THE ROLE OF SUBSECTOR ANALYSIS IN SETTING RESEARCH PRIORITIES

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B/C CRSP Socioeconomics Working Paper 92-4

Paper presented at the USAID sponsored "Symposium on the Impact of Technology on Agricultural Transformation in Africa", Washington, D.C., October 14-16, 1992

Bean/Cowpea CRSP Socioeconomics Working Paper 92-4
and
Agricultural Economics Staff Paper 92-104

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I. INTRODUCTION

Agricultural research has made a major contribution to increasing the productivity of the agricultural sector and reducing food costs, both in the developed and developing world. While empirical studies have shown that investments in agricultural research generally generate high rates of return (ROR), these studies also show that the magnitude of the ROR varies considerably across commodities and countries studied (Oehmke, *et al.*, 1992).

Since an ROR is calculated as the discounted value of benefits minus costs, it follows that strategies to reduce costs or increase benefits (or make the benefits accrue earlier) will raise the ROR. Focusing on the benefits side of the ROR equation, the magnitude of potential benefits is largely determined by 1) the size of the incremental benefit associated with adoption of the new technology (i.e., difference between the value of the benefits generated by the new technology compared with the old technology), 2) the size of the production/utilization base (e.g., area planted to the crop or the amount of the commodity consumed), and 3) the adoption rate (i.e., percent of base over which the technology is adopted).

Therefore, the potential impact of a given research investment can be increased if we initially employ a strategy for setting research priorities that increases the likelihood that the research program addresses major problems constraining the supply of or the demand for a major commodity and generates technologies that will be widely adopted.[3]

II. SUBSECTOR ANALYSIS: AN OVERVIEW

Subsector analysis is one approach that can be used in analyzing issues of technology development and transfer (Staatz and Bernsten, 1992). This approach is emphasized in the Africa Bureau's *Strategic Framework for Agricultural Technology Development and Transfer in Sub-Saharan Africa* (USAID, 1992).

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[1] Paper prepared for the USAID sponsored Symposium on the Impact of Technology on Agricultural Transformation in Africa, October 14-16, 1992.

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[3] Improvements in crops with the largest production/utilization base may not have the greatest potential ROR. In instances where major crops have been the subject of considerable prior research, the marginal impact of additional research may be small. In addition, for equity reasons, it may be appropriate to invest resources in improving minor crops that have been neglected and are grown primarily by limited resource farmers.

A. What is a Subsector?

The agricultural sector or food system of a country can be depicted as a matrix, involving various commodities and stages of production (figure 1). In figure 1, each commodity constitutes a column of the matrix, while the stages of production, going from input distribution through final consumption, are depicted as rows.

A subsector is simply a vertical slice, along commodity lines, of the larger agricultural sector. For example, the millet subsector involves all the stages of millet production running from input supply to final consumption. Shaffer (1973) describes a subsector as "the vertical set of activities in the production and distribution of a closely related set of commodities." Marion (1986) provides a complementary definition: "an interdependent array of organizations, resources, laws, and institutions involved in producing, processing and distributing an agricultural commodity." Key concepts embodied in both of these definitions include the idea that a subsector is a vertical slice by commodity, from input supply to consumer; and that it involves not only organizations or firms, but all the ways (rules, law, business practices, etc.) that help get those organizations or firms to operate in a coordinated way.

The concept of vertical coordination evolved in the U.S. shortly after World War II, as a tool to analyze changing vertical arrangements within a subsector. It was first used to look at vertical arrangements in the poultry subsector, which was rapidly evolving at that time. Economists offer several definitions of vertical coordination, including: "all the ways of harmonizing the vertical stages of production and marketing" (Mighell and Jones, 1963) and "the sufficiency of the system of prices and other mechanisms as carriers of information and incentives and directors of the allocation of resources in a subsector" (Marion, 1986). Thus, coordination has been used to refer to both a process (conduct) and a state (performance). The problem is that the process doesn't always work well.

Poor coordination within a sector is often a major problem. Poor coordination may affect both physical production/distribution tasks (e.g., input production, transport, farm level production, storage) and coordination tasks (e.g., exchange, price formation, quality control, risk management, information transmission).

B. Why Should We be Interested in Subsector Analysis?

Viewed in terms of the food-system matrix shown in figure 1, agricultural research has traditionally focused on individual cells of the matrix (e.g., research on better millet processing) or on one aspect within a given stage of production (e.g., breeding, entomology, or agronomy research within the farm-level production stage). More recently, agricultural scientists have sought to understand systems by analyzing a horizontal slice of the agricultural sector. For example, farming systems research looks at systems interactions between enterprises at the farm level. While the traditional cell-by-cell approach and the farming-systems approach are useful in addressing certain types of issues, as an economy develops and becomes more integrated, it becomes increasingly important to take a vertical slice as well, by commodity.

The subsector (commodity systems) approach represents one way of getting a handle on some very complex issues. As economists interested in technological change, we often face the challenge of trying to predict or evaluate the actual or potential impact of changes in

technologies, institutions, or policies on the agricultural sector (or food system). The problem is that the food system in any country is big and complex and gets more so as the economy develops. For each commodity, there exists various production and distribution functions, as well as the coordination functions discussed above. The challenge is to develop approaches that allow one to take into account key interactions within the food system when analyzing the impact of technological or institutional changes, while avoiding being overwhelmed by the complexity of the system.

C. What is the Value of the Vertical Approach?

Economic development is a process that occurs over time, resulting in major changes in the structure of an economy. The vertical approach helps us to understand better several aspect of this process.

1. Development involves specialization and technological change, both of which lead to greater reliance by farmers on off-farm elements of the economy. Agricultural development represents a movement from subsistence agriculture to a commercial economy. One aspect of this transition is that most technical change gets embodied in some new, usually purchased input (e.g, seed, fertilizer, pesticides) and/or leads to greater reliance on off-farm elements of the food system for processing. Second, these changes create a need for greater coordination across stages, both on the input and output side. A critical question is how this coordination or harmonization takes place--via markets, contracts, vertical integration, etc. Third, as Adam Smith observed in the *Wealth of Nations*, development results in and stems from greater specialization. Farming systems research views the farmer as <u>the</u> research client. This is appropriate where most of population is in semi-subsistence agriculture, since consumers and farmers tend to be one. But, as an economy becomes more specialized, consumers and farmers become more separated, and whole new clientele groups for agricultural research emerge, such as input dealers, middlemen, processors; each facing new challenges regarding technologies, institutions, and policies.

2. Over time, a greater proportion of the population relies on the market for food, due to population growth, urbanization, and income diversification. Even in Sub-Saharan Africa, a large number of rural households, in some cases the majority, depend on the market for food (Weber et al., 1988). Therefore, assuring their food security involves helping the market deliver food to them at lower cost--a key food security challenge. As population pressure grows, these "consumer" clients of agricultural research will likely grow more important, and rely more heavily on non-agricultural sources of income.

Low-cost food is also a key to the viability of non-farm activities, as food cost determines labor cost and hence their competitiveness (Mellor, 1990; Chuta and Liedholm, 1990). Thus, improving the performance of markets for cash-crops and non-agricultural activities is crucial for income growth, equity, and impact. The subsector approach is useful for analyzing these issues as well.

3. Structural adjustment induces major changes in marketing and processing systems. Changes in intermediate stages of the food system (between farmers and consumers) occur not only due to economic development and specialization, but also as a consequence of structural adjustment programs in the economy. In many low-income countries, until recently, many of the marketing and processing stages in major agricultural subsectors were typically coordinated through

mechanisms such as grain-board monopoly marketing arrangements. Such arrangements are frequently no longer financially viable. The challenge facing policy makers today is finding ways to achieve coordination in a financially sustainable way. Issues that must be addressed include what new institutions, technologies, and policies are needed. For example, in Mali prior to cereals market liberalization, the cotton parastatal CMDT bought maize on behalf of the national grain board at a high, guaranteed price (Témé and Boughton, 1992). This made it profitable for farmers to adopt certain new maize technologies, but the practice was financially unsustainable--government piled up huge financial losses. So, the challenge now is to see if there are other ways of coordinating the system and lowering costs in the distribution/processing system to enable farmers and processors to take advantage of some of the technical production possibilities for maize.

4. As economies become increasingly integrated, changes in one level of the system increasingly affect other levels of the system. Given the increasing interdependence between stages within a subsector, subsector problems must be addressed taking a vertical perspective. And because subsector problems cut across traditional disciplinary lines and are often multi-institutional, this analysis requires the participation of multidisciplinary teams or task forces charged with the responsibility of addressing specific problems of specific commodities, as was done in the Latin American Marketing Project in the 1960s (Harrison et al., 1975).

III. CHARACTERISTICS OF THE SUBSECTOR APPROACH

A. Key Characteristics

Subsector analyses employ a systems approach. Three key characteristics of this approach are its vertical orientation, emphasis on understanding interactions, and demand- driven focus.

1. A Vertical orientation, with emphasis on coordination

Increasing productivity of a subsector involves two interrelated efforts: increasing productivity at each stage in the vertical production chain--the traditional focus of agricultural research--and increasing coordination across stages.

First, it is important to keep in mind that simply optimizing at each vertical stage may not lead to the most efficient system because impacts at one level affect other levels, often in unintended ways. For example, in the case of an integrated feed production-poultry operation, optimizing at each stage (i.e., lowest feed costs or highest profit margins for feed) may not optimize the whole system. Second, actions taken at one level need to be coordinated with demands or incentives at other levels. For example, varietal choice by farmer (and breeders) needs to be coordinated with preferences of consumers and processors. Poorly functioning markets don't always transmit the right incentives to ensure this coordination. Finally, a combination of a systems approach and an analytic (Cartesian) approach is required. In other words, individual constraints must be analyzed, but they must be viewed in a systems perspective.

2. Emphasis on understanding the interaction of technologies, institutions, and policies.

Subsector participants do not exist in isolation. Rather, existing rules governing marketing affect the profitability to the farmer of different agricultural technologies. Thus, the payoff to technical

research obviously depends on the institutional setting of the economy into which the new technology is introduced.

3. Demand driven--identification of consumer desires.

The focus on the demand-driven nature of research has two aspects. First, producing things that consumers want and will pay for will generate greater income growth for farmers and lower costs for government--resulting in greater overall economic efficiency. Second, concern for food security in most low-income countries highlights the need to drive down real cost of food to poor consumers, through increasing the efficiency of the subsector (both farm-level production and marketing and processing activities).

Given the importance of purchased foods in diets of the poor, both in urban and rural areas, driving down food costs increases the real incomes of the poor. In the past, governments have attempted to drive down the real price by either squeezing agriculture and traders or through financially unsustainable food subsidies. A far better solution is to increase the efficiency of the food system, which drives down costs and allows lower prices to consumers, while maintaining incentives to farmers and traders.

B. Keeping a Single Subsector in Perspective

While the subsector approach argues for focusing the analysis on a single subsector, linkages among agricultural subsectors are often important. For example, consumer demand for sorghum will depend on changes in the price of close substitutes, like millet. Hence, subsector studies must also analyze key points of interaction between the target subsector and closely related subsectors.

C. Setting Bounds for the Subsector Study

Strict proponents of a systems approach may argue that all agricultural subsectors--and all vertical steps in each subsector--are highly interdependent. Therefore, a comprehensive systems approach is required to describe and diagnose constraints in the target subsector. Researchers are always plagued with the question of how to set bounds on the scope of a proposed study. Given limited resources, setting bounds must be decided in a pragmatic way, depending on the problem at hand. First, the decision as to which subsectors to include should be guided by an assessment of the degree of interdependence between the target subsector and other subsectors. For example, if rice is the target subsector, how important is maize consumption relative to rice, overall, and for various key target groups (such as the poor)? Second, with respect to vertical stages in the target subsector, one does not need to cover every stage in equal detail. Rapid assessment methods should be used to identify key stages or links between stages that need special attention.

IV. APPLICATION OF SUBSECTOR ANALYSIS TO AGRICULTURAL TECHNOLOGY DEVELOPMENT AND TRANSFER

Researchers interested in technology development and transfer issues can use subsector analysis to help set initial technical and socioeconomic research priorities, and to monitor the impact (including often unintended systems impacts) of new technologies and institutional changes.[4]

A. The Importance of Initial Research Priorities

Research priorities are often difficult to change after they are established. Once committed to a set of priorities, we are all reluctant to acknowledge that these priorities may have been wrong. In addition, changing priorities in mid-stream may involve considerable losses on sunk costs. Therefore, it is particularly important that initial priorities be set with as comprehensive an understanding of existing constraints as possible.

Subsector analysis can guide research priorities setting by helping to: (1) identify and prioritize constraints to food security, (2) identify alternative opportunities for innovation in the food system, and (3) specify research initiatives to exploit these opportunities and relax these constraints. Subsector studies can assist this process by providing a view of the "big picture" of the subsector, clarifying the role of the target commodity in the food system and in the food strategy of the poor, and identifying linkages between interdependent components of the subsector as well as linkages between subsectors.

B. The Process--"Rapid Appraisal Subsector Methods"

As originally conceptualized, subsector studies were typically implemented as major research efforts, 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.

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[4] While subsector analysis is a particularly efficient method when employed during the early stages of a new research initiative, the approach may also be employed at later stages in the life of a project as a tool for monitoring the impact of new technologies and institutional changes.

C. Issues to Address

RASS analysis can provide information relevant to establishing technical and social science research priorities, 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?

D. Potential Insights

Analysis of the data collected can help a research project 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 under several socioeconomic and environmental settings--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[5]. 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 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,

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[5]Whether increased domestic food production leads to lower consumer prices depends on, among other things, whether 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. It also depends on how competitive the food marketing system is (Mellor, 1990).

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.[6] 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 discussion with the government, directed to creating a more fertile institutional environment.

E. 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.

RASS analysis is particularly appropriate for setting initial in-country research priorities, since it represents a strategy to rapidly (typically within one month) paint the "big picture" and generate 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. The jointly authored RASS report provides all participants a common understanding of the subsector, existing technical/socioeconomic constraints, and technical/policy options for increasing the contribution of the subsector to food security.

Finally, subsector analysis should not be envisioned as a one-shot exercise. Elements of the rapid assessment subsector analysis may be repeated periodically to monitor subsector developments, as circumstances change.

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

V. CONCLUSION

While subsector analysis is a useful approach, it should not be oversold as the way to answer every technology development and transfer question of interest. For some questions, horizontal approaches are more useful. For example, transport problems are more appropriately analyzed across subsectors.

On the other hand, subsector analysis is appropriate for generating an overview of the role the target subsector in the agricultural economy--a perspective that is particularly important when establishing initial research priorities.

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FIGURE 1
FOOD SYSTEM (AGRICULTURAL SECTOR) MATRIX

PRODUCTION AND DISTRIBUTION FUNCTIONS	SUBSECTORS						
	Millet	Sorghum	Maize	Cotton	Rice	Peanuts	...
Input Distribution	SUBSECTOR APPROACH						
Extension							
Farm-level Production		<——FARMING SYSTEMS APPROACH——>					
Processing							
Storage							
Assembly							
Transportation							
Wholesaling							
Retailing							
Financing							
Consumption							

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