FOOD SECURITY STRATEGIES

One of the most striking results of social science research conducted under the CRSPs and elsewhere in developing countries is how much rural households differ from one another in their resources and institutional environments. Recognition of these differences has been incorporated into how technical and social scientists, working in FSR teams, define their recommendation domains. (For examples, see McCorkle, 1989.) It is now well recognized, for example, that technology that is well-suited for an extended family that has clear title to its land may be inappropriate for a female-headed nuclear family that share-crops.

Less well-appreciated is the wide range of strategies that rural households use to assure their own household food security. These strategies incorporate varying mixes of home-production of staples, production of cash-crops and livestock that are sold or exchanged for food, reliance on non-farm activities to generate income to buy food, seasonal and long-term migration by one or more family members, and development of networks of reciprocal obligations that lead to non-monetary exchanges of food. (For details, see Campbell, 1990; Dioné [1989a]; D'Agostino and Sundberg, forthcoming.) Their strategies often have important gender dimensions, as men and women play different roles in helping assure household food security.[3]

Many household food security strategies rely heavily on earning income to purchase food through the market. The reliance of the rural poor on the market for food is well-recognized in Asia, where there is a large landless class. (See, for example, Mellor, 1990.) Less well-recognized, but nonetheless prevalent, is the reliance of rural African households on the market for food (Weber *et al.*, 1988). This reliance is strong, even in the grain belts of many African

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[3]A germane question, which we don't address due to space limitations, is what is meant by the term "household in this context. Once one begins to disaggregate by gender, the concept of household becomes blurred. What we are really dealing with are a whole range of overlapping managerial decisions and responsibilities taken by different individuals.

countries. Dioné (1989b, p.7), for example, found that following the two relatively abundant harvests of 1985 and 1986, 43% of the households in the two best agricultural zones of Mali (the CMDT and OHV) were net grain buyers. Weber *et al.* (1988) report comparable figures for other areas in Africa.

The dependence of rural African households on the market for food is particularly pronounced during the hungry period just before harvest. Sundberg's (1988) research indicates that in the OHV zone of Mali, 47% of the meals consumed by farm families in the two months before harvest were based on cereals purchased from the market. But reliance on the market is not just a seasonal phenomena. Research from throughout the Sahel indicates that in lower rainfall zones, households follow a strategy of diversifying their income sources away from cropping and placing greater reliance on the market for food (e.g., Reardon, Matlon and Delgado, 1988; Staatz, D'Agostino and Sundberg, 1990; Steffen, forthcoming). Steffen (forthcoming), for example, found that across all seasons, market purchases accounted for 36% of cereals consumption in the rural households he studied in the southern part of the Gao region of Mali in 1988/89 (a year of record harvests for the region). In the northern Gao region, bordering the Sahara, the percentage increased to 65%.

Both Steffen (forthcoming) and Reardon, Matlon, and Delgado (1988) found that those who followed a more diversified income strategy and placed greater reliance on the market for food had a more stable consumption pattern throughout the year than those who derived most of their food and income from their own cropping. A central message coming out of this research is that households living in risky environments (e.g., where rainfall is highly variable from year to year) diversify their sources of income and rely heavily on the market to help assure their food security.

A second key message is the importance of driving down the real price of food for the many poor rural and urban consumers dependent on the market for a good deal of their food supply. Cost-reducing technical change in the production of basic staples plays an important role here. But often equally important are improvements in the efficiency of the marketing system for basic foods. If, as is not unusual in many African countries, marketing costs account for 50% of the final consumer price of staples, then a 10% reduction in marketing costs has the same potential impact on consumers as a 10% decrease in the unit cost of production of basic staples.[4] The next section discusses the implications of these two key findings for technology development strategy.

III. IMPLICATIONS FOR TECHNOLOGY DEVELOPMENT

Implications of Diversified Household Food Security Strategies

Households vary widely in the resources they command and in the physical and institutional environments in which they operate. Consequently, they follow widely varying household food security strategies. Therefore, when designing technology to improve household food security, the first question to ask is whose food security are we trying to improve? For households in relatively high rainfall areas, having secure access to land, and an adequate family work force, the lack of streak-resistant maize varieties may be the major constraint to household food security. For households in semi-arid areas following a diversified income strategy,

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[4]A 10% decrease in unit costs of production is the equivalent of a 10% increase in total factor productivity--i.e., technical change that allows a farmer to get 10% more output for the same value of inputs. This reduction in unit costs is not equivalent to a 10% increase in yields. The impact of a 10% yield increase on consumer prices depends on the price elasticity of demand for the product.

Whether the decrease in marketing costs actually gets passed on to the consumer depends on how competitive the marketing and processing system is. If it less than perfectly competitive, some of the decrease in marketing costs will be captured by those in the least competitive segments of the marketing system. The degree of competition in the marketing system should itself be a subject of research, as it affects the level and distribution of payoffs to research on improving marketing and processing technologies.

In the short run, an increase in production of the commodity at the farm level may lead to an increase in the price of marketing services. The demand for marketing services would rise in response to the increased farm-level production: It will likely take time for the supply of those services to expand sufficiently to bring the price of marketing services back to their original level. A further important topic for research concerns factors that influence how quickly this adjustment takes place (or, to use the economist's jargon, the factors affecting the elasticity of supply of marketing services).

improvements in small-ruminant production may be a more cost-effective way of improving household food security, even though these households may eat very little meat. The increased income from greater small-ruminant production allows them greater access to grain through the market. And for those highly dependent on the market for part of their food, both in rural and urban areas, increased efficiency in staple food production in high-potential zones and improvements in the marketing system may be the most effective ways of improving household food security.

What is needed, then, in guiding technical research to improve household food security is a concept similar to that of recommendation domain used in farming systems research. The main difference between the "food security recommendation domain" and that used in FSR is that, from a food-security perspective, the intended beneficiaries of the research may be different from those who adopt the new technology. Technological improvements can improve the food entitlement of the poor through many mechanisms. For example, poor urban consumers may be the main beneficiaries of improved technology designed for and adopted by large-scale commercial farmers, if such technology drives down the cost of food to those consumers. Scobie and Posada (1990) showed, for example, that 70% of the benefits derived from the introduction of high-yielding rice varieties in Colombia in the late 1960s and early 1970s accrued to the one million poorest urban consumers in the country in the form of lower rice prices.[5] On the other hand, increasing incomes from non-cropping sources may in some circumstances be a more efficient way of improving the food security of certain rural poor than

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[5]The main losers from the introduction of the new technology were the approximately 12,000 small farmers who grew upland rice. They were not able to adopt the new technology but saw rice prices fall as a result of the expanded domestic production. This example illustrates the importance of asking whose food security one is aiming to improve. But as Scobie and Posada note (p. 412), "Under any plausible set of welfare weights, the losses [of the 12,000 upland rice growers] would be more than offset by the gain to more than one million low-income consuming households, implying an overall gain (albeit uncompensated) in some measure of social welfare."

increasing their own food production. Answering the question of whose food security is improved by technical change requires the type of disaggregated information on "food entitlement mappings" mentioned earlier.

The diversified income/food security strategies of poor rural households affect the types of technologies these households are willing to adopt. Non-cropping activities, including off-farm employment and seasonal migration, may occupy a large part of household members' time and be an integral part of their strategy to obtain food for the family. These off-farm activities can imply a high opportunity cost for household labor during certain times of the year. The higher the opportunity cost of labor, the more attractive it becomes for farmers to adopt crop technologies that substitute purchased inputs for labor. For example, the estimated cost of production of maize in southern Mali in 1989 varied between 27 CFAF/kg (U.S. $ .10/kg) and 64 CFAF/kg (U.S. $.24/kg), depending on whether one valued household labor at zero opportunity cost or at the estimated rural off-farm wage rate of 600 CFAF/day ($2.22/day). For millet and sorghum, using manual cultivation, the comparable figures ranged from 2 CFAF/kg (< U.S. $.01/kg) to 63 CFAF/kg (U.S. $.24/kg) (Staatz, 1989, p. 23). Obviously, the relative attractiveness of maize versus millet production depends on what types of outside employment opportunities are available to household members.

The attractiveness of different technologies also depends on the value to the household of additional production, which is a function of the household's food security situation. In many African countries, where there are substantial marketing costs, the value of additional food crop production depends on whether the household is a net seller or net buyer of the commodity. For households that are net buyers (e.g., smaller households following a diversified income strategy), the value of additional output is the money they would have had to pay for additional food when their supplies from home production run out, typically in the high-priced, pre-harvest hungry season. For net sellers, the value of additional production is more typically the sale price at harvest, which is considerably lower (Jayne, forthcoming). This higher value of the food crop for net buyers may encourage them to adopt new, more productive varieties of the crop. But it may also discourage them from adopting or expanding cash-crop or non-farm activities, as the opportunity cost of those activities (in terms of food crop production foregone) may be very high. Therefore, adoption of new technologies aimed at raising incomes by increasing non-food crop activities may be limited to larger farmers who are already producing a surplus of basic staples (Jayne, forthcoming).

The attractiveness of new technologies also depends on the land-tenure arrangements of the household, particularly how the cost of purchased inputs and revenue from additional outputs are shared between the landlord and tenant. Security of tenure also determines the willingness of households to invest in land improvements that pay off over several years.

Similarly, the willingness of rural households to adopt resource-conserving (sustainable agriculture) practices depends on the type of food security strategy followed by the household. Reardon and Islam (1990) observe that many of the practices and investments promoted in the Sahel to conserve resources, such as the construction of dikes and bunds, implicitly assume a very low opportunity cost for household labor during the dry season. The unwillingness of many farm families to adopt such practices, they argue, is a function of the diversified income/food security strategies followed by families in these semi-arid areas (see also Binswanger and Pingali, 1988). The tradeoff families face in the dry season is not between allocating household labor and capital to constructing bunds or having those resources sit idle. Rather, it is between investing that labor and the family's capital in the bunds versus investing them in a bus ticket to the capital city to seek work as a seasonal migrant. Here again, having a better understanding of the household's food security strategy and the opportunity costs it implies for family resources will be critical in designing technologies that prove attractive to farmers.

Implications of Households' Reliance on the Market

The heavy reliance of many rural as well as urban households on the market for some of their food supply has implications for technical research in at least four areas: the commodity focus of research, the need to focus on off-farm as well as on-farm constraints in the food system, the geographic focus of research, and the need for simple market analysis to help target agricultural research.

Commodity Mix

Because farm households, particularly in lower-rainfall areas, derive a significant portion of their access to food from non-crop enterprises, technical research to improve food security needs to embrace more than crop production. The existence of the Small Ruminant CRSP demonstrates recognition of this fact. But other important elements of many households' food security strategies are currently not addressed by any CRSP. In many areas, for example, cash-cropping by smallholders is positively and strongly correlated with increased household food security; hence, technical research on cash crops may make important contributions to household food security.[6] Similarly, technical constraints may limit income from nonfarm activities (Chuta and Liedholm, 1990). While we don't necessarily advocate the creation of a cash-crop or non-farm enterprise CRSP, we do suggest that national agricultural research systems need to consider these activities as part of their food security research portfolio. In particular, CRSPs should strive to develop food-crop and livestock technologies that are complementary to, rather than competitive with, these other enterprises.

[6] The effect of cash cropping on household food security depends on many factors including, among others, the nature of the crops involved and the prevailing land tenure and marketing arrangements. For an introduction to the large literature on this topic, see Maxwell and Fernando; the April, 1988 issue of the <u>IDS Bulletin</u> devoted to this topic; Von Braun and Kennedy; and Dioné (1989a).

Off-Farm Constraints in the Food System

Given the heavy reliance of many poor families on the market for food, a key focus of research should be on how to lower the cost of food delivered to consumers through the market. Traditional research on increasing crop productivity plays an important role here.[7] But often equally important are technical developments that improve the ability to store, market, and process products as well as institutional changes that facilitate marketing. For example, a major constraint to the development of a reliable market for cowpeas in the Sahel is the problem of bruchid infestation during storage (Coulibaly, 1987). This limits the ability to develop the cowpea market as an alternative source of income for low-income farmers and as low-cost source of calories and protein for consumers. Currently the Bean/Cowpea CRSP is addressing this issue in Cameroon by breeding bruchid-resistant varieties and evaluating improvements in on-farm storage technologies. Similarly, technical constraints in maize processing appear to be limiting the potential for developing low-cost maize-based products that could substitute for other coarse grains and rice in Mali. One important aspect of the problem is the need to synchronize technical work in processing with development of new varieties. In particular, varietal selection criteria need to include not only farm-level constraints but also the ease of transforming the variety into products preferred by consumers (Témé and Boughton, 1992).

In thinking about how to reduce the cost of food to poor consumers, one needs to keep in mind that these households, like farm households, may have high opportunity costs of household time. Therefore, the cost to be reduced is the cost of the product delivered to the consumer's plate, not necessarily the cost of the unprocessed product in the market. Particularly in urban areas, women (on whom responsibility for most food preparation tasks still fall) face

[7]From a food-security perspective, this work needs to focus on stabilizing yields and reducing unit costs of production. Reducing unit costs of production may require increasing yields, but not all yield-increasing technologies reduce unit costs of production. For details, see Staatz (1989).

increasing opportunity costs of their time, and fuel costs are high. Innovations such as parboiled sorghum (developed under INSORMIL) that reduce preparation time and fuel costs may lower the final cost to the consumer of the meal, even though its price per kg is higher than the unprocessed product.

In an attempt to add value to raw commodities through processing, many efforts in the marketing and processing areas do not give sufficient attention to the need to drive down the real cost of food to consumers. Some may argue that the development of new, highly processed products is a way of boosting the demand for the raw commodity, thereby increasing the incomes of farmers who grow it (and hence increasing their food security). But given the skewed income distribution in most poor countries, the market for such products will be very limited. Significantly expanding the demand for the raw commodity in most poor countries implies developing new low-cost products for the masses, not upscale products for the urban middle classes. At the same time, these low-cost products also directly contribute to the food security of the poor urban and rural consumers.

Geographic Focus of Research

The importance of driving down the real cost of food to poor consumers suggests that, from a food-security perspective, there can be high payoffs to focusing technical research in areas where there is potential for large productivity gains. Typically, these are higher rainfall areas. The desirability of focusing a high proportion of research resources on these areas depends on several factors. These include, for example, the proportion of the population relying on the market for a significant part of its food (which is often underestimated), tenure arrangements governing access to land in the high-potential areas, and government capacity and willingness to take measures to increase non-cropping income in the lower-potential areas and improve food marketing systems so people in these areas can reduce their real cost of food.

Discussions of where to focus research geographically inevitably raise equity concerns. We are not advocating that research abandon areas that are less endowed with natural resources. But we are suggesting that it may be more efficient and environmentally friendly for people in these areas to produce relatively fewer crops and more non-crop commodities such as livestock, which they could trade for staples, rather than produce the staples directly. Much of the environmental degradation in semi-arid Africa, for example, is due not to a lack of crop-related research for these areas. Instead, it results in part from insufficient productivity growth in staple food production in higher potential areas. The lack of productivity growth in these well-endowed areas, combined with increased population pressure, leads to migration of agriculturalists into more fragile areas that traditionally were devoted to grazing or forestry. This can be clearly seen, for example, in semi-arid areas of Kenya. There, increases in maize productivity in high-potential areas, although impressive, have been less than the very high population growth rate, leading to migration into more fragile areas. In the long term, the best way to address sustainability in the fragile areas may be to focus crop research on higher potential areas, thereby reducing population pressure in the low-resource zones and allow them to revert to their traditional uses.

In the short run, however, a two-pronged approach is necessary. Some work needs to go into stabilizing (and eventually improving) environmental conditions and farm incomes in environmentally fragile areas. But in their understandable desire to deal with poverty and environmental degradation in these areas, the CRSPs should keep in mind that greater productivity in high-potential zones can make major contributions to the food security of the large and growing proportion of the population that depends on the market for some of its food.

Use of Market Analyses to Guide Technical Research

Because so many people rely on the market for part of their food, simple analyses of existing price and market data may help identify research priorities. Such analyses are part of the strategy discussed below of using subsector analysis to guide technical research.

IV. IMPLICATIONS FOR THE ORGANIZATION OF RESEARCH UNDER THE CRSPs

Traditionally, social scientists have had little direct involvement in technology development aimed at improving food security. Most often, their contribution has been limited to conducting *ex post* analyses to assess the economic and social impact of technical change. While such studies provide interesting insights, they have limited impact on the technical research program. First, technical scientists may discount "pessimistic" appraisals as "cheap shots," since it is far easier to judge the past than to anticipate the future. Second, because most social scientists have a limited understanding of technical agriculture, these analyses are sometimes flawed with inaccuracies--and thereby discounted by technical scientists as "naive" assessments. For example, during the early 1980s, some social scientists advising the Office of Technology Assessment on sustainable agriculture in Africa called for technical scientists to develop "low-input/high output" technologies (for details, see Staatz, 1986). While such technologies would clearly be desirable, it is not at all evident they are technically feasible.

Finally, because *ex post* analyses are typically conducted 5-10 years after the research program is initiated, insights gained can only influence the direction of future technical research. Technical scientists facing such *ex-post* critiques often ask where the social scientists were when the basic technologies were being developed. The problem is that the structure of many research programs relegates the social scientist to *ex-post* nay-sayer rather than active participant in technology design (Staatz, 1989).

Factors to Consider in Setting a Social Science Research Agenda to Address Food Security

If social scientists are to contribute to the challenge of increasing the impact of technical research on food security, new approaches are required. These approaches must consider not only the diverse household food strategies discussed above, but also the basic structure of the CRSPs, existing resources constraints, and the information needs of the technical research programs.

1. Structure of the CRSPs

First, most CRSPs support collaborative research and training directed at relaxing constraints to increasing the production and utilization of a single commodity, e.g., beans, cowpeas, sorghum, millet, peanuts, small ruminants, or fish. Since most CRSPs are directed at a specific commodity, we do not attempt to address the issue raised earlier about there possibly being a greater potential for improving food security by focusing on another commodity or on non-farm enterprises. However, we do stress the need to put the CRSP research in the context of the constraints posed by other elements of the households' food security strategies, a perspective similar to the systems approach of farming systems research. For example, farm households in a particular region may attempt to secure their food security by relying heavily on seasonal labor migration to diversify their income sources. Such migration reduces farm labor availability during certain periods of the year--a fact that scientists need to consider in developing new crop technologies.

Second, each CRSP is guided by its Global Plan, which specifies the major world-wide constraints for the respective commodities. In selecting collaborating countries, consideration is given to the potential of the research conducted in that specific country to generate new knowledge and technologies that will have a national, regional, and world-wide impact. Finally, research conducted under the CRSPs is expected to benefit not only developing countries, but also U.S. farmers and consumers. Thus, social science research agenda must complement commodity-specific technical research agendas and seek to generate insights that have implications beyond the collaborating country.

2. Constraints to Conducting Social Science Research

There are two major constraints to implementing social science research in the CRSPs aimed at improving food security. First, financial resources available to the CRSPs are increasingly limited. On the other hand, social science data collection can be quite expensive. For example, it costs a minimum of $40,000 to implement a modest baseline survey and analyze the data generated (Bernsten and Ferguson, 1992). Second, many countries (including the U.S.) have a shortage of social scientists with the experience required to plan, implement, and analyze social science data in a way that generates insights that will contribute to a technical research agenda.

These constraints suggest that CRSP social scientists must place priority on developing cost-effective and replicable methods for implementing technology-generation-relevant social science research. In addition, to develop a cadre of appropriately trained social scientists, the CRSPs must allocate far greater resources to long-term and short-term in-service training of social scientists. Food insecurity is inherently an interdisciplinary problem, being affected by technical, institutional, and policy factors. Hence, the training of social scientists to deal with food security must equip them to work with those outside their own disciplines.

3. Information Needs of Technology-Generating Research Projects

Social scientists could contribute much more than they have in the past to developing appropriate technology that improves the food security of limited-resource farmers and consumers. To achieve this objective, rather than focusing on *ex post* analysis, we must redirect our attention to the more immediate needs of technical research projects (Knipscheer, 1989).

This suggests that we must provide greater assistance in identifying appropriate technical research priorities, assessing (*ex ante*) nascent technologies, and monitoring the initial impact of these technologies in their early stage of diffusion.[8] While social scientists can draw on existing methods to meet these needs, we must be the first to admit that, at best, we can anticipate the future only dimly. Serendipity plays a major role in technology development and the impact (or lack of impact) of new technology is often influenced by exogenous, unanticipated events.

Important Agendas for Social Scientists

Social scientists can make their greatest contributions to improving food security via the CRSPs in three areas: by addressing commodity-specific constraints that threaten food security, by developing and implementing cost-effective and replicable methods designed to help establish research priorities and assess nascent technologies, and by monitoring the initial impacts of these technologies.

1. Setting Initial Research Priorities: The Subsector Approach

Establishing initial research priorities is particularly critical, since these decisions will largely determine the ultimate impact of the technical research program. The priority-setting process must consider the most important constraints to improving household food security,[9] assess alternative opportunities to relax these constraints, and identify specific research strategies.

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[8]Nascent technologies refer to early generation research outputs (lines/ingredients) that must undergo further development and evaluation before being released to farmers/processors/consumers.

[9]As Jim Hooper, a former agronomist colleague at IRRI used to say, "Are we trying to find a solution to a problem that doesn't exist?"

Information Needs

Success in priority setting requires that the participants understand both the role of the commodity in the food system (especially its role in the food security strategies of the poor) and the linkages between interdependent components of the food system. In CRSP-sponsored projects, the target commodity is typically one of many crop-animal species in a cropping-livestock-farming system. The target commodity is linked to the national economy through input and output markets, is influenced by local institutions, and affected by national and international policies. Thus, factors exogenous to the farm are likely to have a major impact on the commodity; and changes in farm-level factors will affect the rest of the economy.

For example, if population grows while forest resources do not, the price of fuelwood will rise, other factors held equal. This increase in the price of fuelwood (a change exogenous to the farm) will shift consumption towards staples such as rice that require less fuel to prepare compared to coarse grains, such as millet. If, as in much of the Sahel, rice is heavily imported while millet is locally grown, such a shift in demand can hurt the country's balance of payments, leading to broader macroeconomic problems. Understanding the links between fuelwood prices and international trade patterns is thus necessary for analyzing changes in the farm-level demand for these commodities.

The Process

Subsector analysis can guide scientists in setting in-country research priorities by helping researchers gain a view of the "big picture." Shaffer (1970) defines a subsector as a "meaningful grouping of economic activities related vertically and horizontally by market relationships." In the context of the CRSPs, the objective of a subsector study is to provide a "conceptual framework for organizing knowledge about the subsector, specify the nature of missing information, and thus provide a basis for organizing future research." Component activities include describing the subsector, diagnosing problems constraining performance, projecting the consequences of specific alternative changes, and prescribing a research agenda (Shaffer, 1970; Témé and Boughton, 1992). Particular attention should be given to those elements of subsector performance that affect the access of the poor to the commodity. For example, understanding the factors affecting the seasonality of prices may be critical to developing policies to alleviate food insecurity during the "hungry season."

As originally conceptualized, subsector studies were typically implemented as a major research effort, extending a year or longer. In recent years, development-oriented economists have merged rapid appraisal techniques designed to assess village-level constraints (Chambers, 1981; Sarimin and Bernsten, 1984) with subsector analysis--thereby creating a rapid appraisal strategy for assessing the role of a commodity in a national economy (Abt Associates, 1988; Holtzman, 1986; Holtzman et. al., 1989; Scott, 1990). Rapid appraisal subsector studies (RASS) are carried out by a multidisciplinary team of social and technical scientists, who focus on synthesizing data collected from secondary sources and key informants to generate an overview of the historical and current status of demand (domestic and foreign), supply (production and imports), institutional environment (e.g., research, extension, marketing system, land tenure), government policies (e.g., prices, subsidies); and insights on gender, access, and equity dimensions of the subsector. From a food-security perspective, it is particularly important to identify which groups in the country are most involved in producing and consuming the commodity and what role the commodity plays in the food security strategies of poor households. For example, is the commodity a primary source of calories for the poor year-round, or is it consumed primarily during certain periods when other commodities are unavailable or very costly?

Simple analysis of existing price data can help identify topics to be further investigated during the RASS. For example, calculation of gross marketing margins and bivariate correlations of prices between markets may suggest areas where transport problems or lack of competition are hindering the movement of commodities. Similarly, simple graphing of prices over time may indicate seasonal price peaks that could be ameliorated through better storage technologies or the development of varieties with differing maturities. Such information is extremely useful in designing strategies for targeting food aid and other relief both seasonally and geographically (Staatz *et al.*, 1989).

Retrospective interviews with household members carried out during a rapid assessment can also provide insights into how households have coped with food shortages in the past. Such interviews provide information on the role that the target commodity plays in the household's food strategy. This information may highlight how improvements in the production technology or marketing arrangements for that commodity may strengthen those coping strategies. For example, they may highlight the need for earlier maturing varieties to "break" the hungry season, thereby reducing the need for food-deficit households to go into debt during this time of the year. Such debts often have to be paid back with labor on others' fields during the planting season, thus putting the food-insecure household further at risk. Similarly, as mentioned earlier, certain coping strategies such as seasonal migration may create resource constraints at the household level that technical scientists need to consider when developing new technologies.

RASS techniques are useful not only in identifying research priorities at the beginning of the project. These studies also need to be repeated periodically to monitor developments in the subsector that have important implications for technical research. For example, are export markets developing that offer remunerative new markets for farmers? Are farmers selling their work animals to cope with drought? If so, should technical research give greater focus in the short run to manual cultivation techniques? Subsector analysis is thus an iterative process that goes on throughout the life of the research (albeit at reduced intensity), not a one-shot affair.

Issues to Address

RASS analysis can provide considerable information relevant to establishing technical and social science research priorities to improve household food security, such as:

- Who consumes the commodity, how important is it in their diet, and in what form it is consumed (type of processed products)?

- When does the commodity become available during the year and how does it fit into the household's food strategy? How might its role in that strategy be modified? For example, in Mali maize is currently grown primarily as a hungry-season crop for on-farm consumption. The breeding strategy to fine-tune this role may be very different from one that focuses on turning maize into a major cash crop (Témé and Boughton).

- What grain characteristics (e.g., size, color, cooking quality) do local consumers prefer? To what extent do households rely on other complementary or joint products, such as leaves for sauces and straw for animal fodder?

- Is there a potential for export or import substitution? If exports are a target market, what are the quality characteristics desired in the target market?

- What are current yields, types/levels of inputs used, costs of production, and major constraints that farmers, traders, and consumers face?

- Who grows the crop--men vs. women, small vs. large land holders, owners vs. tenants, irrigated vs. rainfed farmers--and how important is each group in terms of its share of total production and its share of total farmers producing the commodity?

- Do farmers (*which* farmers) have access to credit, input and output markets, extension services?

- What government policies create incentives/disincentives to farmers, traders and consumers, such as controlled prices, tariffs, subsidies, and export taxes?

Potential Insights

Analysis of the data collected can help the project, for example, to identify major information gaps; recognize inappropriate technical options; highlight equity, access, and gender issues; refine technology options; specify desirable technology characteristics; and identify institutional and policy constraints that may limit adoption of new technologies. The following examples illustrate these potential contributions.

- *Identifying major information gaps*. The RASS analysis may clearly indicate that insects are a major production or storage constraint. Yet, the lack of detailed information may indicate that technical research is first needed to assess the relative economic importance of specific pests, before initiating a breeding program. Similarly, the RASS analysis may indicate the need to carry out a baseline survey to understand better the constraints faced by farmers, traders and consumers. One of the advantages of the RASS is that it helps focus the baseline survey so it doesn't attempt to collect data on every conceivable topic, leading to long delays in data processing and analysis.

- *Recognizing inappropriate technical options*. Although the RASS may show that weeds are a major constraint, analysis of data on labor and herbicide costs may show that herbicides are too expensive, relative to the cost of hand weeding. Such results would suggest that herbicide trials are inappropriate, but research on cultural practices is an appropriate alternative strategy to relax this constraint.

- *Highlighting access, equity, sustainability and gender issues*. The RASS analysis may find that the commodity is produced by both large, canal-irrigated, commercial male farmers with access to credit; and limited-resource, hillside, female farmers without access to credit. Research to address the constraints of the commercial sector would likely have far greater impact on national production, since this group is likely to adopt rapidly the new technologies. This, in turn, could benefit the many poor consumers dependant on the market for their food supply[10]. On the other hand, neglecting the research needs of the subsistence sector would exacerbate existing gender and income inequities--and promote environmental degradation by failing to generate technologies appropriate to the needs of, for example, hillside farmers. These results might suggest the need for a dual-focused research program, directed at addressing the differing constraints facing each group--with special attention paid to, for example, reducing soil erosion on hillside farms, which in turn will extend the useful life of the irrigation infrastructure.

- *Refining technical options*. A lack of processed products in the market may appear to indicate a potential to expand commodity demand by developing a new, highly-nutritious processed products. Yet, analysis of data collected may show there is no effective demand for highly-processed foods, since poor households have insufficient income to purchase the proposed product--a much more expensive source of calories/protein than the currently consumed unprocessed

[10]Whether increased domestic food production leads to lower consumer prices depends on, among other things, whether or not the country is a net importer of the commodity (if the country imports, increased domestic production may simply displace imports, with no change in price); and on how competitive the food marketing system is (Mellor, 1990).

product. These results would suggest the need to refocus the technical research towards developing an equally nutritious, but less highly processed--and less expensive--substitute to enhance household food security of the poor.

- *Specifying technology characteristics.* In certain instances, the RASS analysis will indicate that sufficient information is available to initiate technical research to redress a major constraint, such as low yields due to insect damage. In this case, information gathered on consumer preferences and environmental constraints will suggest grain quality and varietal characteristics that need to be incorporated into the breeding program, e.g., drought tolerance, early maturity, insect-resistance, small red seed type, and rapid cooking time. On the other hand, if the RASS analysis identified export as a major new market for surplus production, further analysis would be needed to identify consumer preferences in the target market.

- *Identifying institutional and policy constraints.* The RASS analysis may find that farmers growing the target commodity do not have access to credit or key inputs; or access is limited to owner-operators with land to offer as collateral--thereby limiting the potential impact of new technologies. Similarly, restrictions on grain movement within the country or on who may legally process it may substantially reduce the potential contribution of a crop to food security--as well as limit the demand for the crop from smallholders.[11] Given such situations, social scientists might develop a research initiative to document the negative impact of these policies. These results could then be used to initiate a policy discussions with the government, directed to creating a more fertile institutional environment.

Benefits and Challenges

The key to the success of a RASS analysis is the active involvement of both technical and social scientists. The role of the technical scientist is primarily to provide insights about the technical aspects of the target commodity. The role of the social scientist is to put the commodity into a subsector context--highlighting farmer, farm-household, trader, consumer, gender, institutional, government policy, and international trade dimensions of the subsector. From a food security perspective, it is particularly important to highlight how the commodity fits into poor households' food-security strategies, both as a consumption good and as a source of revenue.

RASS analysis is particularly appropriate for setting initial in-country research priorities

[11]For an example from Zimbabwe, see Jayne and Chisvo, 1991.

in the CRSPs, since it represents a strategy to generate rapidly (typically within one month) information needed to identify key constraints and research opportunities in the target subsector. In addition, when carried out at the beginning of a project, it provides an opportunity to establish rapport among in-country and U.S. scientists (often resident at different universities) from different disciplines. Finally, the jointly-authored RASS report provides all participants a common understanding of the subsector, the role of the commodity in household and national food security, existing technical/socioeconomic constraints, and technical/policy options for increasing the contribution of the subsector to food security.

2. Implementing Field Research: Screening Nascent Technologies

Once research priorities are set, commodity research projects attempt to relax identified constraints by screening both promising technologies that performed well in other countries and nascent technologies developed by the project. Social scientists can contribute to this assessment by identifying the social factors that need to be considered in this assessment.

Information Needs

Agricultural research projects follow a sequence of stages. Initially, nascent technologies are assessed against technical criteria, under restricted conditions. For example, lines or varieties are evaluated in on-station trials for agronomic characteristics, pest resistance, yield performance, etc. New ingredients (e.g., flour blends) are evaluated in the laboratory for nutrient content, storage and functional properties, and microbiological safety. Based on these tests, the most promising materials are advanced for broader evaluation. For example, preliminary lines and varieties are moved into on-farm trials to assess yield and yield stability under a wide range of environmental conditions. New ingredients may be supplied to commercial firms or expert sensory panels for further evaluation or formulated into products for evaluation by consumer taste panels.

While technical criteria measure many characteristics that determine their ultimate acceptability to farmers, traders and consumers, these measures sometimes overlook factors that subsector participants feel are important. Such factors may include date of maturity, growth habits, storability, taste, grain size, and cooking characteristics (Ferguson *et al.*, 1990). For example, households that face pre-harvest food shortages may be willing to trade off some increase in yield of a new variety for earlier maturity. Thus, the more effectively a research project can incorporate client preferences into the early stages of technology development, the more likely the finished technology will be acceptable to the target group(s).

The Process

Social scientists can help to increase the efficiency of screening by proposing methods to incorporate better the perspective of farmers, traders and consumers as early as possible. Two approaches have been used to achieve this objective. First, anthropologists have assembled "representative farmer panels" to evaluate entries in on-station and on-farm trials. Participating farmers rank each line/variety against technical criteria (similar to those used by the breeders) and give their preferences about color, seed size, maturity dates, etc. (Ashby, *et al.*, 1989; Sperling, 1989). Similarly, food scientists assemble consumer taste panels to assess preferences for both varieties and potential new consumer products.

Second, economists have developed models that seek to incorporate the farmers' perspectives into the evaluation of variety, herbicide, fertilizer, and insecticide trials (Perrin, *et al.*, 1979). This is achieved by estimating the marginal rate of return (MRR) to the alternative treatments, using estimates of input cost and benefits that reflect farmers' actual circumstances.[12] For example, rather than using an average market price to value yield, the

[12] The model actually estimates the marginal rate of return to a given increment in expenditures, i.e., the marginal net benefit (gross field benefit minus total variable costs) divided by the marginal cost (increment in expenditure).

analysis would use the field price at harvest--which may be much less than the average market price.[13] By varying the assumptions about the parameter values (e.g., input and output prices, tenurial arrangements, distance to market, labor costs, credit costs), it is possible to estimate the marginal rate of return that different types of farmers would expect to earn on his or her investment. For example, the rate would differ between, on the one hand, land owners living near the market and having access to subsidized fertilizer and government credit and, on the other hand, share tenants living far from the market without access to subsidized inputs and who must borrow from moneylenders at a high interest rate (Sumagaysay, 1990). Similarly, the marginal rate of return may be higher for food-insecure farmers who are net buyers of the commodity than for more food-secure net sellers.

Issues Addressed

Farmer participation in assessing experimental trials and *ex ante* MRR analysis can provide important insights about the likely acceptability of nascent technologies and their sensitivity to policy changes, such as:

- Do the varieties have characteristics preferred by farmers, traders and consumers? Here it is important to ask which farmers, traders, or consumers we are trying to help, as each of these groups have heterogeneous preferences. Food-insecure consumers may be willing to trade off taste for a significantly lower price, while more food-secure consumers are less likely to accept "sub-standard" staples.

- Do farmers, traders and consumers use the same criteria in assessing varieties as technical scientists?

- What is the potential benefit to earlier-maturing varieties that allow farmers to capture a higher market price (if they are net sellers) or avoid paying a high market price (if they are net buyers)?

- Are farmers likely to adopt a variety that produces a high yield but must be sold

[13] The harvest price for a new variety could be close to or even above the season-average price if the new variety matured much earlier than the main crop.

below the market price for competing local varieties of superior quality? Or are they willing to eat this variety themselves, reserving the traditional varieties for the market?

- How much labor will farmers be willing to invest in carrying out a new crop management practice?

- Will a nascent technology be adopted by only owner-operators, or is it sufficiently profitable to also be adopted by share tenants?

- If the government eliminated input subsidies, would the technology still be profitable?

- If the government reduced or eliminated the guaranteed support price, would the technology still be profitable?

Potential Insights

Results of these analysis help to guide the research program by providing insights about the likely acceptability of nascent technologies in their early stage of development, as illustrated by the following examples.

- *Confirmation of appropriateness.* Where the "representative farmer panels"/MRR analysis indicate that the technology is sufficiently promising, scientists can proceed to test and fine-tune the technology, with greater confidence as to its ultimate acceptability. When considering appropriateness, scientists need to bear in mind the concept of "food security recommendation domain" discussed earlier. What is appropriate for one group of farmers, traders, or consumers may be inappropriate for others. For example, technologies acceptable to farmers who are net sellers of grain may be inappropriate for those who are net buyers. Hence, the RASS findings help to target technologies and institutional changes better to different groups.

- *Potential Conflicts.* On the other hand, if these analyses suggest potential conflicts, the project should explore ways to modify the technology. Insights gained about the factors that reduced its acceptability can guide this process.

Benefits and Challenges

The success of strategies designed to incorporate clients' preferences and circumstances into early assessment of technology depends on the degree to which these analyses accurately reflect subsector participants' preferences and circumstances.

First, several issues arise in implementing "representative farmer panels." How should the participants be selected--randomly or purposively? Which types of farmers, traders and consumers should be included? From a food-security perspective, one should include both food-secure and food-insecure households in order to contrast the role of the commodity in the food strategies of these two groups. How many participants should be included? How should these participants' evaluations be weighted, relative to technical scientists' criteria?

Similar issues must be resolved in structuring MRR analyses. For example, what are the most important "types" of farmers, traders and consumers that should be simulated and how can their circumstances be best incorporated into the model? What values should be used to best reflect labor costs (e.g., zero opportunity cost, the wage rate of hired farm labor, or the non-farm wage rate), input/output prices, tenurial arrangements, etc. that farmers, traders and consumers actually face? (Here we must bear in mind the points raised earlier about how the household's food security strategy affects the opportunity cost of household resources.) What policy options are most important to simulate?

Resolution of these issues is needed to ensure that the proposed *ex ante* analysis validly and reliably reflects clients' circumstances. Efforts to resolve these issues will require the participation of both technical and social scientists. Only through joint resolution will it be possible to convince technical scientists that the approaches proposed have "scientific merit" and can contribute to the assessment and redesign of nascent technologies.

3. Monitoring Impact: Initial Adoption Studies

Once tested under relatively controlled conditions, new technologies become available for extension to farmers, food processors and consumers.

Information Needs

Scientists need to monitor the initial adoption of these technologies, since they are likely to have unanticipated impacts and may perform differently from the predictions of *ex ante* analysis. Early evidence of performance is needed to establish priorities for critical future second-generation research.

The Process

Adoption studies to assess impact are typically carried out several years after technologies have been released.[14] While social scientists can draw on these *ex post* methods, there is also a need to develop studies that track adoption during the initial diffusion period.

In response to this need, CIMMYT's Economics Program has drafted a manual for conducting studies to monitor the adoption of agricultural technology (CIMMYT, 1991). Adoption studies involve collecting data from a representative sample of farmers, traders and consumers to estimate the rate (percent) of adoption, respondents' reasons for adoption/non-adoption, their evaluation of the performance of the technology, and constraints still faced. In addition, data are collected on the socioeconomic characteristics of the respondents. These data are used to analyze the distributional impacts of a new technology, by estimating, and then comparing, the level of benefits received by various types of beneficiaries--large vs. small farmers or traders, net sellers vs. net buyers of basic staples, female vs. male entrepreneurs, irrigated vs. rainfed farmers, consumers at different income levels, etc.

Issues Addressed

Analysis of data collected through adoption studies will increase our understanding about the initial performance of the technology and clarify who has benefitted from the technology. For example:

[14]Often a baseline study is conducted following the subsector rapid appraisal to generate information as to farmers', traders' and consumers' before-project situation, including constraints faced. The information collected in the baseline studies can be used to assess changes that have occurred as a consequence of the project.

- o Is the technology being adopted in all regions of the country or only in well-endowed environments?

- o Is the technology being adopted by all types of farmers, or mainly by male/female, irrigated/rainfed, large/small farmers? Especially important from a food security perspective is the need to distinguish between farmers who are net buyers of the commodity and those who are net sellers. Resource constraints and the value of additional production are likely to differ substantially between these two groups (Jayne, forthcoming).

- o Has the technology performed as well as anticipated, or are improvements needed?

- o Are there institutional or policy-related factors that explain a lack of or differential adoption, such as a lack of farmer access to extension services, credit, input/output markets?

Potential Insights

Answers to the questions outlined above can suggest initiatives that should be taken to improve the performance of the technology and identify opportunities to address better the needs of non-adopters, thereby accelerating adoption. For example:

- o *Poor performance of technology.* Information generated about the initial performance of the technology under differing ecological condition and socioeconomic circumstances and the remaining technical constraints can be used to set priorities for future research.

- o *Institutional and Policy Constraints.* Insights about the impact of access to input and output markets, extension services, credit, etc. will suggest opportunities to work with the private sector and government to redress the identified constraints. For example, if the analysis indicates that availability of seed was a limiting factor, the project could explore with private seed companies or non-governmental organizations appropriate mechanisms for contracting for seed multiplication.

Benefits and Challenges

For adoption analysis to provide valid and reliable insights that can be used to strengthen the technical research program and identify interventions needed to diffuse the benefits of the new technology more widely, several methodological issues must be addressed.

Social scientists, working closely with technical scientists, can contribute to strengthening survey design and analysis of the data by providing advice on the following critical issues.

Regarding sampling: Where should the survey be conducted? What sampling frames should be used to select a random, representative and unbiased sample? How large a sample is necessary to achieve the desired level of precision? How large a sample is necessary to provide adequate representation of the various groups whose food security one wants to improve--e.g., adopters vs. non-adopters of new technologies; net buyers vs. net sellers of basic commodities? What are the tradeoffs between purposive and random sampling to assure adequate coverage of these various groups?

Regarding questionnaire design: What information should be solicited to assess the performance of the technology and to understand the pattern of adoption? How should these needs be made operational through survey questions?

Regarding analysis: What types of insights are required to guide the assessment of the technology and identify unmet needs? What are the appropriate social, institutional, and policy interactions that should be explored in the analysis? Review of previous studies of household food security strategies provides some guidelines here.

V. CONCLUSIONS

Households in developing countries engage in a wide variety of activities to help assure their access to food. The diversity of their activities determines how they react to new technologies developed by agricultural researchers. We have argued that these diverse strategies and the heavy reliance many households place on the market for food have major implications for technology development under the CRSPs.

In particular, the diversity of strategies means that cropping activities must be viewed in a systems context, where the non-crop enterprises help determine the opportunity cost of household resources. These opportunity costs, in turn, affect the farmers' willingness to adopt new technologies. The heavy reliance of many rural as well as urban households on the market for food implies that a major focus of research should be on driving down the real cost of food through increased productivity in both the farm and off-farm elements of the food system.

This vision of food security places technology development in its broad context. But work under the CRSPs, by its very nature, is more narrowly defined. Such work can nonetheless make important contributions to household food security as long as that work bears in mind households' diverse strategies to assure their access to food and the importance of taking a subsector, as opposed to purely a farm-level, perspective.

A major need in the CRSPs is for greater collaboration between social scientists and technical scientists at critical points in technology design and implementation. In particular, we have described how social scientists can make important contributions to identifying research priorities, screening nascent technologies, and monitoring the impact of new agricultural technologies, all aimed at improving household food security.

These activities are not intended to be all-inclusive. But they represent a beginning--a way for social scientists to contribute more to successful technology development and build their credibility with technical scientists. This should, in the long-term, lead to a greater role for social scientists in the CRSPs. As a first step, each CRSP project should identify at least two social scientists to participate as full partners on the research team--one from the U.S. and one from the collaborating developing country.

Several actions could increase the productivity of social scientists working in the CRSPs. Among these, networking and training should have high priority. The development of a network among CRSP social scientists would provide a forum to develop, share, and refine research methods. Successful research approaches aimed at improving food security could be more rapidly diffused across CRSP commodities. Furthermore, such a network would allow CRSP social scientists to appreciate more fully how their individual commodities fit into various multi-commodity household food strategies.

Finally, much more attention must be paid to training LDC social scientists in the skills needed to complement those of technical scientists. Without such an effort, the contributions of social scientists to national agricultural research systems will remain very limited.

We believe that the strategy outlined above will strongly contribute to the productivity of the CRSPs and the credibility of social scientists with technical scientists. This enhanced credibility will in turn lead to increased demand for social science research. We believe that such a "demand-led" strategy for increasing the social science contribution to the CRSPs is a more productive path than establishing guidelines that allocate a fixed percentage of CRSP budgets to social science research.

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