TOWARD INCREASED DOMESTIC CEREALS PRODUCTION IN ETHIOPIA: USING A COMMODITY SYSTEMS APPROACH TO EVALUATE STRATEGIC CONSTRAINTS AND OPPORTUNITIES

by

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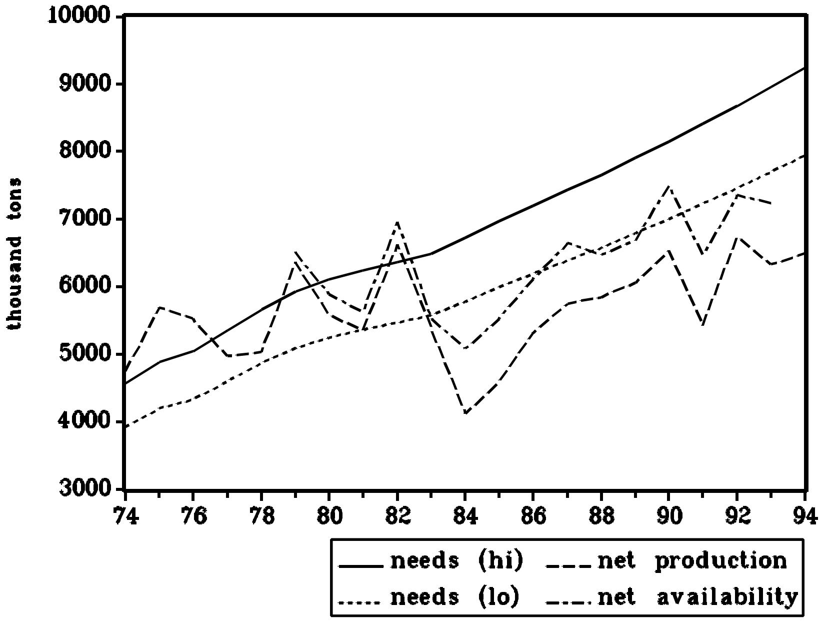
1. INTRODUCTION

Only 40 years ago, Ethiopia exported an average of 90,000 tons of grains and legumes to its East African and Arabian peninsula neighbors annually (Hailu 1991). Cereals production has remained flat since the early 1970s, however. With more than a doubling of population between 1970-90, available food per capita has declined. The country has become increasingly dependent on supplies of donated food aid in recent years (Figures 1,2). Yet Ethiopia is endowed with a wealth of natural resources: diverse agroecological systems, many with adequate rainfall and soils fertile enough to sustain a wide variety of crops. Only 40% of potential arable land, and less than 5% of irrigable land, is currently being used (Faught 1988, cited in Stroud and Mulugetta 1992).

How can Ethiopia's underutilized resources, including its human capital, be better channeled to enable the country to feed itself, and perhaps export foodgrains, once again? The objective of this paper is to present a framework and process that can be used by Ethiopians for strategic planning in the cereals system, to highlight the most important constraints to increased productivity and identify critical investments to alleviate them. The paper uses the framework to take a "first cut" at identifying major constraints and opportunities, and areas requiring further research, drawing on findings from a rapid appraisal of major food surplus and deficit areas.

The objectives of the rapid appraisal were to (a) assess foodgrain production performance; (b) review policies and organizations affecting foodgrain production, storage, marketing and processing of grain; and (c) identify major constraints to increased foodgrain production. The appraisal consisted of a review of major secondary reports and focused interviews with major stakeholders and clients of policies and organizations affecting agricultural production and pricing. These included farmers, traders, service cooperative officers, wholesalers, retailers, truckers, government agriculture and natural resource agency representatives in Addis Ababa and at regional, zonal and woreda levels, agricultural scientists at the major cereals research centers, officials at agricultural credit institutions, representatives of seed and fertilizer agencies, and rural development and non-governmental organization project personnel. The interviews were carried out during May and June 1995 in major cereals surplus and deficit areas of the country: Regions 1, 3, 4, 5 and the Southern Ethiopian Peoples' Region.

Figure 1. **Food Production, Food Aid, and Consumption Requirements, 1974-1994**

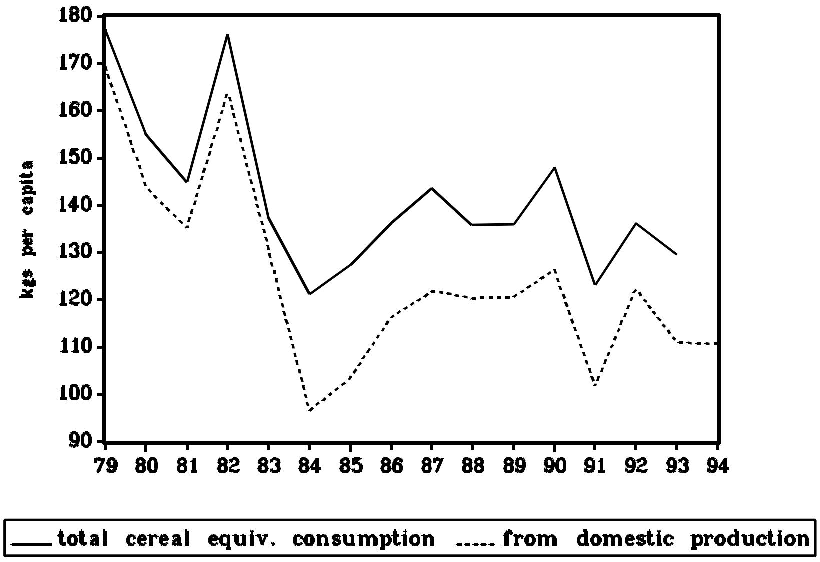


Source:Computed from data provided by Central Statistics Authority.
Notes:Food production and availability includes cereals only.

Needs (hi):Cereal consumption requirements based on population * 225 kgs per person per year (recommended by Ethiopian Medical Association) * .7. Cereals make up approximately 70% of the average Ethiopian's calorie intake.

Needs (lo):Consumption requirements based on population * 182.5 kgs per person per year (RRC estimated ration requirement for relief situation for non-working person) * .7.

Figure 2. **Per Capita Food Consumption from Domestic Production and Total Food Availability, 1979-1994**



Source: Computed from data from Central Statistics Authority.

2. IDENTIFYING STRATEGIC CONSTRAINTS AND OPPORTUNITIES IN ETHIOPIAN CEREALS SYSTEMS

The objective of strategic program planning[1] is to increase the benefits to society from investment in the agricultural sector and hasten the process of agricultural transformation in the developing economy. The extent to which this objective is achieved will depend on the "goodness of fit" between farm-level technology development and complementary investment and innovation in institutions, technology and policy in the off-farm components of the commodity system. This section examines, in the Ethiopian context, the questions that need to be answered to improve this fit over time, the use of a food systems matrix (Figure 3) as a conceptual framework to organize analysis and interactions between participants in the program design and implementation process, and implications for institutionalizing strategic program planning.

Because of the evolving nature of the agriculture sector, it is important to think of strategic planning as an ongoing process of working out resource deployment--of identifying and choosing among sequences of activities leading to different intermediate outcomes, in seeking to achieve the more general goals worked out for the sector.

Strategic planning is thus defined as an ongoing problem solving process. It includes at least three key elements: working out a **vision** of where the county wants to go, a **strategy** that relates how key actions must work together to achieve the vision, and day-to-day **tactics** to carry out the strategy.

Three sets of issues are considered:

- What kind of information and analyses are needed to guide decision-making at different levels in the agricultural sector?

- Where in the agriculture sector does the information and analytical capacity exist and what linkages between different organizations (e.g., Ministry planning units, universities, research institutes) are necessary to mobilize that capacity?

- How can the participation of different client and stakeholder groups in problem diagnosis, planning and implementation be structured in a way that articulates their demands without swamping the planning and agricultural ministries? (Boughton et al. 1995)

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[1] See Appendix 1 for a detailed explanation of the strategic planning approach.

Figure 3. Food System (Agricultural Sector) Matrix

RESEARCH & EXTENSION

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

2.1. Ethiopia's Vision for the Agricultural Sector

The government of Ethiopia's vision for economic development is contained in the EPRDF's Five-Year Development Program[2]. The rural and agricultural sector is viewed as the focal point of development for several reasons. First, since 85% of the country's population is located in rural areas and engaged in agriculture, mobilizing the country's resources for fast development requires working with the rural population to improve agricultural productivity. Second, a broad-based development strategy which shares the benefits of development among many is necessary to maintain peace and ongoing support for the development process. Third, a focus on increasing rural and agricultural productivity is the key to finding a lasting solution to Ethiopia's chronic famine problem.

Other parts of the economy will also benefit from faster growth in the agricultural sector. For example, the urban population will have access to cheaper food. With the growth of agricultural production, the availability of raw materials for industry will also increase, stimulating off-farm employment. Rising rural incomes will accelerate the demand for consumer items and agricultural implements, strengthening these industries.

Increasing the adoption of improved agricultural technology is an important part of the plan's strategy to increase productivity in both high and low potential areas. Specific objectives include

(4) strengthening public and private participation in seed research, extension, multiplication and distribution services;

(5) increasing the availability of fertilizers and pesticides, and improving their distribution through the private sector and service cooperatives;

(6) expanding rural credit and savings services;

(7) improving the extension service, and strengthening links between extension agents, farmers, and the research system.

The plan also recognizes the important role that agricultural markets play in motivating farmers to increase their agricultural production. Farmers will have little incentive to increase production if there is no marketing system through which they can sell their products, and buy agricultural inputs and consumption items at fair prices.

In general, the government will encourage the private sector to play a much larger role in agricultural development than previously, e.g., in the provision of marketing and transportation services, investment in the seed industry and the development of agroindustry. The formation of farmer organizations will also be encouraged to facilitate farmer participation in the political and development process.

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[2] As summarized in the *Addis Tribune*, June 2-July 15, 1995

Other important objectives of the Five-Year Plan include improvement of natural resource management, expansion of irrigated agriculture through the construction of small dams, development of livestock resources, implementation of an equitable land policy, and development of economic and social infrastructure.

2.2. Constraints to Achieving the Vision

The task of planners in Ethiopian agricultural agencies is to translate these general policy guidelines into specific, implementable programs. In working out the practical details of programs, agricultural planners are faced with many hard decisions. They must decide how to weight different performance dimensions--for example, in the research system, what relative attention should be given to programs supporting different Five-Year Plan objectives? For example, what balance should be struck between investment in programs that encourage productivity increases in the short-run and those that preserve natural resources and long-term productivity (e.g., development of improved variety-fertilizer-pesticide packages vs. soil and water conservation)?

Planners are also faced with hard decisions between programs that serve different groups of clients and stakeholders. For example, how should resources be allocated between research programs that serve maize growers in surplus-producing East Wollega, for whom a range of suitable open-pollinated and hybrid varieties already exists, vs. maize growers in lowland drought-prone regions, for whom little technology is available?

2.2.1. Research and Extension

Research and extension systems have the potential to generate and disseminate technologies that increase productivity at every step of the production and distribution system (Figure 3), from input distribution through consumption. Several recent policy actions establish an important foundation for improving the effectiveness of the research and extension system. First, a National Agricultural Research Council (NARC) has been formed. It is one of four sectoral councils[3] that serve as technical advisory committees for the National Science and Technology Council (NSTC). The NSTC is composed of ministers from agricultural, educational and planning agencies and chaired by the Prime Minister.

The NARC is charged with implementing the 1994 National Agricultural Research Policy. The general objectives of that policy are to (1) develop and adapt agricultural technologies that contribute to food self-sufficiency; (2) increase agricultural sector productivity, especially in the smallholder sector; (3) increase the production of import-substituting commodities; and (4) strengthen national agricultural research capacity, while improving coordination within the system.

[3] The other councils are health, natural resources and industry.

Also, the previously separate Ministries of Agriculture, Natural Resources, and Coffee and Tea, including their extension services, were recently merged into a single new ministry. Extension administration will now be decentralized, and extension agents will no longer be expected to carry out non-extension tasks such as animal health, coffee quality control and tax collection.

Constraints to implementing these policies, and improving research and extension effectiveness in Ethiopia, can be examined through horizontal and vertical "slices" of the food system matrix (Figure 3), through both industry and subsector perspectives.

2.2.1.1. Coordination Within the Research and Extension "Industry": The industry approach examines the coordination of supply and demand for services between firms and agencies in the same field. Interviews with research and extension personnel and farmers throughout the country indicated two areas that needed strengthening: (1) the coordination of research within and between different institutes, including the Institute of Agricultural Research (IAR), Alemaya and the agricultural colleges, and non-governmental organizations (NGOs); and (2) research-extension linkages.

Industry performance: development and adoption of technology. A recent review of technology generated by the Ethiopian NARS since its establishment in 1966 shows that the following technology has been developed, tested or released (Science and Technology Commission 1994):

- nearly 250 crop varieties (cereals, oil crops, cash crops, pulses, horticulture crops, spices)
- 25 farm implements
- 28 recommended tree species
- 16 soil and water conservation techniques
- 10 livestock breeds
- 17 forage species

Less than half of these crop varieties are currently under production: many have been supplanted by higher-yielding varieties, others have gone out of production because of disease susceptibility and other factors, and others may never have been widely adopted because of lack of extension, inputs, market opportunities, or other system constraints.

Recent studies (Mulugetta 1993, Chilot et al. 1995) show that wheat-fertilizer technology packages developed by IAR have been widely adopted in the Arssi and Holetta areas. In Arssi, more than 90% of farmers who participated in bread wheat variety demonstrations on their fields, and 55% of nonparticipants, planted improved varieties released between 1975-84 (Dashen, ET-13, Enkoy)(Mulugetta 1993). More than 80% of farmers in both groups applied fertilizer, although most used less than half the recommended rate. In the Holetta area, 49% of wheat farmers used improved wheat varieties in the sample season (Dashen and ET-13), but nearly all had used improved wheat at some time. However, only 12, 12 and 17% of farmers had ever used improved tef, barley and faba bean varieties. Fertilizer was commonly used on wheat and tef, and herbicide on tef, wheat and barley, although again at far lower than the recommended rates (Chilot et al. 1995).

These studies indicate that farmer adoption decisions are affected by the perceived profitability of input use. The incidence of adoption is also affected by institutional variables (input availability, credit access and extension contact), while economic factors (farm size, oxen ownership, labor availability) influence the intensity of use.

Less is known about adoption of other types of technology. Asfaw et al. (1994) indicate that 85% of surveyed farmers in the Bako area have adopted one or more improved maize technologies (variety, fertilizer, row planting or combinations of the above). Forty-two percent adopted the variety, fertilizer and row planting package on at least part of their fields. However, technology adoption in Bako has been influenced by a concentration of extension and NGO attention over the past few years. Nationally, improved maize area is estimated at only 5-10% (Mwangi, personal communication 1995).

Although no formal data exist, observations during the rapid appraisal suggest that adoption of technology has lagged in some cases because the technology was developed with an inadequate understanding of farmer demand. For example, farmers accustomed to wooden "mareshas" (plows) believed that steel tools were too expensive, or too heavy for their animals. Weak linkages with key actors in the subsector are another problem. For example, private animal equipment manufacturers and blacksmiths were unable to sustain tool production after donor project assistance ended. Opportunities for potentially useful collaboration between implement researchers and Rural Technology Centers (charged with dissemination of appropriate technology) have not been fully exploited.

Researchers are just beginning to interact with non-traditional research clients, and these interchanges will be useful in identifying additional opportunities for productivity gains. For example, food quality trials might be conducted in collaboration with the food industry, e.g., pasta manufacturers or millers, to learn how existing varieties could be improved to meet their needs.

Information about adoption patterns and factors that affect them is essential for calculating the economic impact of developed technology, predicting the economic impact (and who will benefit) from alternative new investments in research and extension, and understanding what complementary investments will be necessary to assure a high level of adoption of new technology. The wheat adoption studies also provide another insight about the importance of maintenance research: unfortunately, two of the most widely adopted varieties, Dashen and Enkoy, have recently gone out of production because of their susceptibility to rust.

Interviews with research scientists and farmers indicated that, among the cereals, **technology gaps** are felt to be most severe for wheat varieties (due to disease problems), storage technology, maize varieties for low and high altitudes, and for semi-arid areas generally.

Impact of Regionalization: Regionalization as it has been implemented thus far has weakened coordination between IAR researchers. Before regionalization, IAR maintained two research streams, both funded from the national treasury, nationally- based commodity programs, and zonal-based applied research. Zonal research stations were originally established based on agroecological zones, and often housed both applied and commodity researchers. With regionalization, the facilities and funding responsibilities for some zonal research stations have been transferred to regional governments.

A strong argument for the devolution of the stations to the political regions was that devolution would bring about a sharper focus on region-specific problems by making researchers directly accountable to regional agricultural officials. However, the administrative separation of researchers may actually impede the flow of technology relevant to the region. It may make it more difficult for regions to benefit from "spillover" effects--benefits of technology generated in other political regions that are agroecologically similar. The development of region-appropriate technology may also be hampered if, because of administrative separation and funding problems, it becomes more difficult to put together a "critical mass" of researchers or funding to address a problem. There are already initial indications that a breakdown of communication between commodity (nationally-funded) and applied (regionally-funded) researchers, and between regional researchers themselves, is occurring, now that coordination is voluntary and not mandated by a central agency such as IAR. Deterioration of human capital may also become a problem, if regions are unable to finance training abroad for researchers or facilitate their access to scholarly journals.

In addition, fragmentation of the national system may make it more difficult for researchers to participate in international research networks, or for Ethiopia to benefit from internationally-generated technology "spillovers." With the decline in available funds for agricultural research, major donors are putting less emphasis on strengthening national research systems, instead making more resources available for research projects coordinated through regional research organizations such as ASARECA (for East Africa) and SACCAR (for Southern Africa). Keeping abreast of such opportunities, and effective participation and dissemination of results, implies the need for tighter rather than looser coordination of national researchers. Decentralization of research does not necessarily have to lead to research system fragmentation, however, if alternative organizational linkages between researchers are strengthened, e.g., professional societies.

Coordination between Natural Resource Management and Agriculture Agencies: The merger of the extension services of the Ministry of Agriculture, Ministry of Natural Resources and the Coffee and Tea Authority is a step toward harmonizing agriculture and natural resource extension efforts in the field. There is also a need to integrate the applied **research** on agriculture and natural resource management that generates extension messages, and to facilitate partnerships between researchers and field extension agents (government and NGO personnel) working on resource conservation.

Ethiopia is considered to have one of the most serious soil degradation problems in the world. Past conservation activities have focused on afforestation and building structures such as bunds, terraces, and checkdams to control soil erosion by water and wind. The Ethiopian government launched a massive soil conservation program beginning in the 1970s. Between 1976-90, the following structures and plantings were completed:

- 71,000 ha of soil and stone bunds
- 233,000 ha of hillside terraces for afforestation
- 12,000 km of checkdams in gullied lands
- 390,000 ha of closed areas for natural regeneration
- 448,000 ha of land planted with different tree species
- 526,425 ha of bench terraces

However, by 1990, only 30% of these soil bunds, 25% of the stone bunds, 60% of the hillside terraces, 22% of the land planted in trees, and 7% of the reserve areas still survived (TGE 1994, Nurhussen 1995). Soil erosion continues; the average annual rate of soil loss is estimated at 12 tons/ha. In the highlands, home to 90% of Ethiopia's population, erosion has led to serious degradation of one-quarter of the area and moderate degradation on another one-third. On over two million hectares (4% of highland area), the soil depth is so reduced that the land is no longer able to support cultivation (GOE/IUCN 1990). Soil degradation is not limited to highland areas. In a recent survey, pastoralists and agropastoralists of Eastern Hararghe identified soil fertility and erosion, evidenced by gully and sheet erosion, as one of their most critical problems (Holt and Richards 1995).

The implications of soil losses of such magnitude for medium and long-term agricultural productivity are staggering. Problems with past conservation efforts may be rooted in a lack of understanding of the important interface between resource conservation and agriculture, and of the factors that motivate farmers to invest in conservation techniques over the long term. Past conservation initiatives were usually linked to Food for Work programs. Consequently people have built structures mainly to obtain food, not because they understand the link between their efforts and preserving soil fertility (Nurhussen 1995).

Currently efforts are being made to develop more sustainable soil and water conservation programs through new methods to solicit and incorporate greater participation of farmers in planning, decision-making, implementing and maintaining conservation works (e.g., Rapid Rural Appraisal, Local Level Participatory Planning, and Grassroot Level Land Use Planning). The new approach is also more holistic, considering the broader environmental, economic and social aspects of conservation problems, in addition to technical methods to reduce erosion (Nurhussen 1995).

Agricultural research institutes potentially have much to contribute to conservation research and activities. Currently, only 6% of IAR's budget is devoted to research on soil and water conservation techniques. Much of the effort so far appears to have been devoted to the development of physical barriers, but evaluation of past conservation programs suggests that more effort is needed on biological and agronomic conservation packages, e.g., alley cropping, grass strips and promotion of perennial crops. Developing conservation practices that are more compatible with agriculture is increasingly important in highland areas where population pressure is great and land increasingly scarce.

Farming systems researchers working with extension agents can make an important contribution by analyzing the factors that motivate farmers to invest in conservation measures in their fields over the long-term. A recent study of Rwandan farmers found that such investments were influenced by the security of land tenure, the transfer of knowledge from extension services, the availability of cash and labor resources from off-farm earnings, whether farmers held livestock to provide manure, and whether they planted perennial cash crops (Clay et al. 1995). Studies to identify the factors that motivate farmers to invest in conservation measures in Ethiopia could lead to the development of more sustainable conservation practices and recommendations for policy changes that will increase investment in conservation.

Strategic Planning for Agriculture and Natural Resource Management: A significant step toward improving coordination and planning in research and extension organizations has been taken with the recent formation of the National Agricultural Research Council (NARC). There are three categories of NARC members: (1) recognized scientists in the fields of plant, animal, food, soil and water sciences, forestry, extension, agricultural economics, and agricultural engineering; (2) representatives of key institutions, including the Institute of Agricultural Research (IAR), Alemaya University, the Ministries of Education, Agriculture and Natural Resources, the Ministry of Economic Development and Cooperation and the National Science and Technology Commission (the secretariat for the National Science and Technology Council); and (3) representatives from regions where agriculture is particularly important.

NARC has identified seven priority areas for its work: (1) assessment of the adoption of existing technology and establishment of a technology database; (2) creation of a better process to facilitate coordination between researchers, extension agents and end users; (3) establishment of a release committee for non-varietal technologies; (4) assessment of the strengths and weaknesses of the existing NARS organizational structure and program planning procedures; (5) evaluation of incentive mechanisms for researchers; (6) priority-setting for the short, medium and long-term; (7) identification of areas of research which need more attention, and formulation of plans for strengthening activities in these areas.

Several of these areas correspond directly to research and extension-related productivity constraints identified in the rapid appraisal for this study, including the need for better ex-post and ex-ante assessment of research activities, and evaluation of program planning and organizational strengths and weaknesses (including the impact of regionalization and researcher incentives). The planning for activities to carry out these objectives is now underway. Impact assessments of developed technology (ex-post) and potential technology (ex-ante) are a key input to the planning process. To date relatively few of these studies have been carried out (wheat is an exception), and capacity is limited: there are only 3 M.S.-level economists in IAR, and funding levels for agricultural economics and FSR are the lowest of the 14 national programs in 1994/95 (IAR 1994). Additional training and resources are required to enable NARS and MOPED socioeconomists to contribute fully to the strategic planning process.

The organization of ex-post and ex-ante assessment activities represents an important opportunity to

- consider opportunities and constraints to increased cereals productivity in a broader food system framework, incorporating off-farm as well as on-farm components;

- analyze the relative economic implications of different research paths (including the magnitude of benefits, and which groups will benefit), and of acquiring technology from different sources; and

- purposefully include individuals from a wider array of organizations (who are clients and stakeholders in agricultural research) in the assessment task forces. These representatives will offer a different and important perspective on technology costs, benefits, and constraints to adoption, and also supplement the scarce socioeconomic skills of the NARS.

On the latter point, research-extension coordination and integration of research planning with natural resource management have been identified as particular areas of concern. The direct inclusion of extension and natural resource professionals in technology assessment teams will provide an opportunity to analyze these problems in a specific context and work toward a strategy for overcoming the constraints in future research programs. This might include collaborative program planning and designation of resources for joint field activities among the agencies involved.

The past and future economic impact of technology is linked to the policy environment and the existence of complementary investments in the seed and fertilizer industry, marketing infrastructure, etc. Identifying the policy and investment constraints that affect the development and spread of technology is part of the assessment and strategic planning process. Including policy analysts from the Ministry of Economic Development and Cooperation in the assessment teams would ensure that the expertise needed to diagnose policy and investment constraints is available, and enlist those whose job it is to justify and effect needed policy changes and new investment in the effort from the beginning.

The quality of assessment and planning for agriculture also depends on the availability of reliable agricultural sectoral data regarding area, production and yields of crops and livestock. In recent years questions have been raised concerning the variance between different estimates of these parameters and the reliability of CSA and MOA data and analysis. Resources are required to strengthen the data gathering and analysis capacities of CSA and other agencies responsible for collection, analysis and dissemination of agricultural statistics.

2.2.1.2. Coordination Between Research/Extension and the Rest of the Subsector: The previous section examined the coordination between research institutions and between research and extension organizations. The impact of technology developed and disseminated by research and extension is ultimately measured through its adoption by farmers. Assuring adoption depends on more than good "horizontal" coordination within the "industry" of research and extension. It also depends on how well the technology fits into the "vertical" subsector (Figure 3). For a marketed commodity, this means that there must be a demand for it by the final consumer, and that the coordinating mechanisms must be in place to move the commodity and its inputs through the subsector. If researchers and extensionists are ultimately judged by the level of adoption of a technology, it is in their interest to understand the possible constraints to adoption throughout the subsector, and the likelihood that these can be overcome (perhaps in part through their own efforts), before investing too many resources in developing a particular technology, e.g., improving a crop for which there is no market.

2.2.2. Lessons from SG2000

Through its activities, the Sasakawa-Global 2000 project has convincingly demonstrated the potential of available technology to dramatically increase cereal grain production in Ethiopia. Working with the Ministry of Agriculture's Department of Extension, the project has achieved impressive yield gains on large-scale farmer-managed demonstration plots (e.g., an average five to sixfold increase over traditional maize yields in East Wellega). These plots use an improved technology package consisting of fertilizer applied at full recommendation levels, improved seeds, seed dressings and improved crop husbandry.

The project started in 1993, establishing 161 one-half hectare Extension Management Training Plots (mainly maize and wheat) in different areas of the country, in collaboration with MOA. By 1994, the program had expanded to 1,600 plots, with more than 3,000 planned for 1995. Several important lessons emerge from the SG2000 experience. First, large-scale farmer-managed demonstrations are an effective tool for convincing farmers of the benefits of improved technology. They enable the farmer to see the effect of the purchased inputs, as well as giving him/her a realistic idea of the extra management that will be required to achieve substantial yield improvements. Second, SG2000's success in cereal yield improvement and the interest it has generated among farmers have contributed to putting agricultural research and extension high on the government's policy agenda. This year the TGE launched an initiative along similar lines, the Extension Intervention Program, with 36,000 demonstration plots planned for this season.

A third lesson is that farmers can successfully adopt and manage agricultural technology, and realize significant yield increases, **if all of the inputs are accessible to them**. At the core of the SG2000 program is facilitating farmer access to inputs, including assistance from an extension agent, provision of credit (50%), and on-time, local delivery of inputs. Figure 5 (Appendix 1) shows the important dichotomy at each stage of the production-distribution-consumption sequence. The physical transformation of inputs at the farm level -- improved seed, fertilizer, management practices, and pesticide -- is dependent not only on the combination of those inputs in the correct proportions, but on the series of transactions that must take place in order for the inputs to reach the farm. It is precisely the costliness and uncertainty of those transactions (because of market failures in the input sector) that frequently prevent farmers from adopting technology. In order to generate sustainable yield increases in the cereals system, therefore, **facilitating the creation of cost-effective, reliable input delivery and output marketing systems is as important as the development of the improved seed-fertilizer-pesticide package.** The following sections of the paper discuss some important constraints in Ethiopia's seed, fertilizer and grain markets.

2.2.3. Input Availability and Distribution

2.2.3.1. Seed: A frequent frustration voiced by Ethiopian researchers is "we have developed many varieties; it is the fault of the seed company that they are not in farmers' hands." Table 1 compares released varieties for which breeder seed is available from IAR with the number of varieties available from the Ethiopian Seed Enterprise in 1995.

Table 1. Seed Varieties Available from IAR and ESE

Commodity/No. of varieties	Available from IAR	Available from ESE
Wheat	9	5
Sorghum	10	5
Maize	14	7
Tef	8	4

Sources: Ethiopian Science and Technology Commission 1994, ESE data

The national demand for seeds has been estimated at four million quintals. However, the highest seed production level ever achieved by the State Farms was 300,000 quintals, and, for the last 2 seasons, only 200,000 quintals were available. At first glance, it appears that the seed company is doing a poor job of transmitting technology to farmers if it is only distributing half of the available varieties and meeting 5% of seed demand.

The issue is more complex, however. The model in Figure 5 (Appendix 1) is a reminder of the many transactions and physical transformations required to get seed to the on-farm "physical transformation" stage. A first step is the availability of breeder seed from the research station. Second, the breeder seed must be physically transformed into commercial seed. Third, the commercial seed must be transported to a marketing center, and in the final transaction farmers must obtain cash or credit to purchase the seed.

Structural changes in the agricultural sector over the last several years have created friction in several of these transactions. The primary mandate of the Ethiopian Seed Enterprise, a former parastatal and seed monopolist, was to provide seed to the state farm sector until 1991. It was almost a closed system, in which ESE obtained breeder seed from IAR or Alemaya University, contracted with State Farms to produce commercial seed, and sold most of it back to the sector, with the NGOs as the second largest buyer. Until 1989, it also sold seed through AISCO retail centers.

Since 1994, both the production and marketing conditions for seed have changed dramatically, and ESE has been slow to adjust. In the past, state farms were required to produce commercial seed for ESE, but this is no longer true. Since most seed production is highly mechanized (except tef), and private large-scale seed producers are still rare, ESE has contracted with individual state farms to produce seed, but has been unable to contract sufficient area for seed production. Starting next year, the government will make ten former state farms available for seed multiplication. Although the barriers to private seed production and marketing are being reduced, until they are allowed to import seed (and if it is profitable to do so), private seed producers are likely to face many of the same constraints to production as ESE until private large-scale seed farms are better developed.

On the marketing side, ESE has been slow to adjust from its role as supplier to state farms to seed source for the much more dispersed smallholder sector. ESE has failed to develop a retail distribution system. AISCO formerly distributed ESE seeds, but pulled out of the market in 1989 because it considered seed marketing "too risky." ESE has no sales agents yet, although local private retailers who are marketing fertilizer as AISCO agents have expressed interest in selling seeds. Farmers obtain seed now through their service cooperatives, which purchase seeds at one of ESE's five processing centers and arrange their own delivery or pay ESE a transport fee. ESE has also set up its own shops in some communities and sold seed from mobile units.

ESE officials note that farmers are less aware of the value of improved seed than for fertilizer, and that the effective demand for seed is much less than the Ministry of Agriculture claims. For example, this season ESE received a request for 28,000 quintals of maize seed from one region. As the season approached, ESE requested that the region collect the seed, but they were unable to take delivery because government financing was unavailable. Also, Ambassel (AISCO's sole distributor in Region 3) took 2000 quintals of seed from ESE in the 1995 season, but has complained about very slow sales.

Low effective demand could result from several factors, including inadequate promotion by the extension service; unavailability of seed at the local level; high seed prices; the inability of farmers to obtain credit for seed from the state banks until this season; packaging problems (until this season, seed was available only in 50 kg bags); and because farmers may not consider improved seed superior to local varieties, e.g., some improved sorghum is more vulnerable to birds than local varieties.

More research on constraints to private seed multiplication and distribution is needed. The rapid appraisal indicates that immediate improvements could be made to increase the availability of seed at the local retail level in the short-term, e.g., licensing traders to handle seed as well as fertilizer, and expanding the new credit initiative allowing farmers to obtain credit for seed in addition to fertilizer. The SG2000 experience has shown how farmer demand for improved inputs can be stimulated with large-scale demonstration of technology. Other constraints, including remaining government barriers to the entry of private seed companies (some legitimate) or cooperative-run seed farms, and the availability of capital, land and expertise for large-scale seed farms, will require more time to overcome.

2.2.3.2. Fertilizer: In apparent contrast to the seed sector, the perception of AISCO, researchers and extensionists is that the effective demand for fertilizer in Ethiopia is not being met. This may be one reason why farmers are applying fertilizer at only half the recommended levels for cereals. While total fertilizer use has generally increased over the last 10 years (Figure 4), the rate of fertilizer use in Ethiopia is among the lowest in Africa, 7 kg/ha, equivalent to Senegal, but far lower than Kenya, Malawi or Zimbabwe (Table 2).

The main issues requiring further investigation are:

- determination of the financial and economic profitability of fertilizer use across different crops and regions at varying price/subsidy levels; and

- alternative strategies for increasing private sector and cooperative involvement in fertilizer import and distribution at the wholesale and retail levels.

Table 2. Selected Fertilizer Use Rates in Africa, 1991

Country	Kg/ha 1/
Ethiopia	7
Kenya	39
Malawi	45
Nigeria	13
Senegal	7
Tanzania	15
Zambia	12
Zimbabwe	53

Source: USDA World Agricultural Trade Indicators 1995
1/ Nutrient content equivalent nitrogen, phosphate, potash per hectare of arable and permanent cropland

On the first issue, the rapid appraisal revealed that government representatives are concerned about the impact that removing remaining price and panterritorial subsidies will have on farmer incentives to use fertilizer. Farmers already complain about the high price of fertilizer. When prices rose in the past, their demand dropped significantly. Preliminary evidence from other countries, (e.g., Tanzania, Senegal) indicates that fertilizer use by smallholders has dropped considerably following removal of price subsidies. There are two points to investigate in the Ethiopian context: (1) what is the financial and economic profitability of fertilizer use among different crops and in different regions--how is the removal of subsidies likely to affect farmer decisions to use fertilizer? and (2) what are alternative options for maintaining the price of fertilizer at reasonable levels, e.g., reducing the cost of fertilizer marketing, or more careful targeting of subsidy programs.

On the second issue, it appears that availability of foreign exchange to potential private importers will be a chronic problem for the foreseeable future. Donors will probably have to continue to assist the government to make fertilizer available to the private sector in domestic currency. A second problem is that, given the option of acquiring fertilizer in domestic currency, most private sector companies are unable to amass enough capital to acquire a shipload of fertilizer. Only one company, Ethiopia Amalgamated, imports fertilizer directly. It currently imports 15% of the total fertilizer supply, while AISCO, a government parastatal, handles 85%. More research needs to be carried out on alternative strategies for alleviating this capital constraint.

AISCO has been trying to increase private sector and cooperative involvement in fertilizer distribution over the last several years, but the response has been weak except in the Oromia and Amhara Regions (Table 3). Current policy requires private dealers to be licensed. The license constrains dealers to sell fertilizer at the official price and confines sales to a certain area. Fertilizer dealers interviewed felt that access to working capital and the restriction to sell in a specific area were significant constraints to the expansion of private input markets.

Table 3. Fertilizer Wholesalers, Private Retailers, Service Cooperatives by Region 1995

Region	Wholesalers	Private retailers	Service cooperatives
Tigray	0	1	26
Amhara	1	253	23
Oromia	49	728	253
Region 5	0	2	0
Southern Ethiopia	13	2-3	8-9
Addis	2	1	2

Source: AISCO

2.2.4. Grain Markets and Marketing Constraints

Sustained improvements in productivity growth and household access to food in Ethiopia require the development of more reliable and efficient food markets that (a) create incentives to minimize real costs at various stages in the food system; and (b) offer incentives for rural households to shift from a subsistence-oriented pattern of production and consumption to more productive systems based on specialization and gains from exchange.

The ability to capture the productivity gains from new food system technology and specialization depends on reducing the risks and uncertainty facing food market participants, thus facilitating greater participation in the types of specialized production and consumption patterns involved in the process of structural transformation.

An important feature of grain markets in Ethiopia is the presence, at the national level, of a large number of wholesalers, retailers, farmer-traders, truckers and commission agents with variable purchasing, storage, transporting capacities and market shares. Not all these participants are equally active in all markets, however. In smaller markets the number of traders may be quite limited, with negative implications for competitiveness. There is also no clear cut specialization in grain trading among the participants in the market (Kuawab 1994). Often, wholesalers do retail business and vice versa.

Constraints to the performance of grain marketing in Ethiopia include:

- Widespread inefficiency arising from uncertainties and attitudes towards risk, and lack of access to capital. Many grain traders prefer to stick to limited number of "known" markets, resulting in more segmented markets. Webb et al (1992, cited in Kuawab 1994) showed the existence of a considerable degree of interregional market segmentation.

- The presence of a prohibitive 30 percent customs duty and a 5 percent sales tax on commercial imports of cereals creates distortions by making their domestic prices artificially high, thus taxing consumers and making food unaffordable to the poor.

- Although grain trade licenses are not difficult to obtain, there is widespread unlicensed trading due to lack of enforcement of the appropriate codes. Even those with a license in one type of trading (e.g., wholesaling) may participate in the other (here retailing) without a license. The implication is that it creates unfair trading conditions between those who are properly licensed and those who are not, as such unlicensed (or improperly licensed) trading creates unequal tax burdens among traders. On the other hand, Kuawab (1994) reported that licensing requirements constrain entry into grain wholesale trading business.

- In some smaller markets (Mota, for example), there is a lack of competitiveness due to oligopsonistic behavior, including price-fixing, by agreement among traders. As producers have little or no information on prices in other markets they lose their bargaining power.

- In some other areas (e.g., Pawe Special Woreda), only local traders are allowed to transport grains out of the region, which gives an unfair advantage for traders in the area over those from other regions.

- There exist a number of grain checkpoints set up by local governments which collect municipal, sales and "development" taxes. Kuma and Makonnen (1994) point out that "kella checks and repeated charges appear to be the major problem encountered by grain traders particularly the interregional traders."

- These check points are also inconsistent in their operation, tax rates are not clearly known to market participants, and corruption is apparent in some cases. Not only do the local governments lose revenue, but traders are also uncertain of the amount they have to pay at each check point, thus encouraging them to stick to limited number of "known" markets or routes. Another inconsistency of the checkpoints is that some base their "taxes" on a per quintal basis, while others do it based on value.

As part of the diagnostic assessment, two research team members rode with truckers carrying grain from Alaba to Addis Ababa. Table 4 summarizes observations along the road between Alaba and Addis Ababa.

Table 4. Open and Hidden Costs of Grain Transport Between Alaba and Addis Ababa

Description	First Truck	Second Truck
Type of grain	Maize	Maize
Amount (qts)	99	120
Purchase price (birr/qt)	106	104
Loading/Unloading (birr/qt)	2	2
Number of grain check points where truck was stopped	5	7
Total time spent at the check points	1hr 28min	45 min
Check point "taxes"		
-with receipt (birr/qt)	0.89	0.33
-without receipt (birr/qt)	1.22	1.17
Total (birr/qt)	2.11	1.50
Broker Commission (birr/qt)	1	1
Sales Price (birr/qt)	127	127
"Taxes" without receipt as percent of total taxes	42	78

Source:FSR team investigation

As the above table illustrates, there are many checkpoints where time is being wasted unnecessarily trying to bargain over "taxes." Also, it appears that there is a high degree of corrupt practice. The checkpoint officials apparently pocket most of the fees collected, while the local government appears to receive less than 50 percent of the revenue in both cases.

Recommendations for further activities to address the identified grain marketing constraints include:

- Research into cost-effective ways of improving marketing infrastructure, access to credit for small traders, and market information, to enhance the efficiency of grain markets and marketing and promote market integration.

- A review of the tax on commercial import of cereals in terms of its impact on the food security of poor households. The presence of such a tax is an indirect subsidy to domestic producers and in contradiction to the current government policy of phasing out subsidies (such as those on fertilizer importation). One alternative that could be studied would be the removal of the import levy on an "inferior" cereal that is mostly consumed by poor households.

- Research into alternative administrative mechanisms that could be used to reduce unlicensed trading, monopolistic behavior and administrative barriers to grain market access.

- Research into alternatives to the current system of grain checkpoints for generating public revenue or taxing the grain trade. Until alternative measures are in place, the establishment and operation of the check points should be rationalized and made more transparent. This could be done by limiting their numbers and publicizing "taxes" so that they become part of the traders' information set as they make decisions about transporting grain to other markets.

3. RECOMMENDATIONS FOR A PARTICIPATORY PRODUCTIVITY RESEARCH AND ACTION PROGRAM

Based on this analysis, the research team identified several areas believed to be critical constraints to improving cereals system productivity in Ethiopia in the short- and long-term: the lack of coordination within and between research and extension organizations; the need to explicitly address the relationship between increasing agricultural productivity and conserving the natural resource base, manifested through the lack of coordination of research, policies and program implementation in these areas; constraints to input availability in the smallholder sector; and barriers to grain market development and the movement of grain through marketing channels.

The team recommends a longer-term program that combines strategic assessment and program planning in these areas to fine-tune understanding of specific policy changes and investments needed to reduce these constraints, and facilitate swift policy and program implementation. The forum for the research and planning, and the participation of policymakers as well as policy stakeholders and clients (in both the public and private sectors) in study design, implementation and discussion of results is critical to ensuring the relevance of studies and building a coalition to support implementation of recommended changes and investments.

The team recommends that the **Food Security Research Project support ESTC strategic research assessment and program planning activities** by:

- **Providing general technical support for NARC strategic assessment and planning activities**, emphasizing incorporation of economic analysis, the examination of a broader range of subsector issues affecting technology development, adoption and productivity, and participation by a larger group of stakeholders and clients.

- **Providing support to strengthen agricultural data collection and analysis capability.**

- **Building capacity for strategic research assessment and program planning, by providing training and backstopping for a network of socioeconomists** from various institutions, including MEDAC, IAR, Alemaya University, Mekalle College, Ministry of Agriculture and Natural Resources, CSA. Members of the network will carry out studies that will inform the strategic assessment and planning process, with emphasis placed on involving local and regional government officials, farmers, consumers and businessmen in study design, implementation and feedback sessions. **Study and training areas may include**:

  Technology Assessment and Research/Extension System Organization

  a. Ex-post and ex-ante technology impact assessment, including monitoring and economic analysis of innovative non-governmental organization projects, e.g., SG2000 and FAO.

b. Development and testing of a methodology to compare costs of different means of technology acquisition and dissemination, e.g., development by NARS, acquisition through regional networks or international centers with adaptation by NARS, private sector development.

c. Assessment of different models of research system organization and their implications for effectiveness of technology acquisition, development and transfer.

The Interface Between Agricultural Productivity and Natural Resource Management

d. Investigation of factors affecting farmer decisions to invest in conservation technology, including the impact of land tenure.

Constraints to Input Availability

e. Barriers to effective private sector and cooperative entry into seed multiplication and distribution.

f. Factors affecting farmer access to credit (e.g., land title, group membership) and the development of effective credit delivery systems: lessons from NGO credit projects and projects to stimulate formal sector lending to smallholders.

g. Economic assessment of the impact of removing fertilizer price level subsidies and panterritorial pricing on fertilizer use by farmer category and region, and an evaluation of alternative means of assuring access to fertilizer by smallholders.

Constraints to Grain Market Development and Grain Movement

h. Cost-effective ways of improving marketing infrastructure, access to credit for small traders, and market information to enhance the efficiency of grain markets and promote market integration.

i. A review of the tax on commercial import of cereals in terms of its impact on the food security of poor households, and the study of alternatives such as the removal of the import levy on an "inferior" cereal that is primarily consumed by poor households.

j. Assessment of alternative administrative mechanisms to reduce unlicensed trading, monopolistic behavior and administrative barriers to grain market access.

k. Alternatives to the current system of grain checkpoints for generating public revenue or taxing the grain trade.

APPENDIX 1. USING THE COMMODITY SYSTEMS APPROACH AS A FRAMEWORK FOR CONSTRAINT IDENTIFICATION AND STRATEGIC PLANNING[4]

Much is expected from investments in the agriculture sector, including **improvements in real incomes** for consumers and producers through increased productivity in commodity systems, **alleviation of poverty and food insecurity** for the most vulnerable groups in society, **enhanced sustainability** of the natural resource base, and **agricultural transformation,** as shown by strengthened linkages with other sectors of the economy. The impact of agriculture sector investments on these objectives will depend on the fit between agricultural technology development and farm-level needs, and complementary investment and innovation in institutions, organizations, technology and policy in the off-farm components of the commodity system.

Agricultural sector needs, capacities, and linkages are continually evolving. This is particularly evident in Africa, where political change and structural adjustment policies are rapidly transforming user demands for technologies, agricultural services and consumer products, and the economic environment in which they must perform. Because of the evolving nature of the agriculture sector, it is important to think of planning as an on-going process of working out resource deployment--of identifying and choosing among sequences of activities leading to different intermediate outcomes, in seeking to achieve the more general goals worked out for the sector.

Strategic planning is thus defined as an on-going problem solving process. It includes at least three key elements: working out a **vision** of where one wants to go, a **strategy** that relates how key actions must work together to achieve the vision, and day-to-day **tactics** to implement the strategy.

1.1. The Vision: Agricultural Transformation

The vision that needs to lead the agriculture sector is structural transformation, the transition out of a low-income, low-productivity, subsistence-oriented economy. This involves

- a process by which increasing proportions of employment and output of the economy are accounted for by non-farming sectors. The economy becomes less agriculturally oriented in a relative sense, although farming, and, more broadly, the commodity system continue to grow absolutely and generate important growth linkages to the rest of the economy. Structural transformation thus involves a net resource transfer from agriculture to the other sectors of the economy, over the long term.

- Movement of the economy away from subsistence-oriented household-level production towards an integrated economy based on greater specialization, exchange, and the capturing of economies of scale. Many functions formerly conducted on the farm, such

[4] This section is condensed from Boughton et al. 1995.

as input production and output processing, are shifted to off-farm elements of the economy.

One implication of this process is that driving down the real cost of food to consumers requires increased attention to fostering technical and institutional changes in the off-farm elements of the food system. Increasing productivity at the farm level is absolutely necessary but is alone insufficient to assure decreases in the real price of food to consumers.

Another implication is that for this process of structural transformation to go forward, the economy must develop low-cost means of exchange. High transaction costs in the economy can choke off structural transformation by making it too costly for people to rely on the specialization and exchange necessary to take advantage of the new technologies in the food system. The key to low-cost exchange is coordination, that is, the matching of supplies and demands at prices consistent with sustainable costs of production.

1.2. The Production-Distribution-Consumption Sequence (PDCS)

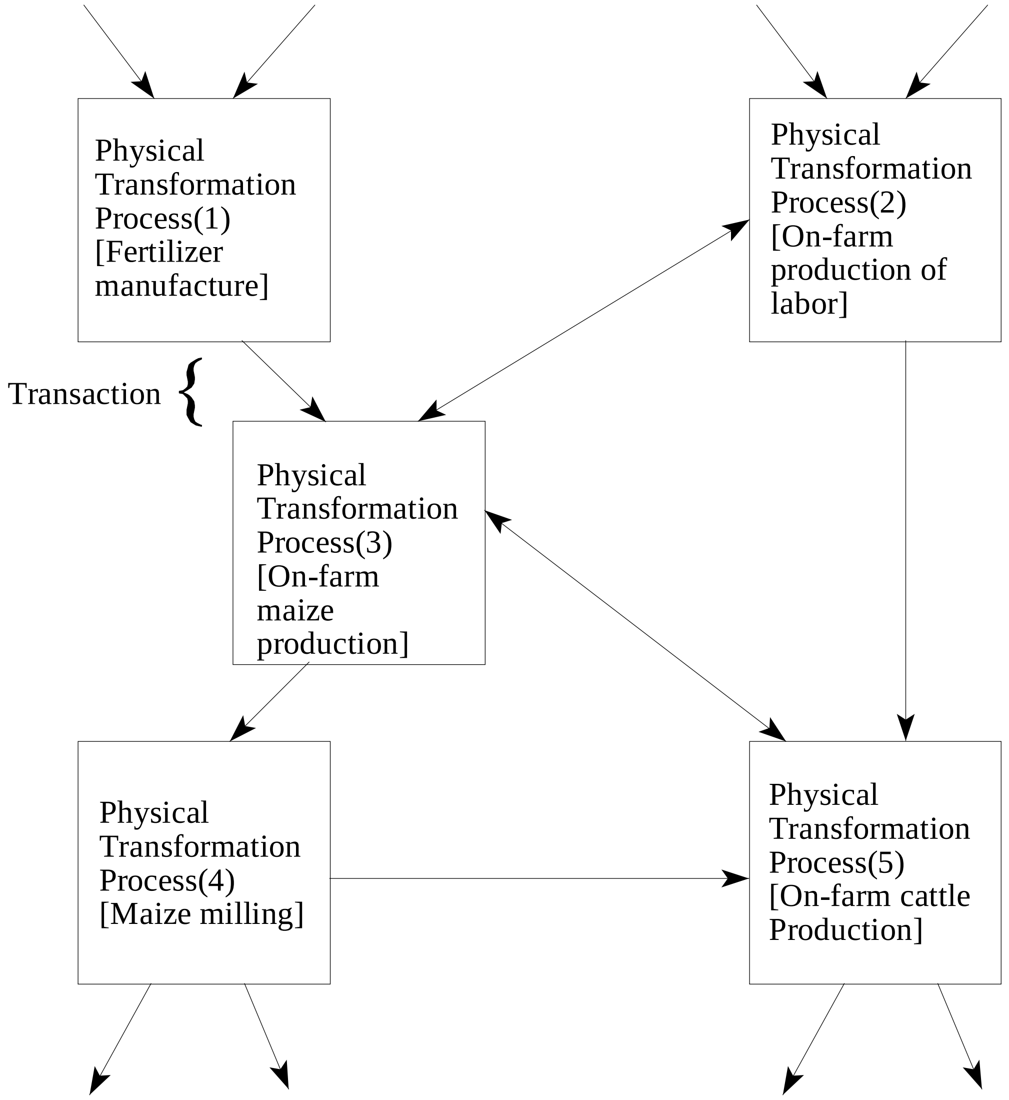
The production-distribution-consumption sequence (PDCS) for any commodity has two basic units of observation: physical transformations and transactions. Physical transformations are the result of combining two or more inputs to make an output. Each transformation is connected to the next in sequence by transactions. For each technologically separable transformation in a PDCS, potential transactions exist for passing outputs from one transformation activity to another. Figure 5 illustrates a portion of one PDCS. The outputs from fertilizer manufacture (PT1), the on-farm production of labor (PT2) and animal power and manure from on-farm livestock production (PT5) are brought together, through transactions, in the on-farm production of maize (PT3). The maize grain and stalks produced, in turn, may be sold, given or trader in the subsequent production of maize meal (PT4), dairy or meat products (PT5), or additional on-farm labor (PT2). Livestock feed is another product of maize milling (PT) and an input to on-farm cattle production (PT5).

With each separable transformation specialization is possible; each separate transformation could be handled by a separate individual or group of individuals. These various groups are then linked by transactions, which can take place within firms or across markets, as specialization can take place within firms or between them.

Facilitating structural transformation thus requires increasing the productivity of the food system PDCS. The productivity can be increased in two important and interdependent ways: raising the productivity of the individual transformations in the PDCS through **technological change** and **improving the coordination** among the individual physical transformations.

Increasing the productivity of individual physical transformations and improving coordination are highly interdependent. In much of the food system, the physical transformations are time-dependent. Fertilizer applied at the wrong time in the growing season may lower rather than raise grain output. Thus, capturing the improved productivity made possible by the development of a new fertilizer-

Figure 5. Nodes in a Production-Distribution-Consumption Sequence (PDCS)



Each node in the PDCS represents a physical transformation process that combines two or more inputs (which are themselves outputs from "upstream" transformation processes) to produce an output. This output serves as an input to subsequent "downstream" transformation processes. The nodes in the system are linked by transaction, which can take place either within a firm or between firms (e.g., through markets). Examples of physical transformation processes are shown in brackets.

dependent variety requires adequate coordination between input providers and farmers. Similarly, improvements in transport and information technologies may help improve coordination. Technological improvements and improved coordination can be seen as two sides of a coin needed to increase productivity and foster structural transformation.

1.3. Operationalizing the Vision

In going from the general mandate (agricultural transformation) to an operational plan, agricultural policymakers and analysts face two challenges. First, they must define their objectives more precisely and the assumptions underlying them. Second, they must come up with a way of describing and analyzing the complexity of the commodity system in a manageable way.

1.3.1. Defining the Dimensions of Performance

The broad agriculture sector policy will set out basic goals. Developing a workable plan, however, demands much more specificity about which aspects of the performance of the food system or the broader economy will be the focus. For example, will agricultural programs focus on increasing the total value of agricultural output in the economy, regardless of where it is produced (an "efficiency" goal)? Should greater weight be given to increasing the productivity of crops grown or consumed by the poor (an income distribution goal)? How should the various dimensions of performance be weighted in deciding the allocation of agriculture program resources?

Some attention has to be paid to the possible tradeoff between short-run and long-run benefits; thus sustainability and degradation of the environment must be considered. Politically, food prices are a critical indicator of system performance. The goal should be to drive prices down for consumers and drive up profitability for farmers, while not destroying the effectiveness of the system that coordinates resources for both farmers and consumers.

1.3.2. Clients and Stakeholders

A client is an intended recipient of specific agency benefits. Improving food security and food system performance requires increased productivity throughout the food system. For example, if, as it is typical in many African countries that marketing costs account for over 50% of the final consumer price of food, then a 10% reduction in marketing costs is equivalent to a costless 10% yield increase. Therefore clients of agricultural policies and programs include farmers, merchants, processors, input suppliers and consumers (Boughton, Staatz and Shaffer 1994).

Stakeholder is a broader concept than that of client. It includes those who have a stake in what the organization does, whether or not they are the intended recipient of the agency's benefits. Just as agricultural policymakers must decide which weights to give to different performance dimensions, so too must they work out how to weight the interests of different clients and stakeholders. For example, should technology development be geared toward the needs of large-scale irrigated farmers in surplus areas or small-scale upland farmers in food deficit areas?

1.3.3. What to Assume About the Future

The objective of strategic planning for the agriculture sector is to improve the probability that resources will be invested where they will have a high payoff. The planning therefore involves making educated guesses about where investments will be most productive. Yet estimates of the payoffs to different investments depend critically on what one assumes about the political-economic conditions that will prevail in the future.[5] For example, whether developing high-yielding, fertilizer-responsive varieties will seem to have a high payoff depends in part on what one assumes about the future availability of fertilizer at the farm level.

- Analysts can assume that current political-economic conditions will continue unchanged. This approach says that investment programs should adapt to current conditions regarding, for example, the availability of purchased inputs, opportunities in export markets, and the overall policy environment. For example, Spencer and Badiane (1994) argue that capital constraints preclude most of sub-Saharan Africa from achieving the levels of infrastructure development that proved so critical to the success of the Green Revolution in South Asia. They therefore argue that agricultural research in Africa should pursue technologies that are much less intensive in purchased inputs and much less reliant on external markets than was the case in Asia.

- One can assume that political-economic conditions will change in the future, and that predictions can be made about how those conditions will evolve. The agricultural investment program will then be designed to take advantage of the predicted conditions in the future. For example, analysts may predict that public infrastructure investments and policy reforms will create a conducive environment for private seed companies to invest in the country. This may make the payoff to developing hybrid seeds more attractive than focusing on open-pollinated varieties. This set of assumptions sees the future as dynamic, but not malleable by the research system itself. Analysts design their programs to fit predictions concerning the future economic environment, but the analysts don't attempt to modify that environment as part of their program.

- Program analysts can assume that the future is both dynamic and malleable. This approach is proactive and assumes that the strategic planning process will:
    --identify changes in the political-economic conditions that could increase the payoffs to particular investments (e.g., reforms in fertilizer import policy that could increase the returns to the development of particular varieties); and

[5] By "political-economic conditions" we mean the general policy environment as well as overall macroeconomic and sectoral conditions.

--help mobilize support to change those conditions. For example, by showing the potential returns to fertilizer-responsive varieties, analysts may be able to demonstrate the payoffs to policymakers of reforming those policies.

This approach does not say that the future will be whatever the analysts want it to be. But it does see agricultural program planners as having an influence over how the future political-economic environment facing the commodity system evolves.

1.4. Description and Analysis: The Food System Matrix

Contributing to improved performance of an economic sector requires an understanding of the sector as a system. Understanding starts with description. However, detailed and comprehensive description of any national food and agricultural sector is not feasible. For example, it is literally true that thousands of specialists coordinated by thousands of transactions contribute to the production and distribution of a single loaf of bread delivered at a grocery store, if all inputs are traced. Thus, the problem is to identify the most useful description for the purposes of identifying potential opportunities to improve performance of the sector.

One way to visualize the food and fiber sector is as a food systems matrix. The matrix is multi-dimensional, and can be viewed as a series of overlaid 2-dimensional matrices.[6] Figure 3 shows one two-dimensional representation of the matrix, with commodities depicted as columns and various stages in the vertical transformation process depicted as columns.

Research and extension can make contributions to all the production and distribution functions shown in the various cells of Figure 3. For example, research on grain wholesaling and urban consumption patterns may be central to discovering ways of increasing the productivity of the food system.

Historically, agricultural research has focused primarily on problems that fall into individual cells—e.g., farm-level production constraints for millet. However, both farming systems research and subsector approaches (described below) address problems that span the various cells in the matrix and analyze how a coordinated approach to research to problems in different cells can increase the productivity of the technology development and transfer system. For example, research on urban consumption patterns for coarse grains may lead to major insights about the attributes that breeders need to stress in their selection programs (Boughton, Staatz, and Shaffer, 1994). Hence, research and extension need to address both physical transformations (represented by individual cells in the table) and the coordination among those transformations.

The design question this paper addresses is how to chart the strategic planning process (and hence, to some extent, the structure and function of the research system) to address these challenges in the most effective way.

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[6] Each two-dimensional matrix is a projection of the n-dimensional matrix into a given two-dimensional space.

The food systems matrix identifies classes of important relationships in the sector viewed as a system. The matrix helps to identify questions and data relevant to evaluating the probable value of alternative programs of research and related programs, by directing attention to important relationships in the system likely to be influenced by the research. The matrix is also useful in structuring inquiry, leading to the identification of barriers to improved performance and unexploited opportunities, thus identifying potential opportunities for high-payoff research and complementary programs. There are at least four cross-cutting constructs (areas of study) useful for organizing information to make projections, diagnose, and analyze food and agricultural sectors. Conceptually these are different ways of slicing an economic sector for examination. Consider them as four ways of slicing the multi-dimensional food systems matrix.

Commodity Subsectors: We start with agricultural commodity subsectors. *Subsectors are defined as the sequence of activities contributing to the production, distribution and use of particular commodities.* The subsector is depicted as a vertical slice in the matrix displayed in Figure 3. The emphasis in subsector analysis is on description of the vertical sequences in production and distribution and their coordination, e.g., from the point where a commodity is produced on farms until it loses its identity in meals or in industrial processes. The scope of a subsector definition is pragmatic. In the case of a crop, it could start with development of the seed varieties and end with the uses in households. It is often useful or economical to group commodities that have similar PDCS, such as the foodgrain subsector, the livestock and meat subsector, and the beverage crops subsector.

Initial description of the subsector diagrams the channels and transformations of the commodity, followed, where possible, with data indicating volumes and values of the commodities in various forms as well as costs, by source, as the commodities pass through the different stages and channels in the sequence. Most importantly, the analysis focuses on the processes of coordination throughout the vertical sequences and on identifying problems and opportunities to improve performance.

Input Subsectors and Markets: A comprehensive description of a food and agricultural sector would include nodes for each stage in the sequence of a commodity subsector, with a description of the input subsectors for every input or relevant missing input for that transformation (Figure 5). One way of thinking about this is to envisage a third dimension rising out of the two-dimensional matrix shown in Figure 3. For example, one horizontal slice in that matrix is "transportation." Yet transportation itself requires various inputs and produces various outputs, and hence can be viewed as a subsector.

Since at least every purchased input is based in turn on another set of inputs, and they, too, on another set, etc., the complexity of such a system quickly exceeds capacity for meaningful description. Nonetheless, some input subsectors will be of critical importance to the performance of the food sector. Examples may include fertilizers and other farm and processing chemicals, transportation, and packaging materials. Coordination failures upstream in specific input subsectors often have a critical influence on the performance of commodity systems.

Knowledge is an especially important and complex input. Understanding the knowledge subsector at some level will be particularly important in strategic planning for an agricultural research agency. How, for example, is knowledge transformed into outputs of economic value when applied to different uses?

Food also serves as an input to agricultural production, through its effect on nourishing workers and influencing wage rates. The role of food as an input is often neglected, with food being treated solely as a consumer good. The evidence is that productivity is highly related to food availability (Vogel 1994).

Monitoring land and labor availability and use as system inputs is also central to planning. Land is especially important in farming, and labor is important as an input in every transformation. Analyzing land and labor as inputs on a subsector-by-subsector basis would miss identification of important problems and opportunities. The process of transformation from low-input, low-income agricultural economies depends on shifting labor out of farming.

Planning decisions based upon static perceptions of the labor market can contribute to stagnation. For example, programs that increase labor productivity in farming would be undervalued if judged on the basis of static estimates of the limited availability of off-farm employment for those released from farming. In the perspective of a dynamic system, which includes research effectively addressing the problems of unemployment in the transformation process, the value of such productivity enhancement could be high.

Industry Studies: Subsector studies examine the coordination of activity in the sequence of production, distribution and consumption of particular commodities, products or inputs ("vertical slices" in Figure 3). Industry studies examine the performance of firms in the same line of business ("horizontal slices" in Figure 3).

As was true for a subsector, the scope of the definition of an industry will depend on the purposes of the inquiry. For example, farming could be treated as a single industry, or maize farming, or retailing. Emphases in industry studies include within-firm coordination, between-firm competition, and coordination of supply and demand at the industry level.

It is useful to analyze the performance of industries as well as subsectors for at least two reasons. First, different perspectives yield different insights into how the food system works. For example, an industry approach may lead to new insights into how prices for grain are set at the wholesale level, taking into account how merchants link pricing decisions across different products. Second, it may be more cost-effective to analyze certain questions from an industry, rather than a subsector, perspective. For example, food retailing is important for most commodities. While there may be unique problems related to retailing for maize and maize products, understanding those problems would be greatly facilitated by a more general study of the food retailing industries.

To date, agricultural research in Africa has concentrated on farming. Farming systems research is largely the study of coordination within farm firms. Farming systems research, one type of "industry study," provides very important information for research planning and should be an important part of any systematic agricultural sector analysis.

Economic Coordination Services: There are several classes of what we call "coordination services" that can greatly influence the effectiveness of the coordination of resources, thereby affecting the performance of the sector and hence the value of alternative research programs.

The identification and enforcement of rights and obligations. As already discussed, transactions across markets are facilitated by this function of government. At the same time, these rules influence values of inputs and outputs and thus will have to be considered in assessing the returns to alternative lines of research. Also included for analysis would be government subsidies, taxes, price fixing, rules on competition, food safety law and enforcement, etc. For example, if the value of a commodity is lower than it otherwise would be because of monopoly in importing food processing equipment, what price should be used in the ex-ante appraisal of the research to increase production of the commodity? Should the research include analysis identifying ways to deal with the monopoly?

Finance. The credit and banking system deals in contracts that create rights to use resources. Credit clearly has a great deal to do with the use of purchased inputs and investment in productivity-enhancing practices. Credit decisions ration the use of inputs and influence the value of outputs at every stage in the transformation process. At the industry level, over-production and under-production of a commodity will be greatly influenced by credit decisions.

Since the banking system creates money, its practices influence the value of money and the coordination of aggregate supply and demand for the economy. Because the credit system creates money, it not only decides on the allocation of savings but also, in effect, takes resources from some and lends them to others. It creates rights to resources. How it functions thus has important equity implications.

Because of the way labor markets work and the barriers to expansion of off-farm enterprises, unemployment is endemic in less-developed countries, greatly inhibiting the transformation from poverty agricultural systems. Both micro credit decisions and aggregate lending have the potential to promote the transformation by creating demand for inputs and outputs and facilitating access to resources by those in the best position to use them to meet the expanded demand. However, failure to coordinate aggregate money supplies effectively with the supply of goods leads to inflation and disruptive effects on investments, production and stocks. The failure in many African countries shows up as a combination of high unemployment and high inflation--stagflation.

Risk Management. Insurance and institutions for risk management are another set of important services facilitating economic coordination. Poor performance or absence of these services is a barrier to making some investments, increases transactions costs, and inhibits the transformation. The transformation to a more market-oriented economy is facilitated by improvements in the predictability of outcomes and the protection against some adverse consequences. Potentially useful services that could be analyzed as part of a research/action program include traditional property insurance, guaranteed warehouse receipts, title insurance, futures markets, crop and revenue insurance, and forward deliverable contract markets.

Information. Transactions and planning are obviously highly dependent on information services. Since many types of information have public goods characteristics (the added cost of an additional user is zero or slight and the cost of excluding a user is high), there is a high propensity to under-invest in information services. This has special implications for a publicly funded research organizations. For example, do farmers have access to reliable and timely market information and the skills to use it in a way that will allow them to profit from a new cash-crop variety? If not, what complementary marketing or extension activities need to accompany the release of the variety?

The Role of Agents and Networks. Transactions, within firms or across markets, are made by people acting as agents for firms, households, government organizations, and possibly associations. Effective coordination of complex food systems depends upon networks of agents generating information and working out solutions to coordination problems. Innovation is the hallmark of the processes of development, and networks are particularly important in achieving adoption of innovation. Networks of vertically related agents may be critical, for example, in gaining adoption of a new variety requiring specialized inputs, unique transportation, a new food processing technique, a change in regulation and different uses in meal preparation. The absence of any one of the adjustments in the vertical sequence may render a potentially useful innovation useless. Therefore, understanding the functioning of such networks may be an important part of the research program.

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APPENDIX 2.

GRAIN MARKET RESEARCH PROJECT HOUSEHOLD SURVEY (1995/96 CROP YEAR): COMPARABILITY WITH CENTRAL STATISTICAL AUTHORITY AGRICULTURAL SURVEY

Jean Charles Le Vallée

The household-level analysis in this report is derived mainly from two sources. The Grain Market Research Project (GMRP) household survey, implemented in June 1996, and the Central Statistical Authority (CSA) Agricultural Survey, implemented in December 1995. The CSA survey is drawn from a nationally-representative sample of 14,800 households using the CSA sampling frame. The GMRP survey involved 4,218 households included in the CSA survey (hence the GMRP sample is a sub-sample of the CSA survey) and is also nationally-representative with respect to the major agricultural regions of the country, namely Tigray, Oromiya, Amhara, and Southern Regions. The following sub-regions are also considered nationally-representative: Tigray (Tigray); North and South Gonder, East and West Gojam, Agewawi, North and South Wello, Wag Hamra, North Shewa and Oromiya zone (Amhara); East and West Welega, Illubabor and Jima, North, East and West Shewa, Arsi, Bale, Borena, East and West Harerge and Somali (Oromiya); Yem, Keficho, Maji, Shekicho, Bench, North and South Omo, Derashe, Konso, Hadia, Kembata and Gurage, Sidama, Gedeo, Burhi and Amaro (Southern regions). The remaining smaller regions, Afar, Somali, Beni-Shangul and Gumuz, Gambella, Harari, Addis Ababa and Dire Dawa, do not contain sufficient observations for the survey to be considered strictly representative of their region.

The purpose of this annex is to present descriptive statistics on the comparability of key variables contained in the GMRP Household Survey (1995/96 crop year) and the CSA Agricultural Survey (1995/96 crop year). This annex focuses on three key variables in agricultural production: meher crop production, crop area cultivated, and household fertilizer use.

For grain crop production, there are three different national estimates available for the meher season: (a) farmer recall from the GMRP Household Survey; (b) farmer recall from the CSA Agricultural Survey; and (c) crop-cut estimates from the CSA Agricultural Survey (Table 1). Crop cutting involves direct physical measurement within the fields harvested while farmer recall estimates are obtained through surveying farmers after the crops have been harvested (1-2 months after in the case of the CSA Agricultural Survey and 4-5 months afterward in the case of the GMRP survey).

Table 2 shows the correlation coefficients of the three measures of production, with the household being the unit of observation. Strong correlations can be found between the GMRP and CSA farmer recall estimates, particularly for maize, wheat, barley and millet. Correlation coefficients are generally lower between the CSA crop-cut estimates and either the CSA or GMRP farmer recall estimates.

Table 1. National Meher Grain Production Estimates

Source of Estimate	Estimated Production (million metric tons)
GMRP Household Survey Farmer Recall	7.84
CSA Agricultural Survey Farmer Recall	8.51
CSA Agricultural Survey Crop-cut	9.27

As is the case with the CSA data, it is generally found that the measurement of production from crop cuts result in higher estimates than the estimates from farmer recall. A review of the empirical tests of crop-cut versus farmer recall data collection supports the conclusions that crop-cut estimates of production result in upward biases due to a combination of errors (Murphy et al. 1991, Poate and Casley 1985, Verma et al. 1988). These errors relate to biases resulting from poorly executed techniques (Rozelle 1991), large variances due to heterogeneity of crop conditions within farmer plots (Casley and Kumar 1988), and non-random location of sub-plots and tendencies to harvest crop-cut plots more thoroughly than farmers (Murphy et al. 1991). Verma et al. (1988) found that farmer estimates are closer to actual production (derived from weighing farmers' harvests) than crop-cut estimates. In general, tests of crop-cut estimates in Africa have been found to be overestimated by between 18% and 38% (Verma et al. 1988). Farmer recall was also found to result in a smaller variance in production estimates than crop-cut estimates. On the other hand, crop-cut estimates were found to provide more accurate measurements of crop yield.

Table 3 provides estimate of total cropped area by killil. Using the crop-cut method for estimating area, the results give 8 million hectares nationally for both sample sizes.

ANOVA tests were made on production and area data to see if the sub-sample (GMRP survey) was statistically different of the bigger sample size (CSA survey), in other words, if the sub-sample was representative of the bigger sample if randomly selected. At the national level and also at the regional level (i.e. killil), for all grains, we found no results that showed that these two sample sizes were significantly different at the 0.01 level: thus the sub-sample is representative of the bigger sample.

A comparison of mean household fertilizer use can be found in Table 4. Both sample sizes give very similar results.

Table 2. Correlation Coefficients of the Three Measures of Production

	Grain groups	GMRP production (FR)	CSA production (FR)	CSA production (CC)
Maize	GMRP production (FR)	1,000**		
	CSA production (FR)	636**	1000	
	CSA production (CC)	222**	128**	1000
	Number of observations	2370	4352	4304
Wheat	GMRP production (FR)	1		
	CSA production (FR)	702**	1000	
	CSA production (CC)	228**	269**	1,000
	Number of observations	1106	2101	2120
Teff	GMRP production (FR)	1,000		
	CSA production (FR)	470**	1,000	
	CSA production (CC)	384**	285**	1000
	Number of observations	2112	4105	4044
Barley	GMRP production (FR)	1,000		
	CSA production (FR)	676**	1,000	
	CSA production (CC)	347**	269**	1000
	Number of observations	1391	2637	2613
Sorghum	GMRP production (FR)	1,000		
	CSA production (FR)	410**	1,000	
	CSA production (CC)	423**	333**	1000
	Number of observations	1852	3608	3552
Millet	GMRP production (FR)	1,000		
	CSA production (FR)	622**	1,000	
	CSA production (CC)	416**	284**	1000
	Number of observations	424	822	806
Pulses	GMRP production (FR)	1000		
	CSA production (FR)	200**	1,000	
	CSA production (CC)	109**	224**	1000
	Number of observations	1785	3354	3322
Oil seeds	GMRP production (FR)	1000		
	CSA production (FR)	537**	1,000	
	CSA production (CC)	369**	103**	1,000
	Number of observations	666	1250	1193

** Correlation is significant at the 0.01 level (2-tailed)

Table 3. Total Crop Area Compared Between Both Surveys

Killil	Area (MHa) CSA Survey n=14512	Area (MHa) FSS Survey n= 3653
Tigray	481	484
Afar	24	21
Amhara	2938	3116
Oromiya	3617	3533
Somali	60	58
Benishangul	95	93
SNNPR	6978	7188
Gambela	101	39
Harari	44	45
Addis Ababa	98	96
Dire Dawa	74	59
Total	7.94	8.05

Table 4. Mean Percentage of Households Using Fertilizer by Killil.

Killil	% hh fert use (CSA survey)	% hh fert use (GMRP Survey)
Tigray	45	40
Afar	13	3
Amhara	39	36
Oromiya	49	45
Somali	6	6
Benishangul	23	28
SNNPR	36	29
Gambela	0	0
Harari	81	83
Addis Ababa	97	79
Dire Dawa	34	29

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